Applied argument analysis, Nappe tectonics and Palynostratigraphy in the middle Lahn-syncline

Stratigraphy and facies relations in the Devonian and Lower Carboniferous of the middle Lahn-syncline between Weilburg and ruin Aardeck

[Nappe tectonics, Gaudernbacher Schichten, cyclic sequences, fractal analysis, palynostratigraphy, palynofacies, sedimentary pyrite, applied argument analysis]

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André Werner Vogt

aus Kassel

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Erklärung:

Hiermit versichere ich, André Werner Vogt, geb. 23.01.1965 in Kassel, dass ich die vorliegende Dissertation selbständig, ohne unerlaubte Hilfe, angefertigt und mich dabei keiner anderen als der von mir ausdrücklich bezeichneten Quellen und Hilfsmittel bedient habe.

Marburg, 01.04.2003 ______________________________________

... dedicated to Irmgard Hartmann

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1. Berichterstatter: Prof. Dr. Willi Ziegler (†)
2. Berichterstatter: Prof. Dr. Heinrich Zankl

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Part A

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A 1 Summary

Short summary / Headlines

1. The Gaudernbach layers do not exist.
2. Remnants of the Giessen nappe have been encountered in the area between Weilburg and Holzheim.
3. The Giessen nappe in the middle Lahn-syncline comprises
   - late Viséan Kulm-slates (Kulmtonschiefer)
   - the Viséan Bruchberg sandstone north of Limburg
   - Viséan light flinty-slates
   - Tournaisian dark flinty-slates
   - Tournaisian dark slates
   - Deckdiabas and Erdbach limestone
   - newly encountered early Famennian debris flow sediments and small occurrences of greywacke.
4. The clasts of the Viséan Bruchberg sandstone were derived from the north (Laurussia), whereas the components of the Famennian greywackes came from a southerly situated source region.
5. Milankovitch cycles have been detected within the background sediments of the Bruchberg sandstone formation and the Helle Lydite (Light flinty slate) formation. Sedimentation rates in the order of less than 10 mm/ka have been derived for both analysed sediments with the obtained data.
6. Autochthonous and allochthonous lithologies show no differences in their fractal properties. But apart from that, fractal analysis proved to be a valuable tool for the quantification of tectonic trends.
7. A new Lower Carboniferous correlation chart (LCC2003) is presented.
8. Applied argument analysis has been introduced to geology for the first time. In exemplary analyses the reliability of the Giessen-Harz Nappe concept is analysed and a scheme to make appropriate judgements on the speculative nature of two palaeogeographic texts is presented.
9. A scheme for the structured registration of biostratigraphic results in electronically processable data sets is presented.
10. 18 drill cores from mostly Upper Devonian and Lower Carboniferous lithologies, drilled north of Limburg, have been analysed and their strata graphically rotated to zero dip for palaeofacies analysis.
11. The palynostratigraphy has been - for the first time - successfully applied in the area between Weilburg and Holzheim. Palynofacies determinations have been undertaken. For the first time reliable statistical data about to what extent reworked fossils could be comprised in greywacke-bearing Upper Devonian debris flow sediments become available.
12. Special attention has been paid on the description of occurrence and formation of framboidal pyrite in pelites and in phycomata of acritarchs therein.
13. A geological sketch map 1:25000, featuring the area between Weilburg and Holzheim, is presented in enclosure 2.
14. Hypothetical reconnaissance maps showing the northern Gondwana — southern Laurussia topography during the Middle Devonian and Lower Carboniferous are presented.

Gaudernbach layers

The study area is situated in Germany in the federal state Hesse at the eastern margin of the Rheinisches Schiefergebirge within the Lahn syncline. It is part of the former Variscan geosyncline. In 1910 and 1921 AHLBURG developed a new concept for the interpretation of the geological situation in the Lahn region between Marburg and Limburg: the syncline-theory. Within this "Lahn-syncline" an idealised symmetrical succession of structural and facies features - most obvious within Middle Devonian strata - was proposed. He recognised a general trend to a basinal facies from Emsian to Upper Devonian times within the "syncline", which was divided from the Middle Devonian onwards by the build-up of volcanoes and reefs in its middle part. The syncline was thus 3-fold divided into: a) the "Southern Marginal Facies", b) a zone of volcanic ridges and reefs in the *middle* and c) the "Northern Marginal Facies" which nowadays is called Hörre-facies. Small remnants of proposed Upper Devonian basinal facies within the middle volcano-and-reef facies were attributed by him to the Northern Marginal Facies; but since no direct contact to the latter was observable, he gave them a separate name: "Gaudernbacher Schichten (layers)".
Within this study the struggle which persisted over 80 years about the nature, origin, spatial distribution and palaeogeographic setting of the "Gaudernbacher Schichten" sensu AHLBURG (1918) will be settled: *The Gaudernbach layers as a separate stratigraphic unit does not exist!* It will be shown in this study that this conclusion can be, in the first instance, verified solely by logical inferences and historical contradictions. But what else - if not the occurrence of a "special facies" - could have forced AHLBURG to recognise something *unique* in this region?

In order to solve this problem the following methods have been applied:

Palynostratigraphy and palynofacies
Within this study for the first time palynostratigraphical results will be presented from the region between Weilburg and Holzheim - apart from the publication of preliminary (herein completed) results for 2 Viséan samples in WIERICH & VOGT (1997: 106f). High effort was employed in properly documenting the achieved results. This, because the preservation of most recovered fossils is generally medium to low with highly carbonised, mostly opaque, palynomorphs. The obtained thermal alteration index (TAI = 4-5) allows for the correlation to peak metamorphic temperatures in the range 250 - 300°C. Most organic matter in the residue after processing shows clear evidence of pre-, syn- or postdepositional biodegradation. Therefore, statistical population-analysis of species and their distribution through time and space is impossible. In order to gain at least some information of pre- or syndepositional conditions a systematic classification procedure for the organic and inorganic material of the processed samples was employed. In many samples several reworked fossils (= "ghost faunas/floras") have been detected besides first-cycle species.
The most interesting lithological unit is an early Famennian (approx. Latest *crepida*-zone) debris flow sediment with a relatively well preserved flora. 59 different spore and 58 different acritarch species (within 34 spore and 31 acritarch genera) from Silurian up to Famennian age have been detected within this sediment. From a statistical viewpoint, both for the spores and acritarchs, the preserved floral spectrum is relatively poor in individuals (individuenarm) but rich in different species (artenreich). If we

consider the whole spore- & acritarch-spectrum (see chapter D 2.4.2.2), *80.4% of all identified species do not reflect the true age of the analysed debris flow sediments*. The percentages of species (spores + acritarchs) with sufficient stratigraphic indication are as follows: Famennian (19.6%), Frasnian (33.4%), Middle Devonian (22.5%), Emsian (18.6%), Silurian (5.9%). Therewith, for the first time reliable statistical data as to what extent reworked fossils could be comprised in greywacke-bearing Upper Devonian debris flow sediments are available.

In the Famennian the acritarch spectrum dominates over the spore spectrum, therefore indicates an open-marine, far-shore palaeoenvironment. During the Frasnian the ratio spores/acritarchs is nearly equal - indicating a far-shore, open-marine palaeoposition, but closer to terrestrial areas than in the Famennian. In the Middle Devonian (Givetian) and the Emsian the flora was dominated by spores, which is evident in a relatively near-shore, but fully marine palaeoenvironment. The sparse Silurian flora consists almost entirely of acritarchs; chitinozoans are also present. This indicates an open-marine, far-shore palaeoenvironment. Since reworked Silurian species are also present in Emsian sediments in the study area, the Silurian species within the debris flow are interpreted as reworked species from reworked Emsian components.

Argument analysis

The history of geological research in the area between Weilburg and Holzheim is not only to be seen in the light of differing general views in geology but also in that of different authors and their methods applied to problem solutions. To the analyser of historical geological texts it is most disappointing that one has to spend much time in trying to find out what kind of data each author presented in order to support the presented conclusions - and of what quality they are. However, such an analysis is necessary since one cannot discuss and evaluate what one does not fully understand. In this study the argument analysis scheme presented by FISHER (1993) has been - for the first time in geosciences - adapted and applied to the interpretation of geological texts. It is important to note, that - by using the method - we are solely interested in finding out the truth about things rather than in scoring points off the author whose text is analysed. The revelation of the argument structure is based on the assertibility question: "*What argument or evidence would justify me in asserting the conclusion C (What would I have to know or believe to be justified in accepting C?)*". In order to do that the presented arguments, reasons and conclusions in a text have to be extracted and properly judged. I begin by describing how to recognise contexts in which reasoning is taking place. It is then described how to uncover and display the structure of a piece of reasoning. In a last step it is explained how to decide whether the reasoning is correct or incorrect. The method in full is explained on a text from Wolfgang FRANKE (1995) about the Giessen-Harz nappe. In the second example two texts dealing with palaeogeographic reconstructions for the Palaeozoic have been analysed in order to reveal to what extent they have to be judged "speculative". With an easy applicable scheme it can be shown that both texts deal with highly speculative topics. Since it would have been too time-consuming to apply this formal methodology to all texts, it has strictly been used only for the discussion of the original data presented by the several authors. That means, only the following data have been extracted from the original texts in a strictly structured way: a) coordinates, b) location, c) lithological descriptions, d) original stratigraphic correlations and e) listed fossils (see appendix F 1). In doing so, all original *interpretations* and *speculations* by the different authors become removed in order to allow for the detection and evaluation of the presented *evidence*. The extracted and actualised data become then available for new interpretations and reconstructions of the palaeoenvironment.

Our present-day considerations and conclusions may be judged false in the course of later explorations. Therefore, it is most important to present our newly explored *data* and *facts* in a clear and well structured manner in order to enable future scientists to use our data - rather than allowing for burial under the dust of time our then false conclusions and declaring our data as unreliable or not worth to be considered. At this time no global data management for stratigraphic results exists. It is suggested, that every geoscientist who "produces" such data should be convinced to submit these data in the proposed structured way to a central data base, which would be well situated at the Forschungsinstitut Senckenberg in Frankfurt.

New correlation charts and historical analysis

Most efforts have been undertaken to structurise and re-evaluate historical biostratigraphic results and present them in a common time-scale. In this study the recently published stratigraphic correlation chart (DK 1996) for the Devonian system, edited by WEDDIGE (1996) with permission of the German Subcommission on Devonian Stratigraphy, was applied. Since no equivalent Carboniferous correlation chart existed, a new correlation chart for the Lower Carboniferous (LCC2003) was compiled in order to maintain a monomethodic correlation. It is standardised on conodont stratigraphy for the Tournaisian and Viséan stages and was created by equal subdivision with the indicative amount of nowadays in Germany acceptable conodont zones for this time range. All other bio- and lithostratigraphic listings then have been - as separate columns - fitted into this conodont-based correlation chart. The DK1996 and LCC2003 correlation charts are regarded to be only *special synoptic correlation charts* which allow *for a more detailed discussion*. Up to now there is no sufficient evidence available in order to use the "time-ruler" for absolute time calibrations.

Milankovitch cycles

At least from Upper Devonian to Lower Carboniferous times a basinal marine environment is observable in the sediments which cover the area between Weilburg and Holzheim. In this basinal facies with prevailing low energy conditions and low sediment supply, evidence for orbitally driven cyclic sedimentation is preserved in the pelitic background sediment of the Bruchberg sandstone formation and in the Helle Lydite (Light flinty slate) formation.

In the Bruchberg sandstone formation the 17.1ka and 20.3ka precession orbital cycles have been detected within a 18cm core sample (AV 204). The calculated sedimentation rate for the pelitic background sedimentation of the Bruchberg sandstone formation in the middle Lahn-syncline lies most probably somewhere within the range: 1.9mm/ka — 10mm/ka. Therefore, the 18cm core sample would cover a time-span somewhere between 95ka — 18ka.

In the Helle Lydite (Light flinty slate) formation the 100ka and possibly 400ka and 1.3Ma or 2.0Ma eccentricity orbital cycles have been detected within 1248cm compacted sediment. The average layer-thickness for this sediment is 6.8cm. Probably a weak signal of the 20.3ka precession cycle is also observable. The calculated sedimentation rates of 2.6 - 4.1mm/ka are slightly higher but still in good agreement with a guess of GURSKY (1997: 75), who mentions an estimated sedimentation rate of 1.8mm/ka for the Rhenohercynian flinty slates of Lower Carboniferous age.

Fractal analysis

Fractal (self-similar) behaviour of the discontinuity network in Emsian and Tournaisian slates has been detected, described and with a box-counting method analysed over several orders of magnitude. The results are:

The fractal dimensions for the discontinuity network, block density and fracture density vary only by 1-3% for Emsian and Tournaisian slates from 2 locations which lie approx. 12km apart, but on a line subparallel to the average strike direction of major SW-NE-trending fold- and thrust-structures. The data for the Tournaisian slate have been obtained from a small ($36cm^2$) polished sample-surface; whereas these for the Emsian slate were derived from several outcrop surfaces ($0.41m^2$ to $0.85m^2$).

The analysed Emsian slates are in a proposed parautochthonous position whereas the Tournaisian slates are probably part of the Giessen nappe. This implies that for both - the parautochthonous as well as for the allochthonous - units in the analysed region the same stress field, hence the same style of tectonic deformation, acted from a certain point in geological history onwards. In other words: it seems *impossible to distinguish between autochthonous/allochthonous lithologic units only by using small (outcrop-) scale standard tectonic analyses*.

Intensive tests revealed that for future fractal analyses in this region it is sufficient to analyse only small polished samples instead of large outcrop surfaces, i. e. the scale invariance is approved. This very much reduces the necessary expenditures. No upper and lower limits for the scale over which the discontinuity network shows self-similar property have been detected - at least within the observed range 2mm to 0.23m.

The obtained fractal dimension D_{dn} of the discontinuity network indicates that the extent of brittle deformation has reached nearly its expected maximum state. However, when analysed in 3 dimensions it becomes obvious: although the discontinuity network has reached a very complex structure, the intensity of the discontinuities (measured through D_{fd}) and the interconnectivity of the discontinuities (measured through D_{bd}) lie a quarter to a third below their theoretical maximum value. This has a *practical implication*: for measurements across a tectonic deformation front the D_{dn} data would now no longer be indicative since their maximum, within the limits of the observed R-ranges, is nearly reached. The D_{fd} and D_{bd} data, however, could further be used for palaeostress-analysis.

The observed discontinuity network at outcrop scale (enclosure 1) is much more complex than the general structural features, we get via standard structural analysis, would imply. Traces of the latter structures are hard to detect within the observed discontinuity network. This, because in the fractal analysis all tectonic structures are analysed together. The complex structure of the visible discontinuity network is generated

because of inhomogeneities in the original sediment/rock mass. The presence of such inhomogenities at the microlevel, e. g. microflaws or heterogenous material, creates therefore a stochastic fractal with no regular pattern.
Rotations of the observed discontinuity network do only yield changes in the fractal dimensions, if there is an anisotropy measurable within the discontinuity network. But the observed changes are relatively low (difference of less than 4%). That means: it is not inevitably necessary for a reconnaissance analysis that the lines of a square counting box lie parallel or perpendicular to the cleavage and/or bedding planes.

Petrographic analyses

Detailed descriptions of the component-spectrum of important lithologic units have been undertaken. The aim was the reconstruction of the most probable fate of single and/or composite grains from e.g. greywackes or sandstones. Information about the nature of the source area for the sedimentary components and about the palaeoenvironment have been obtained.
Two lithologic units had never been properly described before from the analysed region: the Famennian debris flow sediments with plastic deformed greywacke and the Viséan Bruchberg sandstone. Results from the petrographic analysis of the Bruchberg sandstone had been published earlier in WIERICH & VOGT (1997). The authors demonstrated the petrologic uniformity of sandstones and conglomerates of the Bruchberg sandstone formation along a distance of more than 300km, with a source area in the north (Laurussia, see fig. D 4.2).
The grainsize of the analysed Famennian greywackes lies mostly in the range coarse silt to coarse sand. The shape of grains varies between very angular to subrounded, seldom rounded. The grains are moderately to poorly sorted with many different components in a mostly silty-pelitic matrix which accounts for approx. 5 - 15% of the total mass. The component-spectrum consists of 30-40% detrital single mineral grains, 20-30% clasts of reworked sedimentary rocks, approx. 5 - 10% clasts of magmatic rocks or their derivatives and approx. < 5% clasts of reworked metamorphic rocks. The source region is proposed to have lain somewhere in the south in a - not yet localised - major rift region.

Drill core descriptions

18 drill cores from mostly Upper Devonian and Lower Carboniferous lithologies, drilled north of Limburg during the planning phase for the new railway track Cologne-Frankfurt, were selected, described, sampled, diagrammatically presented and their strata rotated to zero dip for palaeofacies analysis.
Only two drill cores within the Bruchberg sandstone formation have been directly correlated to each other (BK 3004/13 and /14), since their strata overlap for approx. 16m. More important, however, was to try to find out what total thickness the formation may reach in the analysed region. The best location for such an attempt was decided to be the northern slope of the Greifenberg near Limburg. There, 5 appropriate drillings had been selected and their strata seemed to be relatively unaffected by small scale folding. After exclusion of the overlap of two drillings and rotation to zero dip an added net thickness of approx. 52m had been derived. But also the gaps without record between the drill sites had to be recognised, which

amounted to approx. 68m. Therefore a total minimum thickness of approx. 120m can be derived for the Bruchberg sandstone formation, if we assume the lithologic succession to be without major faults.
From the drillings within the early Famennian debris flows near Limburg a minimum net thickness of approx. 20m has been derived after rotation of strata to zero dip.

Arguments in favour of a nappe emplacement

1) The newly explored early Famennian greywackes are petrographically almost identical to Upper Devonian greywackes from the Giessen nappe. They do not contain limestone fragments, nor major amounts of magmatic rocks, as would be expected for sediments derived from the only known important submarine highs at that time: the (then tectonically reactivated?) remnants of middle Devonian reefs on top of magmatic ridges. The considerable content of metamorphic rocks (together with other evidence) indicates a source region somewhere in the south in a "mid-German" palaeoposition. The clasts which were shed from there could impossibly be transported directly to their present day position by passing over the remnants of the magmatic ridges of the Lahn-syncline.
2) The early Famennian debris flow sediment does neither contain considerable amounts of calcareous fragments nor any basalts or pyroclastics - as would be expected if their present position had been identical with their relative palaeoposition. Since the palynological analysis revealed that all - clayey to sandy and only seldomly calcareous - sediments from Emsian to early Famennian times are confined in the debris flow (within less than 20m (condensed?) sediment pile) a palaeoposition relatively far away from the magmatic ridges of the Lahn-syncline is evident.
3) At least approx. 120m late Viséan Bruchberg sandstone formation has been found on top of the approx. 20m thick Famennian debris flow sediments north of Limburg. Since no concordant succession is detectable, both units are most probably divided by major faults. This is only possible if the original palaeogeographical position of the Bruchberg sandstones had been - even approx. 30 million years later - south of the relative palaeopositon of these debris flows during the Famennian. In turn this implies that the Bruchberg sandstones - at least from the region north of Limburg - must have been transported as younger parts of the Giessen nappe.
4) The Viséan Erdbach limestone III from an outcrop near Steeden yielded a trilobite fauna which is significantly different to other Erdbach limestone faunas of the eastern Rheinisches Schiefergebirge and reveal closer relations to contemporaneous Harz-faunas from the Winterberg (HAHN, HAHN & MÜLLER (1998: 199).
5) The Deckdiabas as well as parts of the Light flinty slates inhabit intercalations of Erdbach limestones, but without sufficient faunal evidence for an attribution to a different faunal province. However, both are always in a structural position *without* connection to significantly older, e. g . Upper Devonian strata in concordant succession.

6) Small remnants of Viséan (*Goniatites* III β/γ) greywacke north of Hadamar near Oberzeuzheim had been encountered by HENNINGSEN 1970. These occurrences are situated approx. 9km northwest of an outcrop with Famennian greywacke in the analysed area near Eschenau. Due to HENNINGSEN (1970: 196), these greywackes are identical to the Lower Carboniferous Giessen-greywackes, which are nowadays interpreted as forming part of the Giessen nappe.
7) A small outcrop with proposed Upper Devonian greywackes north of Hadamar near Elbgrund had been described by HENNINGSEN (1970). The outcrop lies approx. 11km northwest of an outcrop with Famennian greywacke west of Eschenau. Due to HENNINGSEN (1970: 198) these greywackes are similar to the Upper Devonian (Nehdenian - Hembergian) Hörre-greywackes southeast of Nenderoth.
8) Nappe emplacement must have taken place early in the Variscan compressional cycle since no major differences in the tectonic style between autochthonous and allochthonous units are detectable at outcrop scale.
9) The recovered palynomorphs from the Viséan Bruchberg sandstone formation and the Famennian debris flows are slightly less carbonised than the ones from autochthonous units; in both formations even transparent specimens occur. A plausible explanation for this is: The allochthonous units have been overthrust somewhere around the borderline Lower/Upper Carboniferous, thus placed at least several hundred metres on top of the parautochthonous units. Therefore, later (in the course of the Variscan orogeny) they became less deeply buried and hence less thermally altered, probably in the range 10 - 40 °C. That seems to be the most conclusive reason why younger greywacke units of the Famennian are datable at all - with the sometimes good preservation of palynomorphs not significantly limited by thermal alteration but in majority by bacterial attack, weathering and pyritization prior to final deposition.

A 2 Zusammenfassung

Kurzfassung (Schlagzeilen)

1. Die Gaudernbacher Schichten gibt es nicht.
2. Neu entdeckte Überreste der Giessener Decke werden aus der Region zwischen Weilburg und Holzheim beschrieben.
3. Die Giessener Decke in der mittleren Lahn-Mulde beinhaltet folgende Einheiten:
   - Kulmtonschiefer (Viséum)
   - Bruchberg Sandstein nördlich von Limburg (Viséum)
   - Helle Lydite (Viséum)
   - Dunkle Lydite (Tournaisium)
   - Dunkle Tonschiefer des Tournaisiums
   - Deckdiabas und Erdbacher Kalk
   - neu entdeckte Vorkommen von oberdevonischen Debris Flow (Famennium) Sedimenten (Schlammstromsedimente, submarine Gleitmassen) und Grauwacken.
4. Die Lithoklasten der Bruchberg Sandsteine stammen von einem nördlich gelegenen Liefergebiet (Laurussia), wohingegen diejenigen der oberdevonischen Grauwacken von einem südlich gelegenen Liefergebiet abzuleiten sind.
5. Im pelitischen Hintergrundsediment der Bruchberg Sandstein Formation und in den Hellen Lyditen sind Milankovitch-Zyklen entdeckt worden. Mit den Ergebnissen der Zyklenauswertung konnten Sedimentationsraten in der Größenordnung von weniger als 10mm/ka für beide Sedimente errechnet werden.
6. Sowohl autochthone als auch allochthone Lithologien weisen keine Unterschiede in ihren fraktalen Kennwerten auf. Aber abgesehen davon erwies sich die Fraktalanalyse als wertvoll zur Quantifizierung tektonischer Trends.
7. Eine neue stratigraphische Korrelationstabelle für das Unterkarbon (LCC2003) wird vorgestellt.
8. Die *Angewandte Argumentanalyse* wird erstmals in der Geologie eingesetzt. In Beispiel-Analysen wird die Verläßlichkeit des Giessen-Harz-Decken - Konzepts untersucht und ein Schema zur Wertung über den spekulativen Charakter von zwei paläogeographischen Texten vorgestellt.
9. Ein Schema zur strukturierten EDV-Erfassung von biostratigraphischen Ergebnissen wird präsentiert.
10. 18 nördlich von Limburg abgeteufte Bohrkerne, von meist oberdevonischen und unterkarbonischen Lithologien, wurden aufgenommen und ihre Schichten zur Durchführung von Paläofaziesanalysen graphisch in die Horizontale rückrotiert.
11. Die Palynostratigraphie wird erstmals - erfolgreich - in der Region zwischen Weilburg und Holzheim angewandt. Paläofaziesbestimmungen wurden durchgeführt. Zum ersten Mal werden verläßliche statistische Daten zur Frage, bis zu welchem Ausmaß umgelagerte Fossilien in Grauwacke-führenden oberdevonischen Debris Flow - Sedimenten Vorkommen, zur Verfügung gestellt.
12. Besonderer Wert wurde auf die Beschreibung von Vorkommen und Bildung framboidalen Pyrits in Peliten sowie in darin enthaltenen Phycomata von Acritarchen gelegt.
13. Eine "Geologische Themen-Karte" 1:25000 für die Region zwischen Weilburg und Holzheim wird in Beilage 2 vorgestellt.
14. Die Topographie des Bereiches Nord-Gondwana — Süd-Laurussia während des Mitteldevons und Unterkarbons wird in hypothetischen Übersichtskarten skizziert.

Gaudernbacher Schichten

Das Arbeitsgebiet liegt in Deutschland (im Bundesland Hessen) am Ostrand des Rheinischen Schiefergebirges innerhalb der Lahn-Mulde und ist Teil der früheren variszischen Geosynklinale. In den Jahren 1910 und 1921 entwickelte AHLBURG ein neues Konzept zur Interpretation der geologischen Verhältnisse in der Lahn-Region zwischen Marburg und Limburg: die Mulden-Theorie. Er schlug vor die "Lahn-Mulde" als idealisierte symmetrische Abfolge struktureller und fazieller Einheiten anzusehen - am deutlichsten erkennbar in mitteldevonischen Schichten. AHLBURG konnte einen generellen Trend zur Beckenfazies vom Emsium zum Oberdevon innerhalb der "Mulde" beobachten, welche ab dem Mitteldevon durch den Aufbau von Vulkanen und Riffen in der Mitte klar 3-fach unterteilbar wurde. Daraufhin unterschied er die Mulde in a) eine "Südliche Randfazies", b) eine Zone vulkanischer Rücken und Riffe in der *Mitte* und c) eine "Nördliche Randfazies", welche heute als Hörre-Fazies bezeichnet wird. Kleine Vorkommen von vermuteter oberdevonischer Beckenfazies inmitten der mittleren ehemaligen Vulkan-Riff-Fazies wurden zur Nördlichen Randfazies gezählt; da aber kein direkter sedimentärer Kontakt zur letzteren beobachtet werden konnte, gab er ihnen einen separaten Namen: "Gaudernbacher Schichten".
Mit dieser Studie wird ein über 80 Jahre währender Streit über die Art, die Herkunft, die räumliche Verbreitung und die paläogeographische Position der "Gaudernbacher Schichten" beendet: *Die "Gaudernbacher Schichten" als eigenständige stratigraphische Einheit gibt es nicht!* Es wird mit dieser Studie gezeigt, daß diese Schlußfolgerung, in erster Instanz, allein durch logische Argumentanalysen und historische Widersprüche erreicht werden kann. Aber was dann - wenn nicht das Vorkommen einer "Sonderfazies" - könnte AHLBURG dazu veranlaßt haben etwas "spezielles" in dieser Region zu erkennen?

Um dieses Problem zu lösen wurden folgende Methoden angewandt:

Palynostratigraphie und Palynofazies

Mit dieser Studie werden zum ersten mal palynostratigraphische Ergebnisse aus der Region zwischen Weilburg und Holzheim vorgestellt - abgesehen von der vorab-Publikation vorläufiger (hierin vervollständigter) Ergebnisse für 2 Proben mit Viséum-Alter in WIERICH & VOGT (1997: 106f). Größte Sorgfalt wurde auf die jederzeit nachvollziehbare Dokumentation der ermittelten Resultate verwendet. Dies besonders, weil die Erhaltung der meisten rückgewonnenen Fossilien generell als mittel bis niedrig einzustufen ist, mit hochinkohlten, meist opaken, Palynomorphen. Der ermittelte Thermal Alteration Index (TAI 4-5) erlaubt eine Korrelation mit metamorphen Spitzentemperaturen im Bereich zwischen 250-300 °C. Meistens zeigt die organische Substanz im Aufbereitungsrückstand klare Anzeichen von prä-, syn- oder postdepositionaler Biodegradation. Es ist deshalb unmöglich, statistische Populationsanalysen für die Arten und ihre Veränderung in Zeit und Raum durchzuführen. Um zumindest ein paar wichtige Informationen zu den prä- oder syndepositionalen Bedingungen zu erhalten, wurde eine systematische Klassifikation für das organische und anorganische Material der aufbereiteten Proben durchgeführt. In vielen Proben konnten umgelagerte Fossilien ("Geisterfaunen/-floren") neben offensichtlich zeitäquivalenten Spezies aufgespürt werden.

Als interessanteste lithologische Einheit erwies sich ein Debris Flow - Sediment (Schlammstrom-sedimente, submarine Gleitmassen und Grauwacken) von frühem Famennium-Alter (ca. späteste *crepida*-Zone), das relativ gut erhaltene Floren beinhaltet. 59 verschiedene Sporen- und 58 verschiedene Acritarchen-Arten (innerhalb von 34 Sporen- und 31 Acritarchen-Gattungen) von silurischem bis zu Famennium-Alter wurden in diesem Sediment entdeckt. Aus statistischer Sicht ist sowohl das noch erhaltene Sporen- als auch das Acritarchenspektrum als individuenarm, aber artenreich anzusprechen. Wenn wir das erhaltene Gesamtspektrum an Acritarchen & Sporen betrachten (siehe Kapitel D 2.4.2.2) fällt auf, *daß 80,4% aller identifizierten Arten nicht das wahre (jüngste) Alter der untersuchten Debris Flow - Sedimente anzeigen*. Die prozentualen Anteile der Sporen- und Acritarchenarten mit hinreichender stratigraphischer Korrelation sind wie folgt: Famennium (19.6%), Frasnium (33.4%), Mitteldevon (22.5%), Emsium (18.6%), Silurium (5.9%). Damit werden erstmals verläßliche statistische Daten zur Frage, bis zu welchem Ausmaß umgelagerte Fossilien in Grauwacke-führenden oberdevonischen Debris Flow-Sedimenten vorkommen können, präsentiert.

Im Famennium dominiert das Acritarchenspektrum über das Sporenspektrum, was ein offen-marines, strandfernes Paläoenvironment anzeigt. Während des Frasniums war das Verhältnis Sporen/Acritarchen nahezu gleich - ein Hinweis auf eine strandferne, offen-marine Paläoposition, die jedoch festlandsnäher war als im Famennium. Im Mitteldevon (Givetium) und im Emsium wurde die Flora durch Sporen dominiert, was als Hinweis auf ein relativ strandnahes, jedoch offen-marines Paläoenvironment gelten kann. Die spärliche silurische Flora besteht fast ausschließlich aus Acritarchen, jedoch kommen auch Chitinozoen vor. Dies weist auf ein offen-marines, strandfernes Paläoenvironment hin. Da umgelagerte silurische Arten auch in Emsium-Sedimenten im Untersuchungsgebiet vorkommen, werden die silurischen Anteile am Artenspektrum der Debris Flows ebenfalls als umgelagerte Arten aus umgelagerten Emsium-Komponenten interpretiert.

Angewandte Argumentanalyse

Die Geschichte der geologischen Erforschung des Gebietes zwischen Weilburg und Holzheim darf nicht nur im Lichte sich ändernder genereller Ansichten in der Geologie betrachtet werden, sondern ebenso in dem verschiedener Autoren und ihren verwendeten Methoden zur Problemlösung. Für den Analytiker historischer geologischer Texte erweist es sich als äußerst unbefriedigend, daß man sehr viel Zeit darauf verwenden muß, zu versuchen herauszufinden welche Art von Daten jeder Autor zur Unterstützung seiner Schlußfolgerungen vorgestellt hat - und von welcher Qualität diese sind. Aber dies ist notwendig, denn man kann nicht über etwas diskutieren und es gar bewerten, wenn man es nicht vollständig verstanden hat. In dieser Studie ist die von FISHER (1993) publizierte Methode der Argumentanalyse - zum ersten mal in den Geowissenschaften - adaptiert und zur Interpretation geologischer Texte herangezogen worden. Es muß besonders betont werden, daß - wenn wir diese Methode benutzen - es einzig darum geht, die Wahrheit über bestimmte Sachverhalte zu ermitteln und nicht den Autor des analysierten Textes bloßzustellen. Die Klärung der Argumentstruktur wird mit der "Überzeugungsfrage" eingeleitet: *"Welches Argument oder welcher Beweis würde mich davon überzeugen von der Schlußfolgerung S überzeugt zu sein (Was müßte ich wissen oder glauben um S akzeptieren zu können?)*. Um diese Klärung durchführen zu können, müssen die in einem Text präsentierten Argumente, Begründungen und Schlußfolgerungen extrahiert und bewertet werden. Ich beginne dazu mit der Beschreibung, wie man Textstellen, in denen Begründungen vorkommen, erkennt. Es wird sodann beschrieben, wie man die Struktur einer Begründungskette aufdeckt und darstellt. Im letzten Schritt wird erklärt, wie man darüber entscheidet, ob die aufgedeckte Begründungskette richtig entwickelt wurde oder falsch ist. Die Methode wird am Beispiel eines Textes von Wolfgang FRANKE (1995) über die Giessen-Harz Decke ausführlich erläutert. Im zweiten Beispiel sind zwei Texte, die sich mit paläogeographischen Rekonstruktionen im Paläozoikum beschäftigen, analysiert worden, um zu ermitteln, in welchem Umfang sie als "spekulativ" einzustufen seien. Mit Hilfe eines einfach anwendbaren Verfahrens kann gezeigt werden, daß beide Texte hoch spekulativ sind. Da es zu zeitaufwendig gewesen wäre diese formale Methodologie in allen Texten anzuwenden, wurde sie im strikten Sinne nur bei der Diskussion der von den jeweiligen Autoren angeführten Originaldaten genutzt. Dies bedeutet, nur die im Folgenden aufgeführten Daten sind aus den Originaltexten in klar strukturierter Weise extrahiert worden: a) Koordinaten, b) Ortsbeschreibung, c) lithologische Beschreibung, d) ursprüngliche stratigraphische Korrelation und e) aufgelistete Fossilien (siehe Appendix F 1). Durch diese Verfahrensweise werden alle *Interpretationen* und *Mutmaßungen* der jeweiligen Autoren beseitigt und es wird damit ermöglicht, die präsentierten *Beweismittel* klar erkennen und bewerten zu können. Die extrahierten und aktualisierten Daten stehen dann für neue Interpretationen und Rekonstruktionen des Paläoenvironments zur Verfügung.

Unsere heutigen Überlegungen und Schlußfolgerungen mögen im Zuge weiterer Untersuchungen in Zukunft als falsch bewertet werden. Deshalb ist es besonders wichtig unsere neugewonnenen Daten und Fakten klar strukturiert zu dokumentieren, damit nachfolgende Wissenschaftler diese ohne großen Aufwand nutzen können. Dies, um zu verhindern, daß unsere dann evtl. als falsch erkannten Schlußfolgerungen *zusammen* mit unseren Daten als unzuverlässig oder nicht beachtenswert bewertet und unter dem Staub der Geschichte begraben werden. Zur Zeit existiert leider noch kein globales Datenmanagement für stratigraphische Ergebnisse. Es wird daher vorgeschlagen, daß jeder Geowissenschaftler, der solche Daten bereitstellt, dazu gedrängt werden sollte, diese Aufzeichnungen in der oben bzw. den Appendices F 1 und F 2 angeführten strukturierten Weise an eine zentrale Datenbank zu übermitteln, die am besten beim Forschungsinstitut Senckenberg in Frankfurt angesiedelt werden sollte.

Neue Korrelationstabellen und historische Analyse

Größte Anstrengungen wurden unternommen, um historische biostratigraphische Ergebnisse neu zu strukturieren und zu bewerten, damit sie in einer gemeinsamen Zeitskala dargestellt werden können. In dieser Studie wurde die von WEDDIGE (1996) mit Zustimmung der deutschen Subkommission für Devon-Stratigraphie herausgegebene Korrelationstabelle (DK 1996) für das Devon angewandt. Da keine äquivalente Tabelle für das Karbon existierte, wurde eine neue Korrelationstabelle für das Unterkarbon (LCC2003) erarbeitet, um eine monomethodische Vergleichbarkeit zu gewährleisten. Sie ist an der Conodonten-Stratigraphie für das Tournaisium und Viséum geeicht und wurde erstellt, indem dieser Zeitraum gleichmäßig durch alle derzeit in Deutschland für diesen Zeitbereich akzeptierbaren

Conodonten-Zonen gleichrangig geteilt wurde. Alle anderen bio- und lithostratigraphischen Auflistungen sind dann - als separate Spalten - in diese Conodonten-geeichte Korrelationstabelle eingepaßt worden. Die DK1996 und LCC2003 Korrelationstabellen werden nur als *spezielle synoptische Korrelationstabellen* bewertet, *die eine detailliertere Diskussion ermöglichen*. Bis zum heutigen Tage wurden noch keine ausreichenden Belege publiziert, um dieses "Zeitlineal" auch für absolute Zeitkalibrierungen benutzen zu können.

Milankovitch-Zyklen

Zumindest für den Zeitbereich Oberdevon bis Unterkarbon ist ein durchgängig marines Ablagerungsmilieu für die Sedimente zwischen Weilburg und Holzheim zu beobachten. In dieser landfernen Becken-Fazies, mit vorherrschend niedrig-energetischen Bedingungen und geringem Sedimenteintrag, sind Beweise für orbitalgesteuerte zyklische Sedimentation im pelitischen Hintergrundsediment der Bruchberg Sandstein Formation und den Hellen Lyditen gefunden worden. In der Bruchberg Sandstein Formation sind innerhalb eines 18cm langen Bohrkerns (AV 204) die 17.1ka und 20.3ka orbitalen Zyklen der Erd-Präzession entdeckt worden. Die errechenbare Sedimentationsrate für das pelitische Hintergrundsediment der Bruchberg Sandstein Formation liegt höchstwahrscheinlich im Bereich zwischen 1.9mm/ka bis 10mm/ka. Das 18cm Kernstück würde damit einen Zeitraum irgendwo zwischen 95ka — 18ka dokumentieren. In den Hellen Lyditen sind innerhalb von 1248cm kompaktiertem Sediment die 100ka und möglicherweise auch 400ka sowie 1.3Ma bzw. 2.0Ma orbitalen Zyklen der Erd-Exzentrizität entdeckt worden. Die durchschnittliche Schichtdicke in diesem Sediment beträgt 6.8cm. Wahrscheinlich kann auch ein schwaches Signal des 20.3ka Präzessions-Zyklus beobachtet werden. Die errechneten Sedimentationsraten von 2.6 - 4.1mm/ka sind zwar etwas höher, jedoch noch in guter Übereinstimmung mit einer Schätzung von GURSKY (1997: 75), der von einer Sedimentationsrate von 1.8mm/ka für die unterkarbonischen kieseligen Schiefer des Rhenoherzynikums ausgeht.

Fraktalanalyse

In kieseligen Schiefern des Emsium und Tournaisium ist fraktales (selbstähnliches) Verhalten im untersuchten Diskontinuitäts-Netzwerks festgestellt, beschrieben und für verschiedene Größenordnungsbereiche mittels box-counting Methode analysiert worden. Folgende Resultate wurden erzielt:

Die fraktalen Dimensionen für das Diskontinuitätsnetzwerk, die Blockdichte und die Kluftdichte variieren nur um 1-3% für Tournais- und Visé-Schiefer in zwei 12km voneinander entfernten Aufschlüssen, die auf einer Linie subparallel zur generell SW-NE gerichteten Streichrichtung der tektonischen Großstrukturen in diesem Gebiet liegen. Die Daten für den Tournais-Schiefer wurden von einer kleinen (36cm²) polierten Oberfläche abgeleitet, während jene für den Ems-Schiefer von verschiedenen kleinen Aufschlußflächen (0.41m² bis 0.85m²) ermittelt wurden.

Die untersuchten Ems-Schiefer sind in einer parautochthonen Position, während die Tournais-Schiefer wahrscheinlich ein Teil der Giessener Decke sind. Damit ist zu folgern, daß beide - die parautochthonen und die allochthonen - Lithologien in der untersuchten Region ab einem bestimmten Zeitpunkt in der geologischen Historie dem gleichen Stressfeld und ebenso dem gleichen Deformationsstil unterworfen wurden. Mit anderen Worten: es scheint *unmöglich zu sein zwischen autochthonen und allochthonen lithologischen Einheiten mit Hilfe kleinräumig (aufschlußgroß) angelegter tektonischer Standardanalysen zu unterscheiden*.

Durch intensive Tests konnte festgestellt werden, daß es bei zukünftigen Fraktalanalysen in dieser Region völlig ausreicht, kleine polierte Handstücke und nicht größere Aufschlußflächen zu untersuchen, d. h. die dimensionsfreie Selbstähnlichkeit wird bestätigt. Dies reduziert den notwendigen Analysenaufwand erheblich. Es konnten keine oberen oder unteren Grenzbereiche ermittelt werden, in denen die Selbstähnlichkeit des Diskontinuitätsnetzwerkes nicht mehr gegeben wäre - zumindest nicht im beobachteten Zählbereich zwischen 2mm und 0.23m.

Die ermittelte fraktale Dimension D_{dn} für das Diskontinuitätsnetzwerk deutet an, daß das Ausmaß der bruchhaften Deformation nahezu das erwartbare Maximum erreicht hat. Wenn man die Analyse jedoch auf die 3. Dimension ausweitet, zeigt sich, daß obwohl das Diskontinuitätsnetzwerk schon eine sehr komplexe Struktur erreicht hat, die Intensität der Diskontinuitäten (gemessen als D_{fd}) und die Interkonnektivität der Diskontinuitäten (gemessen als D_{bd}) um ein Viertel bis ein Drittel unter ihrem theoretischen Maximalwert liegen. Dies hat durchaus eine *praktische Bedeutung*: bei Messungen entlang einer Linie quer zur tektonischen Deformationsfront würden zwar die D_{dn} - Daten nun nicht mehr aussagekräftig sein können, da ihr Maximum, zumindest innerhalb der beobachteten R-Bereiche (Einheitsquadratlängen), nahezu erreicht ist. Die D_{fd} und D_{bd} -Daten könnten jedoch weiterhin für die Paläostressanalyse benutzt werden.

Das im Aufschluß beobachtete Diskontinuitätsnetzwerk (Beilage 1) ist sehr viel komplexer als die mittels tektonischer Standardanalysen ermittelbaren Strukturen erwarten lassen würden. Letztgenannte Strukturen sind im beobachteten Diskontinuitätsnetzwerk nur schwer identifizierbar. Das liegt daran, daß bei der Fraktalanalyse alle tektonischen Strukturen zusammen untersucht werden. Die komplexe Struktur des Diskontinuitätsnetzwerkes wird durch Inhomogenitäten im Sediment oder Gestein generiert. Das Vorhandensein solcher Inhomogenitäten im Mikromaßstab, z. B. Mikroschlieren, oder heterogenes Material, kreiert daher ein stochastisches Fraktal ohne reguläres Muster.

Rotationen des beobachteten Diskontinuitätsnetzwerkes bewirken nur dann Änderungen in der fraktalen Dimension, wenn Anisotropien innerhalb des Diskontinuitätsnetzwerkes nachweisbar sind. Jedoch sind die dabei beobachteten Veränderungen relativ gering (Unterschiede von weniger als 4%). Dies bedeutet: es ist für eine Übersichtsanalyse nicht unbedingt nötig, daß die Linien der quadratischen Zählbox parallel oder senkrecht zu den Schieferungs- oder Schichtflächen liegen.

Petrographische Analysen

Für wichtige lithologische Einheiten wurden detaillierte Beschreibungen des Komponentenspektrums angefertigt. Damit wurde das Ziel verfolgt, das wahrscheinlichste Schicksal von Einzelmineralen oder Gesteinsbruchstücken, z. B. von Grauwacken oder Sandsteinen, zu rekonstruieren. Dabei konnten Informationen über die Art des Liefergebietes der sedimentären Komponenten und über das Paläoenvironment gewonnen werden.

Zwei lithologische Einheiten der Region waren niemals zuvor ausreichend beschrieben worden: die Debris Flow Sedimente mit plastisch deformierter Grauwacke aus dem Famennium und der Bruchberg Sandstein aus dem Viséum. Erste Resultate der petrographischen Analyse der Bruchberg Sandsteine sind bereits in WIERICH & VOGT (1997) publiziert worden. Die Autoren demonstrierten darin die petrologische Uniformität der Sandsteine und Konglomerate der Bruchberg Sandstein Formation in einer über 300km langen Zone, mit einem ursprünglichen Liefergebiet im Norden (Laurussia, siehe Abb. D 4.2).
Die Korngrößen der untersuchten Grauwacken aus dem Famennium liegen meistens im Bereich zwischen Grobsilt und Grobsand. Die Kornform variiert zwischen sehr angular bis angerundet, selten auch gerundet. Die Klasten sind moderat bis schlecht klassiert mit vielen verschiedenen Komponenten in einer meist siltig-pelitischen Matrix, die ca. 5-15% der Gesamtmasse ausmachen kann. Das Komponentenspektrum wird aufgebaut aus: 30-40% detrischen Einzelmineralkörnern, 20-30% Klasten von aufgearbeiteten Sedimentgesteinen, ca. 5-10% Klasten von Magmatiten oder deren Abkömmlingen und ca. <5% Klasten von Metamorphiten. Als Liefergebiet wird eine irgendwo im Süden gelegene - bisher nicht lokalisierte, größere Rift-Region vorgeschlagen.

Bohrkernbeschreibungen

18 Bohrkerne, in meist oberdevonischen und unterkarbonischen Lithologien nördlich von Limburg im Zuge der Planungsarbeiten für die neue Eisenbahn-Strecke Köln-Frankfurt abgeteuft, wurden ausgewählt, aufgenommen, beprobt, in bildlicher Form ausgewertet und ihre Schichten zur Durchführung von Paläofaziesanalysen graphisch in die Horizontale rückrotiert (appendix F 3).
Nur zwei der in der Bruchberg Sandstein Formation abgeteuften Bohrungen (BK 3004/13 und /14) erwiesen sich als direkt miteinander korrelierbar, da ihre Schichten sich über eine Strecke von ca. 16m überlappen. Wichtiger als die direkte Korrelation war daher der Versuch herauszufinden, welche Gesamtmächtigkeit die Formation im Untersuchungsbebiet erreichen könnte. Als idealste Region für die diesbezügliche Analyse erwies sich der Nordhang des Greifenberges nahe Limburg. Dort waren 5 auswertbare Bohrungen abgeteuft worden, deren Schichtenfolge durch kleinmaßstäblichen Faltungen kaum beeinträchtigt wurde. Nachdem die Überlappung von zwei Bohrungen berücksichtigt und die Schichten graphisch zur Horizontale rückrotiert worden waren, konnte eine aufsummierte Netto-Mächtigkeit von ca. 52m abgeleitet werden. Nun mußten noch die Lücken im Profil zwischen den verschiedenen Bohrungen addiert werden, die zusammen ca. 68m ergaben. Als Gesamt-Mindestmächtigkeit konnten somit ca. 120m für die Bruchberg Sandstein Formation ermittelt werden - zumindest unter der Annahme einer möglichst ungestörten Abfolge (Beilage 2 und 3).
Mittels der nahe Limburg abgeteuften Bohrungen innerhalb des Debris Flows aus dem frühen Famennium konnte nach graphischer Rückrotation der Schichten eine Mindest-Gesamtmächtigkeit von ca. 20m für dieses Sediment abgeleitet werden.

Argumente die für eine Deckenüberschiebung sprechen:

1) Die neu beschriebenen Grauwacken des frühen Famenniums sind petrographisch nahezu identisch mit oberdevonischen Grauwacken der Giessener Decke. Sie führen weder Kalksteingerölle, noch größere Anteile magmatischer Gesteine, wie dies bei einer Herleitung von den einzig bekannten submarinen regionalen Erhöhungen jener Zeit, den (dazu tektonisch mobilisierten ?) Resten mitteldevonischer Riffe auf magmatischen Rücken, für diese Sedimente zu erwarten gewesen wäre. Der nicht unerhebliche Anteil metamorper Gesteinsbruchstücke weist (zusammen mit ergänzenden Hinweisen) auf ein südlich gelegenes Liefergebiet in einer "Mittel-Deutschen" Paläoposition. Die von einem solchen Hochgebiet geschütteten Klasten konnten unmöglich - über die Reste der magmatischen Rücken in der Lahn-Mulde hinweg - in ihre heutige Position hinein sedimentiert werden.
2) Die Debris Flow Sedimente des frühen Famenniums führen weder nennenswerte Anteile an kalkigen Fragmenten noch irgendwelche Basalte oder Pyroklastika - wie man es eigentlich erwarten müßte, wenn ihre heutige relative Position identisch wäre mit ihrer relativen Paläoposition. Da mittels palynologischer Analyse geklärt werden konnte, daß alle - tonig-sandigen und nur selten kalkigen - Sedimente vom Emsium bis zum frühen Famennium Bestandteile des Debris Flows sind (in weniger als 20m (kondensierter?) Sedimentsäule), muß eine relativ fern von den magmatischen Rücken der Lahn-Mulde gelegene Paläoposition abgeleitet werden.
3) Nördlich von Limburg werden mindestens ca. 20m mächtige Debris Flow Sedimente des Famenniums von maximal ca. 120m Bruchberg Sandstein Formation überlagert. Beide Einheiten werden wahrscheinlich - da keine konkordante Abfolge ermittelt werden konnte - durch größere Störungen voneinander getrennt. Dies ist nur möglich wenn sich die ursprüngliche paläogeographische Position der Bruchberg Sandsteine - sogar ca. 30Ma später - südlich der relativen Paläoposition dieser Debris Flow Sedimente im Famennium befunden hat. Der Umkehrschluß liegt nahe, daß die Bruchberg Sandsteine - zumindest jene in der Region nördlich von Limburg - als jüngere Anteile der Giessener Decke in die jetzige Position transportiert wurden.
4) Der unterkarbonische Erdbacher Kalk III aus einem Steinbruch nahe Steeden lieferte eine Trilobitenfauna, die sich von der anderer gleichalter Erdbacher Kalke des östlichen Rheinischen Schiefergebirges signifikant unterscheidet und größere Gemeinsamkeiten mit Harz-Faunen vom Winterberg aufweist (HAHN, HAHN & MÜLLER (1998: 199).
5) Der Deckdiabas und Teile der Hellen Lydite beinhalten gelegentlich Einschaltungen von Erdbacher Kalken, aber ohne ausreichende Fossilbelege, die eine Zuordnung zu einer anderen Faunenprovinz gestatten würden. Beide Lithologien befinden sich stets in strukturellen Positionen, die keine Verbindung zu signifikant älteren, z. B. oberdevonischen, Schichten in konkordanter Abfolge erkennen lassen.
6) Kleine Reste von Visé- (*Goniatites* III β/γ) Grauwacke wurden von HENNINGSEN (1970) aus der Gegend nördlich von Hadamar nahe Oberzeuzheim beschrieben. Diese Vorkommen befinden sich ca. 9km nordwestlich eines Aufschlusses im Arbeitsgebiet nahe Eschenau, in dem Famenne-Grauwacken vorkommen. Laut HENNINGSEN (1970: 196) sind diese Grauwacken identisch mit den unterkarbonischen Giessener Grauwacken, welche heutzutage als Teile der Giessener Decke interpretiert werden.

7) Ein kleiner Aufschluß mit wahrscheinlich oberdevonischen Grauwacken wurde von HENNINGSEN (1970) aus der Gegend nördlich von Hadamar nahe Elbgrund beschrieben. Der Aufschluß liegt ca. 11km nordwestlich eines Aufschlusses im Arbeitsgebiet nahe Eschenau, in dem Famenne-Grauwacken vorkommen. Laut HENNINGSEN (1970: 198) sind diese Grauwacken den oberdevonischen (Nehdenium-Hembergium) Hörre-Grauwacken südöstlich von Nenderoth sehr ähnlich.
8) Die Deckenüberschiebung muß sehr früh im variszischen Kompressionszyklus stattgefunden haben, da zumindest im durch Aufschlüsse dokumentierten Maßstab keine Unterschiede im tektonischen Baustil zwischen autochthonen und allochthonen Einheiten feststellbar sind.
9) Die aus dem Bruchberg Sandstein des Viséums und den Debris Flows des Famenniums rückgewonnenen Palynomorphen sind etwas weniger hoch inkohlt als jene aus den autochthonen Einheiten; in beiden Formationen kommen sogar transparente Formen vor. Eine mögliche, jedoch plausible, Erklärung ist wie folgt: Die allochthonen Einheiten wurden irgendwann im Grenzbereich Unter-/Oberkarbon überschoben und damit zumindest einige hundert Meter über den parautochthonen Einheiten plaziert. Erstere wurden daher später (im Zuge der variszischen Orogenese) weniger tief begraben und damit auch weniger stark aufgeheizt, wahrscheinlich im Bereich einer Minderung um ca. 10 - 40°C. Dies scheint auch die schlüssigste Begründung dafür zu sein, warum die jüngeren Grauwacke-Einheiten im Famennium überhaupt datierbar sind - dies sogar mit zuweilen guter Fossilerhaltung, die scheinbar nicht durch die thermale Alteration, sondern vordringlich eingeschränkt wird durch bakterielle Degradation, Verwitterung und Pyritisierung vor der endgültigen Sedimentation.

Part B

Problems and problem solution strategies

B 1 Introduction

The study area lies at the eastern margin of the Rheinisches Schiefergebirge within the Lahn syncline and is part of the former Variscan geosyncline (see figure B 1.1). The borders of the Schiefergebirge have been formed through erosion and/or major thrust systems. Only in the north, at the borderline Schiefergebirge/Ruhr-Karbon, a normal, concordant, succession is observable.

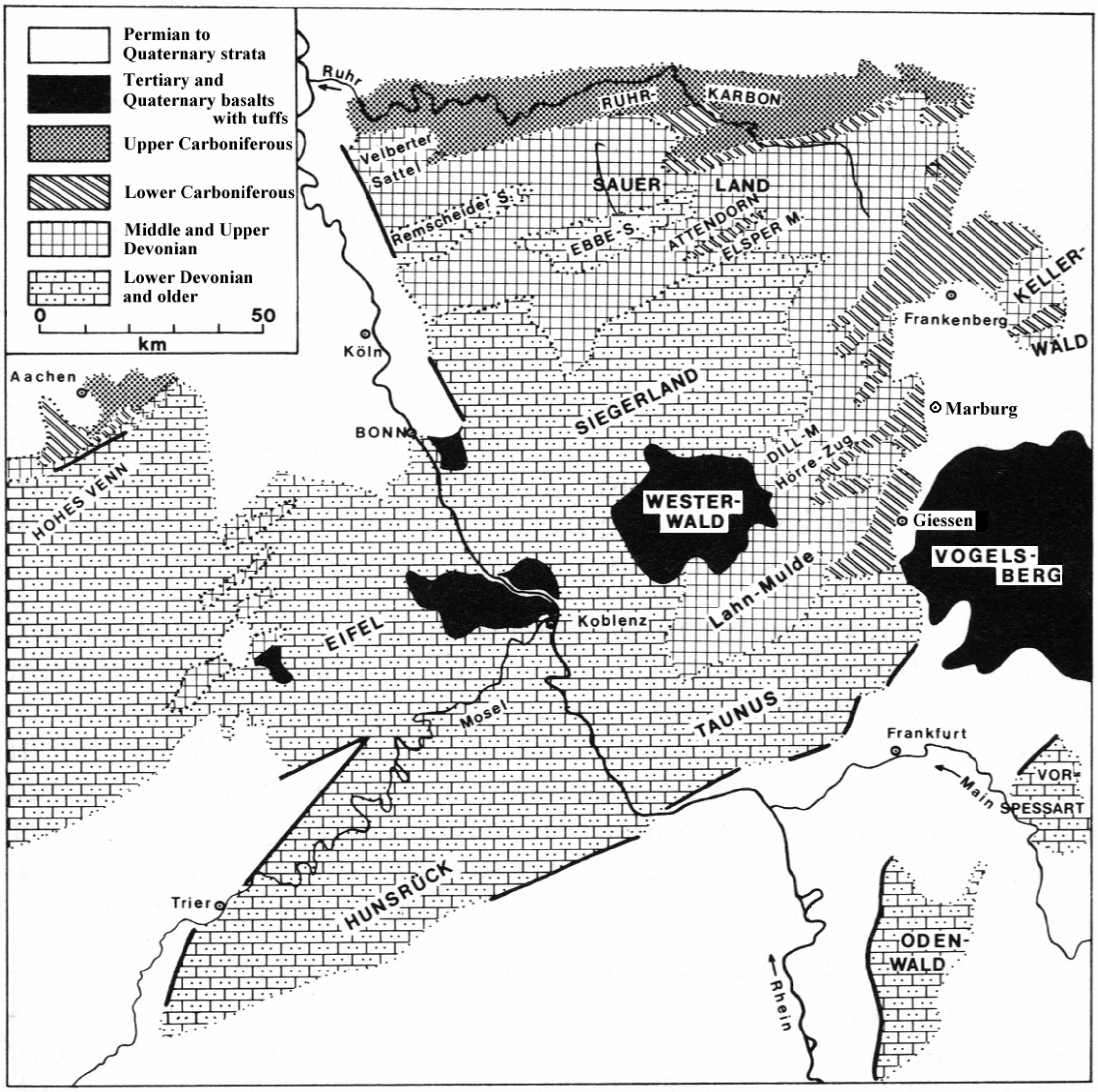


Fig. B 1.1: Geological reconnaissance map of the Rheinisches Schiefergebirge (Rhenish slate mountains. Slightly modified after HENNINGSEN & KATZUNG 1992: 43). Sattel, S. = anticline. Mulde, M. = syncline. Zug = ridge. Rhein = Rhine. Köln = Cologne.

In 1910 and 1921 AHLBURG developed a new concept for the interpretation of the geological situation in the Lahn region between Marburg and Limburg: the syncline-theory. Within this Lahn-syncline an idealised symmetrical succession of structural and facies features - most obvious within Middle Devonian strata - was proposed. He recognised a general trend to a basinal facies from Emsian to Upper Devonian times within the "syncline", which was divided from the Middle Devonian onwards by the build-up of volcanoes and reefs in the middle (see fig. B 2.1). The syncline was subdivided into 3 parts: a) the

"Southern Marginal Facies", b) a zone of volcanic ridges and reefs in the *middle* and c) the "Northern Marginal Facies" which nowadays is called Hörre-facies. Small remnants of proposed Upper Devonian basinal facies within the middle volcano-and-reef facies were attributed by him to the Northern Marginal Facies; but since no direct contact to the latter was observable, he gave them a separate name: "Gaudernbacher Schichten (layers)" (see fig. B 1.2).

Fig. B 1.2: Geological reconnaissance map of the eastern margin of the Rheinisches Schiefergebirge. Analysed area enclosed by stippled rectangle in the southwest (compare enclosure 4). White areas: Permian to Quaternary strata. Light grey: Middle Devonian to Lower Carboniferous. Dark grey: Lower Devonian (and older?). Dotted: Giessen nappe and newly encountered similar lithologies in the southwest (formerly known as "Gaudernbach layers").
L.B. = Limburg Basin (Tertiary to Quaternary graben system). Hessian Slate Series = Hessische Schieferserie. Hessian Depression = Hessische Senke. Schalstein Main Anticline = Schalstein-Hauptsattel. Southern Marginal Facies = Südliche Randfazies. Hörre ≈ Nördliche Randfazies, Northern Marginal Facies.

In 1918, AHLBURG formally established the new facies within the "normal" Upper Devonian succession of the Lahn-Syncline in the following way:

„The lithologies, which lay on top of the Diabas-blanket (stream-top) consist of a thick stratigraphic succession of dark, sometimes roofing-slate like slates with intercalations of Kieselschiefer [= flinty slates, lydites; ...], competent finegrained greywackes and [...] grey quartzites. This strange succession [...], which will be shortly called „Gaudernbach layers„ is petrographically absolutely equivalent to [...] northwards of the "Unterdevon-Hauptsattel" [Lower Devonian Main-Anticline] developed Upper Devonian lithologies of the "Nördliche Randzone" [Northern Marginal Zone]."
„The whole formation [= Gaudernbach layers] is forming a continuous, from [the creek] Oderbach northerly of [the village] Odersbach to the southwestern map-margin [geol. map Weilburg, 1:25000] and beyond that point on maps Hadamar and Limburg [there called Lower Devonian „Chondritenschiefer„ (KAYSER, KOCH 1886)] observable succession , which inhabits the innermost part of the great [...] Upper Devonian syncline.„ (AHLBURG 1918). This was the whole "definition".

The Gaudernbach layers occupy an elongated, approx. 23 km long and - at its greatest extension approx. 1.8 km wide- area between Weilburg and Limburg (approx. 60 km north of Frankfurt, Germany, Hesse).
AHLBURG could only find a few stratigraphically useful fossils, so his conclusions about the age of the members of the formation were almost entirely derived from logical inferences.
The "Northern Marginal Zone"-facies (which has the character of a sedimentary *group*) itself was also introduced by AHLBURG (1910, 1921) without accounting for the need of substancial evidence.
Hence, both concepts - for the *group* as well as for the *formation* - have to be treated as hypotheses.

One has to think a that bad definition for a group or formation would soon have been vanished from geological history without further evidence put forward in favour of its existence. But it will be shown, that it is obviously much easier to establish and even hold on an insufficiently defined formation than to account for severe contradictions within the concept.

The characteristic but indistinguishable "dark slates", interpreted by AHLBURG (1918) as Upper Devonian "deep-water" basinal facies, had always been the main problem. In the course of the development of new biostratigraphic approaches, more and more criteria had been found to divide these "dark slates" into several members of different age and depositional environment.

All efforts to explain the structural and palaeoenvironmental development became strongly influenced by three milestones in biostratigraphical approaches:
For convenience they are called herein:
a) the macrofossil (brachiopods, bivalves, trilobites, etc.) time-correlation realm (SEDGWICK & MURCHISON 1842 — DILLMANN 1953)
b) the conodont time-correlation realm (BISCHOFF & ZIEGLER 1957 — recently culminating in biofacies analyses by OETKEN 1997) and
c) the palynological time-correlation realm (this study).

All these realms contributed and still contribute to a major step forward in the better understanding of the palaeofacies development.

Due to the relatively few outcrops in the analysed area, the region seems not suitable for special tectonic analyses which especially try to reveal differences between autochthonous and allochthonous units. But small- (outcrop-) scale tectonic analyses seldomly prove to be successful in gaining additional tectonic information which superimposes the known structural trends in the Lahn syncline. It will be shown in this study, that ALBERTI (1995: 24) is right when he states: "The state of the tectonic exploration is to a good extent dependent on stratigraphy".

The following authors supplied important contributions towards a better understanding of the geological development in the area between Weilburg and Limburg:
A. SEDGWICK & R. I. MURCHISON 1842, Guido & Fridolin SANDBERGER (1850-56), Emanuel KAYSER (& Carl KOCH 1886), Johannes AHLBURG (1910a+b, 1917a+b,1918, 1921), Wilhelm KEGEL (1922), Franz MICHELS (1926, 1929), Albert SCHWARZ (1928), Franz KREKELER (1928), Gerhard SOLLE (1942 a+b), Wolfgang DILLMANN (1952, 1953), Günther BISCHOFF & Willi ZIEGLER (1957), Otto H. WALLISER (1960), Helga TRAUTWEIN & Hanspeter WITTEKIND (1960), Dierk HENNINGSEN (1965), Siegfried RIETSCHEL (1966), Jürgen KEGLER (1967 a-c), Klaus-Jürgen GOLDMANN & Jürgen KEGLER (1968), Wolfgang KREBS (1971), Witigo STENGEL-RUTKOWSKI (1976, 1988), Heiner FLICK (1978), Ibrahim MIRSAL (1978), Ibrahim MIRSAL & Heinrich ZANKL (1979), Joe-Dietrich THEWS (1979, 1989, 1996), M. VOSSOUGHI-ABEDINI (1979), Carsten MUNK (1981), Gerhard & Renate HAHN (1982), Brigitte FEY (1983, 1985), Sabine BAUMGARTEN (1983/1984, manuscript), Gerd KAPP (1987), Hans-Dieter NESBOR & Heiner FLICK (1987 a+b, 1988), Heiner FLICK & Hans-Dieter NESBOR (1988), Werner BUGGISCH & Erik FLÜGEL (1992), Roman BEHNISCH (1993), Hans-Dieter NESBOR & Werner BUGGISCH & Heiner FLICK & Manfred HORN & Hans-Jürgen LIPPERT (1993), Stephan OETKEN & Heinrich ZANKL (1993), Matthias PIECHA (1993), Peter BENDER & Peter KÖNIGSHOF (1994), Rainer BRAUN & Stephan OETKEN & Peter KÖNIGSHOF & Ludwig KORNDER & Achim WEHRMANN (1994), Kirsten PETER (1994), André W. VOGT (1996), Stephan OETKEN (1997), Frank WIERICH & André W. VOGT (1997), Gerhard & Renate HAHN & Peter MÜLLER (1998), Hartmut JÄGER (1999 a+b), H. JÄGER & Hans-J. GURSKY (2000), Dieter RIEMANN (2000), Martin SALAMON (2002). The diploma-theses of MUNK, BAUMGARTEN, KAPP and PETER had been initiated and supervised by Heinrich ZANKL (with some maintenance by Peter BENDER), who - together with Willi ZIEGLER - also initiated the works of OETKEN and VOGT. The diploma-thesis of RIEMANN had been initiated by W. S. VOGLER and largely supervised by A.W. VOGT.

B 2 Applied problem solution methods

The focus on what has to be treated as being *special* in the geology of the region between Weilburg and Holzheim, changed several times during the work on this study. Initially, simply the stratigraphic and facies relations in the area should become revealed. Most lithologies, especially the proposed deep-marine facies of the "Gaudernbach layers" during the Upper Devonian (KEGLER 1967), were found to be insufficiently described. This was particularly true for the description of the components of the lithologic column, their stratigraphic correlation and their relation to the Hörre-facies. Also their source area and the reasons for the development of a distinctly confined narrow graben structure, which was proposed to be the depositional environment of the Gaudernbach layers, remained entirely enigmatic. Nearly all new fossils, which were found by several researchers, did not ease but complicate the interpretation of the palaeoenvironment. Many of these sites yielded macrofossils as well as conodonts. Some of these findings had been placed into the Lower Carboniferous. Only a few sites had been left out, where - maybe - further crucial findings of conodonts and macrofossils could have been expected. It will be shown in this study (app. F 1), that these expectations were disillusioned by the obtained results after sampling.

So, other strategies had to be explored. Firstly, it became clear in the course of detailed research, that the wealth of information we can get from the published fossil-lists and other data had never been explored in a clear and structured way. Therefore, a structured revision was necessary (chapter C 3 and appendix F 1). For a proper and reproducible judgement about what published information has to be treated as important or negligible, a new argument analysis procedure was introduced (chapter C 2).

In addition to that, it was found that most of the dark slates of proposed Upper Devonian age in the area between Weilburg and Holzheim had not even been dated and or were datable at all. These dark, non-calcareous, siliceous pelites yielded no - or only rarely - conodonts on bedding planes. Their age-correlation rested entirely on their relative position between dated lithologic units. After confirmation of these results a new biostratigraphic method had to be introduced in this area: palynology (chapter C 4, C 5 and appendix F 2).

With the additional results of palynological analysis new hypotheses for the palaeofacies development in the Devonian and Lower Carboniferous were generated. In a next step it was tried to reconstruct the structural development. In doing so, it was most important to detect any hints for a narrow palaeograben structure or maybe some tectonic evidence for a nappe emplacement. But, disappointingly, it was found that a) most of the analysed area (70.7%) was covered by Tertiary and Quaternary sediments; b) all outcrops were too small and spatially irregularly scattered for a detection of more prominent tectonic features, e. g. duplex structures at the base of an expected nappe.

To overcome these problems it was tested, if the fractal analysis would yield some new and - for such questions - crucial hints. The idea was, autochthonous and allochthonous units could display different fractal properties if they had undergone different tectonic developments - at least at some time in their history (chapter C 11).

B 2.1 Argument analysis and historical review

The history of geological research in the area between Weilburg and Holzheim is not only to be seen in the light of differing general views in geology but even more due to different authors and their methods applied to problem solutions. Furthermore, in most articles analysed there exist no easy-to-decode formal text structures. Most studies follow the general rule: {introduction/historical summary} → {presentation of new data; often mixed with assumptions and suggestions about their origin and relation to other data} → {discussion and conclusion; also often mixed}. To the analyser of historical geological texts it appears most disappointing that one has to spend much time in trying to find out:

a) where the then as new presented data are hidden in the text,
b) of what quality they are,
c) where they had been obtained (coordinates?) and in which way,
d) in which lithologies they had been obtained, of what quality the lithological descriptions are,
e) if these lithologies had been dated (and in which way) or if only, e. g., "similar appearing rocks nearby" had been dated,
f) in what palaeoenvironment sedimentation /eruption / intrusion took place,
g) how the authors got their stratigraphic results (for most authors took the superior view that the reader has to know the known lifetime-range of e. g. *Knoxisporites hederatus*, or even worse: has to believe their final conclusions),
h) if the original stratigraphic correlation still can be regarded to be reliable, or if there certain doubts are to apply?

All the necessary actions in order to answer the above mentioned questions prevent an easy insight into the regional geology. Hence, in turn this often lead to questionable developments. Because it was disappointing or even impossible for the historical investigators to recover the original data from the text, often only the summarizing "results" had been taken to be true and used for further interpretation. In doing so the new data obtained by succeeding authors had been reflected in the light of older discussions and results. The main problem with the "Gaudernbach layers" became fixed onto the question, whether or not the "characteristic dark slates" (which were generally accepted as being distinctive for a deeper water basinal facies) are of Upper Devonian, Lower Devonian to Lower Carboniferous, or Upper Devonian to Lower Carboniferous age. By applying the different theories, the "Gaudernbach layers" were regarded as representing e. g.:

a) an Upper Devonian facies transitional (?hemipelagic) to the Northern Marginal (= Hörre) Facies, nowadays in the centre of a syncline (AHLBURG 1918),
b) a succession of late Lower Devonian to Lower Carboniferous marine lithologies, nowadays forming the centre of an anticline (MICHELS 1926, DILLMANN 1952),
c) an Upper Devonian "special" basinal facies (narrow "graben" structure?, proposed to be similar to later developments represented by the Hörre facies) within the "normal" Lahn-syncline facies (KEGLER 1967).

Apart from presenting and discussing new data obtained during the course of research, sometimes hypothetical or suppositional reasoning had been employed by several authors; i. e. for the sake of their own argumentation some at that time unavailable data had been proposed as being obtainable later on (and therefore being true).

One typical example of that kind of hypothetical/suppositional reasoning is presented hereafter. AHLBURG (1918:46; see also A 6 in appendix F 1.1) detected a rare and badly preserved fauna in dark slates adjacent to normal Upper Devonian facies rocks (e. g. red/green/grey *Cypridina*-slates). The fossil assemblage contained bivalves, gastropods and crinoids of - in AHLBURG's opinion - Upper Devonian age. At that time he seemed convinced that he was able to distinguish between slates of e. g. Lower and Upper Devonian age, because he started his investigations "from the South":
AHLBURG (1910b:474, in german, translated by VOGT) wrote: "To understand the viewpoint of KAYSER one has to consider that he approached *from the North*, from lithologies of which Silurian age it seemed he had no doubts, to the red slates in question and therefore was surely preoccupied in his age determinations. I had been, since I started my mapping *in the South* and went successively to the North, in a better position, because I approached these layers by passing stratigraphically doubtless lithological units of upper Middle Devonian age".
Since he was convinced to be able to recognise the red slates as part of the Upper Devonian succession, he postulated that this age correlation had to be true also for the adjacent dark slates, as long as they would not show characteristic features of Lower Devonian dark slates.

This example of reasoning in due course turned out to be wrong, especially when Lower Carboniferous age correlations for parts of these proposed Upper Devonian dark slate facies had been confirmed by succeeding researchers. But they, in turn often failed when trying to deduce age correlations for rocks which they could not directly date.

The general method of argument analysis (due to FISHER 1993) applied for the analyses of the historical texts is outlined in chapter C 2 - and there also three examples are presented. The main tool for making judgements with this method is the Assertibility Question (FISHER 1993:22):

"*What argument or evidence would justify me in asserting the conclusion C (What would I have to know or believe to be justified in accepting C?)*".

In order to do that the presented arguments, reasons and conclusions in a text have to be extracted and properly judged. In using this method "you have to make a judgement about 'appropriate standards'. That judgement will be *yours*; it is a judgement which requires justification and which is open to criticism. Set too severe a standard and it will seem that nothing can be known with certainty; set too unimaginative a standard and you will be led easily into error." (FISHER 1993:133).

Since it would have been too time-consuming to apply this formal methodology to all texts, it has strictly been used only for the discussion of the original data presented by the several authors - but in a more structured way. The results of these analyses are shown in chapter C 3 and appendix F 1.

B 2.2 Biostratigraphy

"The state of the tectonic exploration is to a good extent dependent on stratigraphy" (ALBERTI 1995: 24). It is *wholly* dependent on stratigraphy when outcrops are too small for large scale correlation of tectonic structures. In this case, which is true for the region between Weilburg and Holzheim, only biostratigraphy presents the necessary evidences for ordering rock strata into meaningful units. In biostratigraphy the fossil contents of the layers are used in evaluating the historical sequence.

A lot of macrofossils (brachiopods, ammonoids, bivalves, corals, etc) had been described from this region by former authors (chapter C 3 and app. F 1). Most of them were derived from former reef localities (limestone quarries), but some had also been found in marine dark slates. The first microfossils - conodonts - had been detected by BISCHOFF & ZIEGLER (1957). And to KEGLER (1967) the credit is principally due that nearly all limestone-bearing units in the region (apart from feef-limestones) have been sampled for search of conodonts (appendix F 1.7). In the present study the focus concentrated on the detection of fossil spores and acritarchs (chapter C 5 and appendix F 2).

For all the fossils found, it has been tried to reveal the published lifetime-ranges of the species. But this attempt was only successful for some species. The lifetime-ranges were normally related to special biostratigraphic charts (e. g. conodont-stratigraphy, brachiopod-stratigraphy), dependant on which sort of fossil was described. Therefore, it was necessary to find monomethodic means of presenting all these different data in a single scheme which would allow for a reproducible correlation of these data sets. This was done by using the Devonian correlation chart edited by WEDDIGE (1996) and the newly compiled Lower Carboniferous correlation chart (chapter C 1).

At last, some conclusive remarks have to be spent on the question, why whole lithological successions had not been sampled layer-by-layer and analysed for their fossil content. For the spores and acritarchs it can be said, that the preservation of these fossils in the analysed region is generally medium to low; hence, no sufficient data sets are available, both at outcrop-scale or even layer by layer. This, because we do know that physical and biological degradation took place - but not always to which extent. For the conodonts the only interesting place for such an analysis (apart from Middle Devonian localities recently described by OETKEN 1997) was the proposed Upper Devonian / Lower Carboniferous succession near Steeden, first described by HENNINGSEN (1965), because there enough calcareous layers were present. But, as mentioned, this locality *had been* described (see appendix F 1.6, the formerly described taxa taken to be true), so only a reconstruction of the lithological column with the positions of the sample-sites had been undertaken (fig. D 2.8).
In addition to that and since most of the Devonian and Lower Carboniferous pelites in the region are intensively folded and faulted, it is often very complicated, if not impossible, to trace a whole rock succession along several metres (especially in the prevailing small outcrops).

B 2.3 Lithological descriptions

Sedimentary logs and cross-sections have been created, where a) relevant lithological successions occur and b) the layers can be traced along several metres in spite of folding and faulting (e. g. fig. D 2.4 and fig. D 2.11). One outcrop with dark pelites near the ruin Aardeck has been described in very detail for fractal analysis.

Petrographic screen-analyses have been undertaken on most lithologic units of the analysed area at different orders of magnitude (compare, e. g. fig. D 2.7 and fig. C 7.1); but only on the more important lithological units very detailed petrographic descriptions of grain-assemblages observable in thin-section have been undertaken. The detailed results for Famennian greywackes, Famennian pyroclastic deposits and Viséan Bruchberg sandstone are presented in chapter C 7.
For the reconstruction of particle size distributions from thin sections the line-cut procedure, firstly presented by MÜNZNER & SCHNEIDERHÖHN (1953), was revived (chapter C 6).

The Deutsche Bahn AG, Frankfurt, granted access to the drill cores of the new railway track Cologne — Frankfurt near Limburg. 18 drill cores from mostly Upper Devonian and Lower Carboniferous lithologies, drilled north of Limburg, have been analysed and their strata graphically rotated to zero dip for palaeofacies analysis (chapter C 12 and F 3).

B 2.4 Palaeoenvironment

Apart from the fossil content and the examination of the lithologic column some additional hints for the reconstruction of the palaeoenvironment have been gained by the following analyses.

First AHLBURG (1918) and later on especially KEGLER (1967) used the colouration of the clayey-silty pelites in the area between Weilburg and Holzheim as important indicators for the analysis of palaeofacies and palaeoenvironment during the Middle and Upper Devonian.
Dark slates should have been formed solely under euxinic, O_2-depleted, conditions with low rates of slow sedimentation at the deeper shelf in water-depths greater than approx. 200m. The origin of the red colourations in pelites was thought to be created a) by clastic influx of detritic particular hematite from terrestrial areas under semi-arid conditions (FALKE 1964, VAN HOUTEN 1961) or b) by authigenic mineral growth in the marine environment in Fe- and O_2-enriched bottom waters (FÜCHTBAUER et al 1977, FRANKE & PAUL 1980). FRANKE & PAUL (1980) postulated, that every Devonian sediment with Fe^{3+}-content > approx. 2 % will be red. In chapter C 9 a short summary of possible causes for the colouration of slates is listed. The meaning and importance of the colouration is shortly discussed for all pelitic sediments in the sub-chapters of D 2.

The ratio spores / acritarchs in a sample gives valuable hints towards a near- or far-shore palaeoposition. Phytoclasts (miospores, megaspores, wood, cuticular fragments, etc.) and heavy minerals (e. g. pyrite) have been evaluated for palynofacies determination and special attention has been focussed on the state of preservation (chapters C 4 and C 10).

Did the palaeoenvironment influence the enhanced occurrence and formation of sedimentary pyrite in the pelites, or were postdepositional factors (hydrothermal fluids, etc.) more important (chapter C 10)?

The variation of the receipt of solar energy with latitude over the year and therefore the distribution of climatic zones on the Earth is influenced by astronomical parameters. They cause variations in the rate of delivery of all direct solar energy per unit of horizontal Earth surface. Are in the Devonian and Lower Carboniferous basinal facies, with prevailing low energy conditions and low sediment supply, any evidences for orbitally driven cyclic sedimentations preserved? The results of this research are presented in chapter C 8.

What influence on the Upper Devonian palaeofacies development did have the occurrence and spatial distribution of reef-limestones and volcanic ridges during the Givetian and early Frasnian? In fig. B 2.1 the areal distribution of the reef-limestones (Massenkalk) on top of volcanic ridges in the Lahn-syncline (from OETKEN 1997) is displayed.

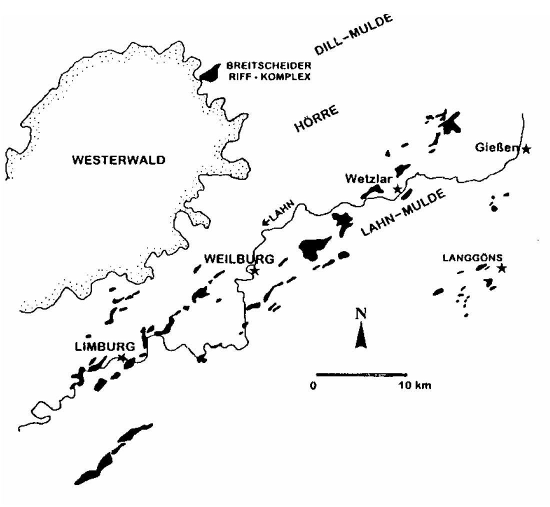


Fig. B 2.1: Areal distribution of Givetian — lowermost Frasnian reef-limestone (Massenkalk) on top of volcanic ridges in the Lahn-syncline (from OETKEN 1997). Riff-Komplex = reef-complex. Mulde = syncline.

These lithologies formed the only major submarine highs during the Devonian and Lower Carboniferous in the analysed region, in an elsewise basinal marine environment. Their importance is discussed at several locations in this study, especially in the sub-chapters of C 3 and appendix F 1.

B 2.5 Tectonic analysis and structural development

More than 2/3 of the analysed area between Weilburg and Holzheim is covered by Tertiary and Quaternary rocks. Less than 1% of the area allows direct access to the Palaeozoic strata via outcrops and small quarries. These are obviously insufficient conditions for a detailed tectonic analysis, especially if hints for a nappe emplacement have to be searched for. Typical larger outcrops display only some tens of metres long and a few metres high outcrop surfaces, which allow for a description of

a) a generally SW — NE trending strike direction of the strata,

b) mostly metre scale tight, but simple, folding (true for both amplitudes and wavelenghts) with axial planes generally dipping with > 45° towards the southeast and

c) intensive faulting, with smaller or larger fault- (thrust- ?) planes every few metres.

Under these conditions the reconstruction of the structural development is only possible by applying additional analytical methods - apart from standard tectonic analytical techniques:

a) The reconstruction of palaeotectonics via detailed petrography on coarser grained sediments. Petrographic analyses have been undertaken on most lithologic units of the analysed area. Interesting new findings about the origin and fate of Palaeozoic coarser grained sediments base on the very detailed description of light minerals (WIERICH & VOGLER 1997, WIERICH & VOGT 1997).

b) Fractal analysis. The fractal (abbreviation for "fractional") dimension quantitatively determines the ruggedness of an object. The fractal dimension D should be specific for specific rock masses on which a certain stress field was applied. Therefore, investigations into the fractal properties of apparently similar reacting rock masses from different locations and times should reveal additional information about similarities or differences in the applied stress history. Fractal (self-similar) behaviour of the discontinuity network in Emsian and Tournaisian slates has been detected, described and via box-counting method analysed over several orders of magnitude. The results are presented in chapter C 11.

c) Geological reconnaissance map. A geological sketch map 1:25,000, showing only the relative or proposed positions of Palaeozoic strata, was created in order to allow for an easier insight into the complex tectonic structure of the area between Weilburg and Holzheim (enclosure 2). It is termed "sketch map", because 70.7% of the displayed area is covered by Tertiary and Quaternary rocks (chapter C 13), hence do not allow for an exact but approximate modelling of the underlying Palaeozoic strata.

d) Detailed local maps (fig. F 2.1 and fig. F 2.2), outcrop descriptions (appendix F 1, F 2, chapters C 8 and C 11) and drill core descriptions (chapter C 12, appendix F 3, enclosure 2 and 3).

Part C

Methodology, detailed observations and conclusions

C 1

Stratigraphic correlation charts

In this study the recently published stratigraphic correlation chart for the Devonian system, edited by WEDDIGE (1996) in cooperation with the German Subcommission on Devonian Stratigraphy, is applied. The aim for this correlation chart is to combine the means of electronic data processing with traditional presentation of stratigraphic data on correlation charts. The applied method is called: "absolute time proportioning of correlation charts by feed-back harmonising (AFH)". Each correlation chart for the Lower, Middle and Upper Devonian is subdivided into 20cm long columns. "A time-ruler is applied to the left margin of each [...column]. Thus, all stratigraphic data of a [...column] could be indicated by coordinates and permit definite on-line data transmission without synoptic charts." (WEDDIGE 1996).

Columns exist for several fossil animal groups, like conodonts, ammonoids, tentaculites, brachiopods, etc. - but no one for spores is available. Therefore the columns for conodonts were transferred from WEDDIGE (1996) and correlated with the spore-zone scheme presented by RICHARDSON & MCGREGOR (1986); only correlations named by these authors have been used.

Up to now no accepted equivalent correlation chart to the Devonian one exists for the Carboniferous. In order to maintain a monomethodic correlation - **a new correlation chart for the Lower Carboniferous (LCC 2003)** is presented in this publication. It is standardised on conodont stratigraphy mainly presented by CLAUSEN, LEUTERITZ & ZIEGLER 1989 (which itself is to a great extent based on LANE, SANDBERG & ZIEGLER 1980) for the Tournaisian and Viséan stages. The internationally accepted boundaries for the "Lower Carboniferous Subsystem" have not been taken into account. The zonal incrementation was created by equal subdivision with the indicative amount of conodont zones for this time range now available in Germany. All other bio- and lithostratigraphic columns then have been fitted into this conodont-based correlation chart.

The authors of the different *synoptic* Lower Carboniferous correlation charts (which were used as basic data sets) are mentioned on top of each column. In order to take responsibility for the new compilations in the LCC 2003 I also added my name in the following form: "compiled by VOGT, based on AUTHOR(S) YEAR".

The Lower Carboniferous correlation chart (LCC 2003) is only intended to be used as a means of clarification for this publication; nevertheless it can act as one possible step towards a formally approved Carboniferous correlation chart.

Some relevant remarks on the correlation charts and the applied AFH-method have to be stated.

First we have to ask what real function the "time-ruler" can fulfill (compare WEDDIGE 2000). It is a scale. And in some way it is also a *time*-scale which we may use for statistical considerations, e.g.:
If we assume a time coverage of 29 mio. years for the Lower Carboniferous 20cm "time-ruler" we can deduce a statistical time span of ca. 145 000 years for each mm of the time ruler; therefore each conodont zone would cover ca. 2.4 mio. years. But, in turn, *we are not allowed* to induce that every mm covers 145000 a and therefore every conodont-zone lasts 2.4 mio. a, because we do not know if the conodont-zones really covered equal *time* spans. Compared with the well explored Upper Devonian conodont succession with a first estimate statistical range of ca. 450000 a for each zone (15 mio. a divided by 33 zones), it is obvious that much more detailed work on Lower Carboniferous conodonts is necessary, since up to now there only exists a stratigraphy which is 5 times less detailed (2.4 mio. a each zone).

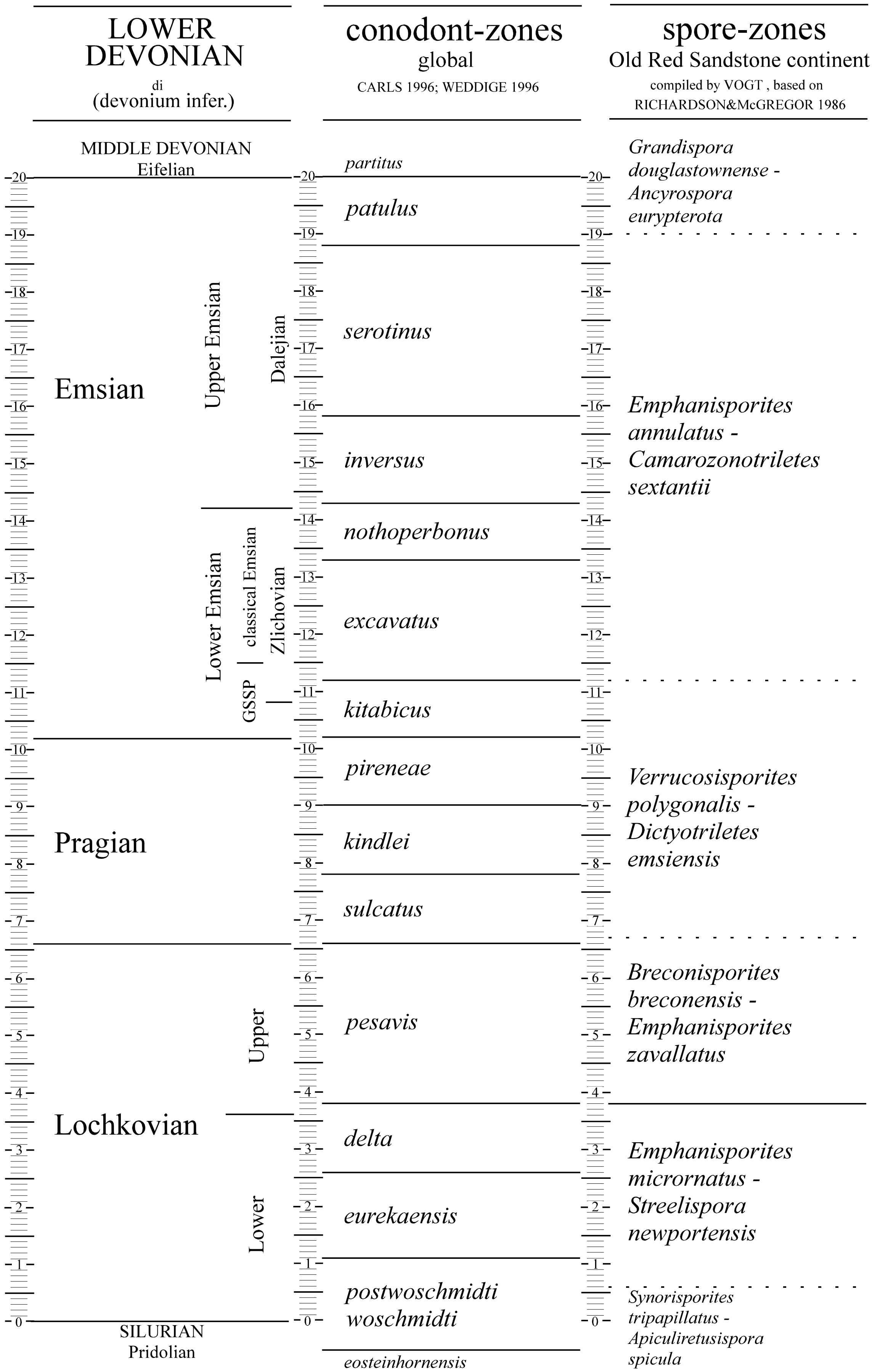
Concerns - mostly informal - have been put forward which employ some general doubts about the usage of "metric" biostratigraphic correlation charts and therefore: if the whole procedure is in accordance with the basic principles of biostratigraphy. Some of the arguments for and against, to which I have access or I could imagine are listed in table C 1.1. The most important reason for using these charts is to avoid relative statements like
a) "near the top of the X-zone" or
b) "ca. in the middle of zone Y".
It is far better and reproducible to use the "time-ruler" in order to tell coordinates of the stratigraphic position in question (e.g. in case a): DK1996: dm: 7.6 cm). In this way *we have to know what we are talking about* (hence, endless discussions are prohibited) and are forced to *exactly* submit our present-day opinion. ***This opinion may be judged wrong in future times***, but since it is exactly defined it will exactly *become transferable to new coordinates*.

I regard the DK1996 and LCC2003 correlation charts only as ***special synoptic correlation charts*** with mm-subdivisions which allow *for a more detailed discussion*. Up to now, there is no sufficient evidence available in order to use the "time-ruler" for absolute time calibrations.

Tab. C 1.1: Some arguments pro and contra the use of the Devonian and Lower Carboniferous correlation charts DK 1996 & LCC 2003.

Arguments contra the use of the DK 1996 & LCC 2003	**Arguments pro the use of the DK 1996 & LCC 2003**
The 20cm rulers cover different time spans: Lower Carboniferous: ca. 29 mio. a (statistically 145000 a each mm) Upper Devonian: ca. 15 mio. a (statistically 75000 a each mm) Middle Devonian: ca. 12 mio. a (statistically 60000 a each mm) Lower Devonian: ca. 19 mio. a (statistically 95000 a each mm)	The examples presented on the left side make it plain that the "time-ruler" does cover and describe time-units only on a statistical level. It is *not* allowed e.g. to deduce: since the biozone x lies within the limits of the Middle Devonian coordinates dm: 3.4 - 3.9cm, that exactly 180000 a (=3 x 60000 a) have passed within this range. A correlation chart with the "time-ruler" is only a special *synoptic* correlation chart. Therefore, instead of AFH, it would better be called "*Relative* time proportioning ..." = **R**FH. It allows for an exact discussion of data obtained by different authors of different biostratigraphic and lithostratigraphic correlation charts.
Columns with divergent biostratigraphic concepts (assemblage zone, oppel zone etc.) are attached together. This, although the different quality of the various biostratigraphic listings prohibit a direct comparison at a general level up to now.	The authors of the columns are aware of this problem (hopefully), but the applied method of "A"FH does help to always work on this topic. Changes are expected, not feared.
Biostratigraphic columns are presented at the same detailed level as lithostratigraphic colums.	Again, since "A"FH is applied, this procedure delivers reproducible results and is open to changes.
In principle, every geologist or palaeontologist can deliver a bio- or lithostratigraphic column. Therefore, it seems easy to compile such listings by copying the published results of other researchers.	Presented columns are opinions of the authors who delivered them. They are clearly marked by the name of the respective authors. If insufficient data are published this fact will become obvious in due course.
"Apples and Peas" are compared for the sake of simplified electronic data processing.	By using the stratigraphic coordinates electronic data processing and comparison is simplified.

Because of all this difficulties the subdivision of coordinates to fractions of less than 1mm is avoided (i.e. all coordinate-data are rounded to full millimetres).


LOWER DEVONIAN
di
(devonium infer.)
conodont-zones
global
CARLS 1996; WEDDIGE 1996
spore-zones
Old Red Sandstone continent
compiled by VOGT , based on
RICHARDSON&McGREGOR 1986
MIDDLE DEVONIAN
Eifelian
partitus
Grandispora douglastownense - Ancyrospora eurypterota
20
19
18
17
16
15
14
13
12
11
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9
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7
6
5
4
3
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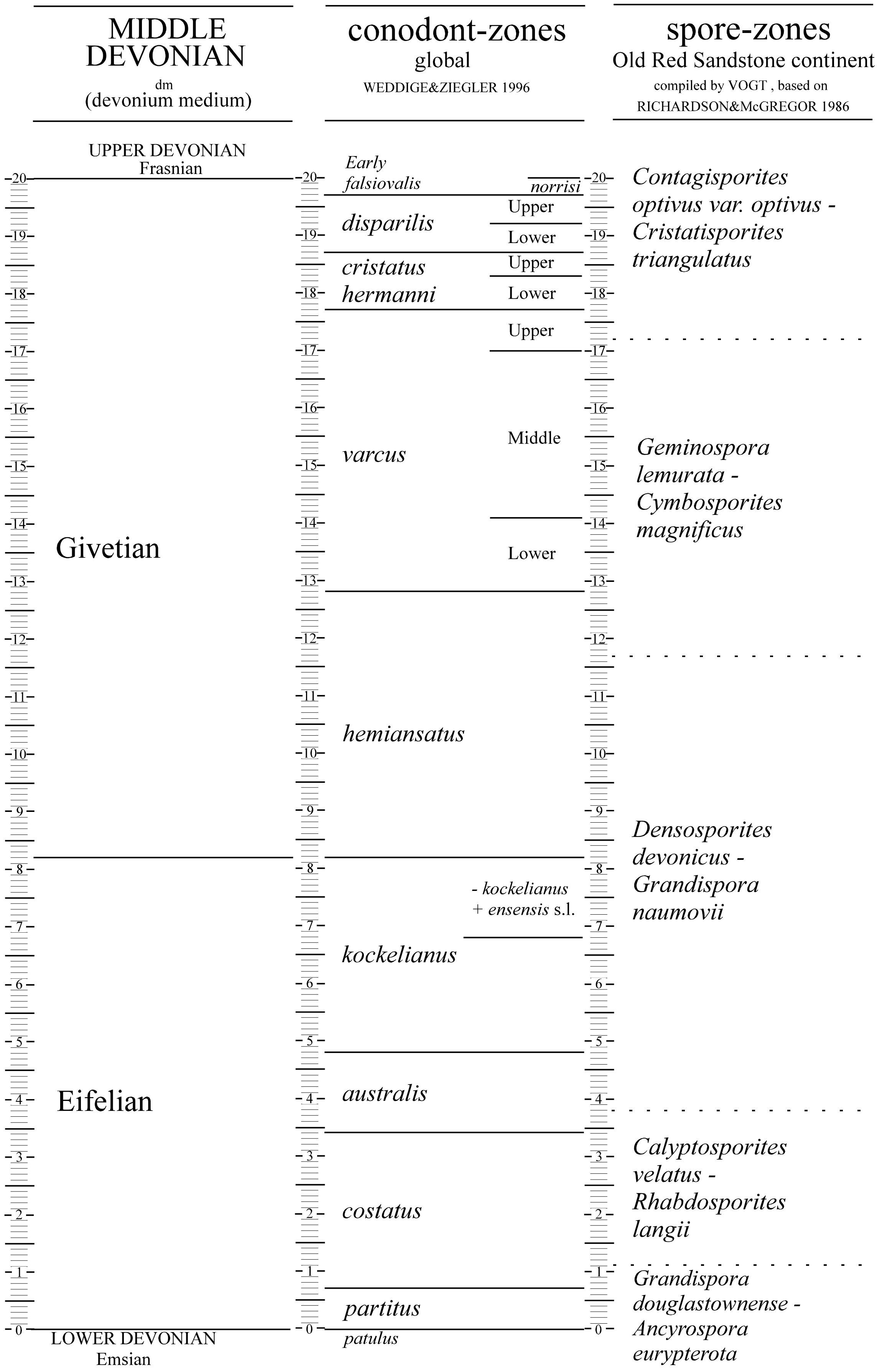
1
0
patulus
serotinus
Emsian
Upper Emsian
Dalejian
inversus
Emphanisporites annulatus - Camarozonotriletes sextantii
nothoperbonus
Lower Emsian
classical Emsian
Zlichovian
GSSP
excavatus
kitabicus
Pragian
pireneae
kindlei
sulcatus
Verrucosisporites polygonalis - Dictyotriletes emsiensis
Lochkovian
Upper
Lower
pesavis
Breconisporites breconensis - Emphanisporites zavallatus
delta
eurekaensis
Emphanisporites micrornatus - Streelispora newportensis
postwoschmidti
woschmidti
Synorisporites tripapillatus - Apiculiretusispora spicula
SILURIAN
Pridolian
eosteinhornensis


MIDDLE DEVONIAN
dm
(devonium medium)
conodont-zones
global
WEDDIGE&ZIEGLER 1996
spore-zones
Old Red Sandstone continent
compiled by VOGT , based on
RICHARDSON&McGREGOR 1986
UPPER DEVONIAN
Frasnian
Givetian
Eifelian
LOWER DEVONIAN
Emsian
Early falsiovalis
norrisi
disparilis
Upper
Lower
cristatus
Upper
hermanni
Lower
Upper
varcus
Middle
Lower
hemiansatus
- kockelianus
+ ensensis s.l.
kockelianus
australis
costatus
partitus
patulus
Contagisporites optivus var. optivus - Cristatisporites triangulatus
Geminospora lemurata - Cymbosporites magnificus
Densosporites devonicus - Grandispora naumovii
Calyptosporites velatus - Rhabdosporites langii
Grandispora douglastownense - Ancyrospora eurypterota
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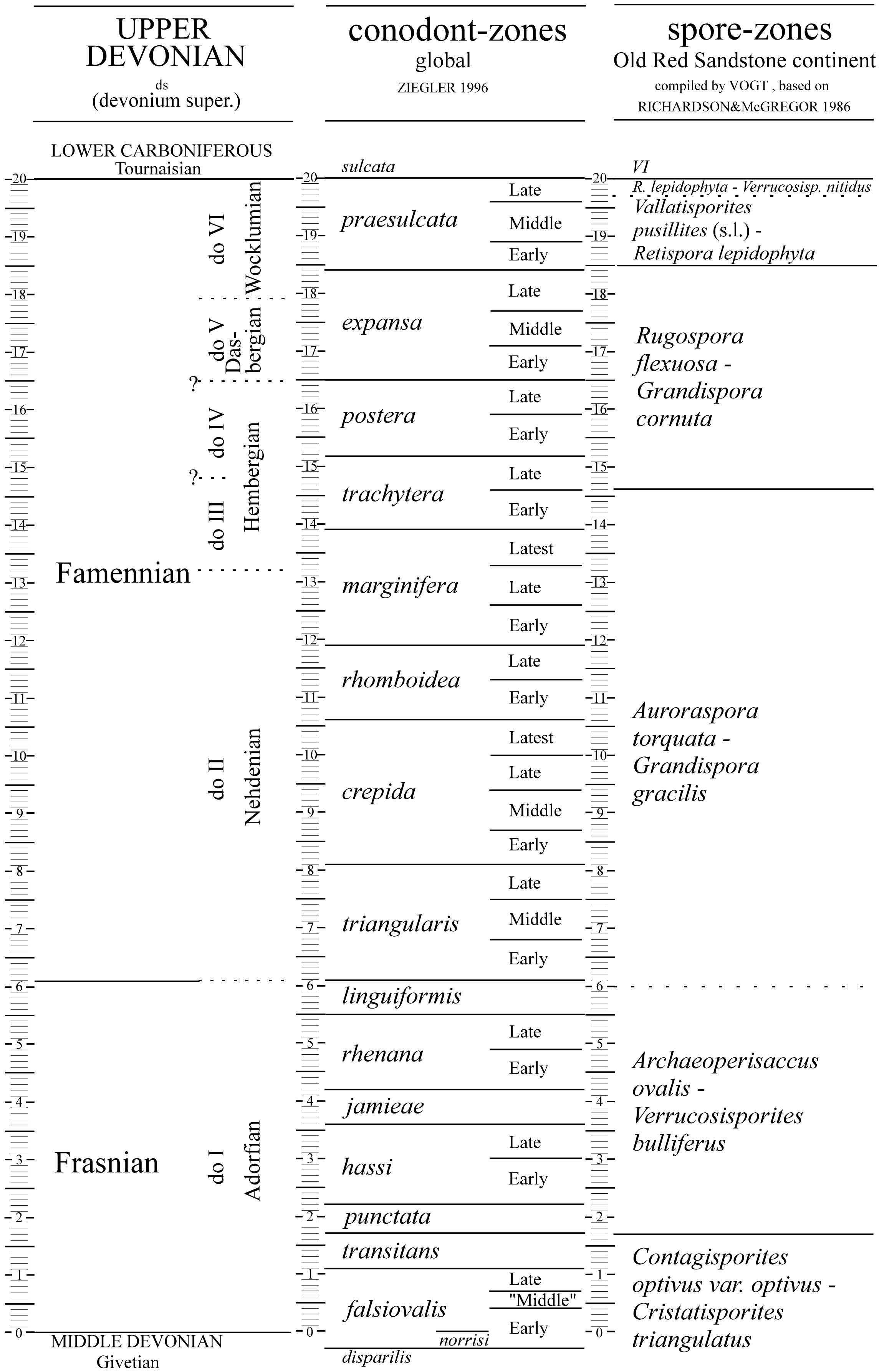
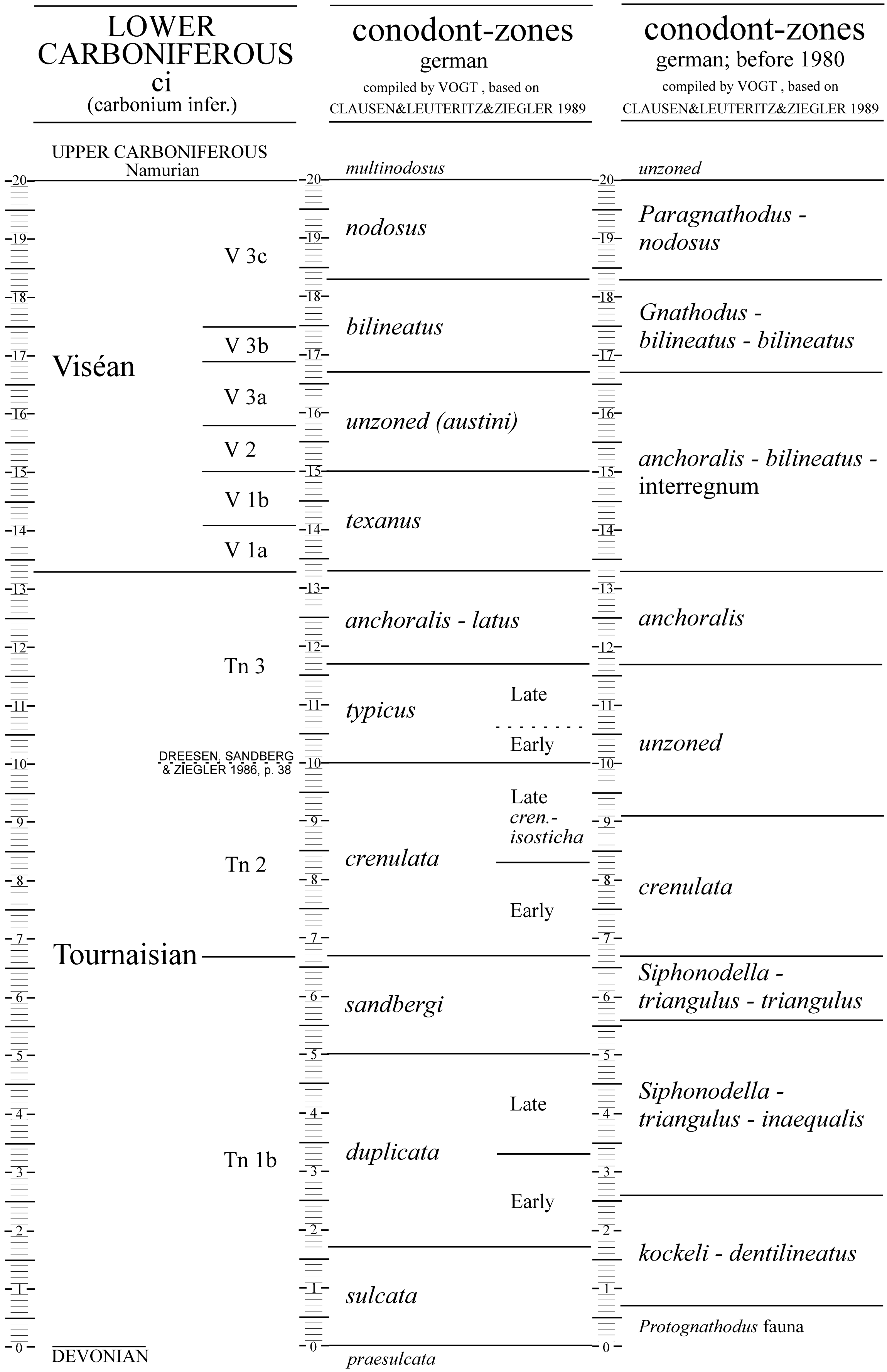

UPPER DEVONIAN
ds
(devonium super.)
conodont-zones
global
ZIEGLER 1996
spore-zones
Old Red Sandstone continent
compiled by VOGT , based on
RICHARDSON&McGREGOR 1986
LOWER CARBONIFEROUS
Tournaisian
sulcata
VI
R. lepidophyta - Verrucosisp. nitidus
Vallatisporites pusillites (s.l.) - Retispora lepidophyta
praesulcata
Late
Middle
Early
do VI
Wocklumian
expansa
do V
Das-bergian
Rugospora flexuosa - Grandispora cornuta
postera
do IV
do III
Hembergian
trachytera
marginifera
Latest
Famennian
rhomboidea
crepida
do II
Nehdenian
Auroraspora torquata - Grandispora gracilis
triangularis
linguiformis
rhenana
Archaeoperisaccus ovalis - Verrucosisporites bulliferus
jamieae
hassi
Frasnian
do I
Adorfian
punctata
transitans
Contagisporites optivus var. optivus - Cristatisporites triangulatus
falsiovalis
"Middle"
norrisi
disparilis
MIDDLE DEVONIAN
Givetian



LOWER CARBONIFEROUS
ci
(carbonium infer.)
conodont-zones
german
compiled by VOGT , based on
CLAUSEN&LEUTERITZ&ZIEGLER 1989
conodont-zones
german; before 1980
compiled by VOGT , based on
CLAUSEN&LEUTERITZ&ZIEGLER 1989
UPPER CARBONIFEROUS
Namurian
multinodosus
unzoned
Paragnathodus - nodosus
nodosus
V 3c
bilineatus
Gnathodus - bilineatus - bilineatus
V 3b
Viséan
V 3a
unzoned (austini)
V 2
anchoralis - bilineatus - interregnum
V 1b
texanus
V 1a
anchoralis - latus
anchoralis
Tn 3
typicus
Late
Early
unzoned
DREESEN, SANDBERG & ZIEGLER 1986, p. 38
Late
cren.- isosticha
crenulata
Tn 2
crenulata
Early
Tournaisian
Siphonodella - triangulus - triangulus
sandbergi
Siphonodella - triangulus - inaequalis
Late
duplicata
Tn 1b
Early
kockeli - dentilineatus
sulcata
Protognathodus fauna
DEVONIAN
praesulcata
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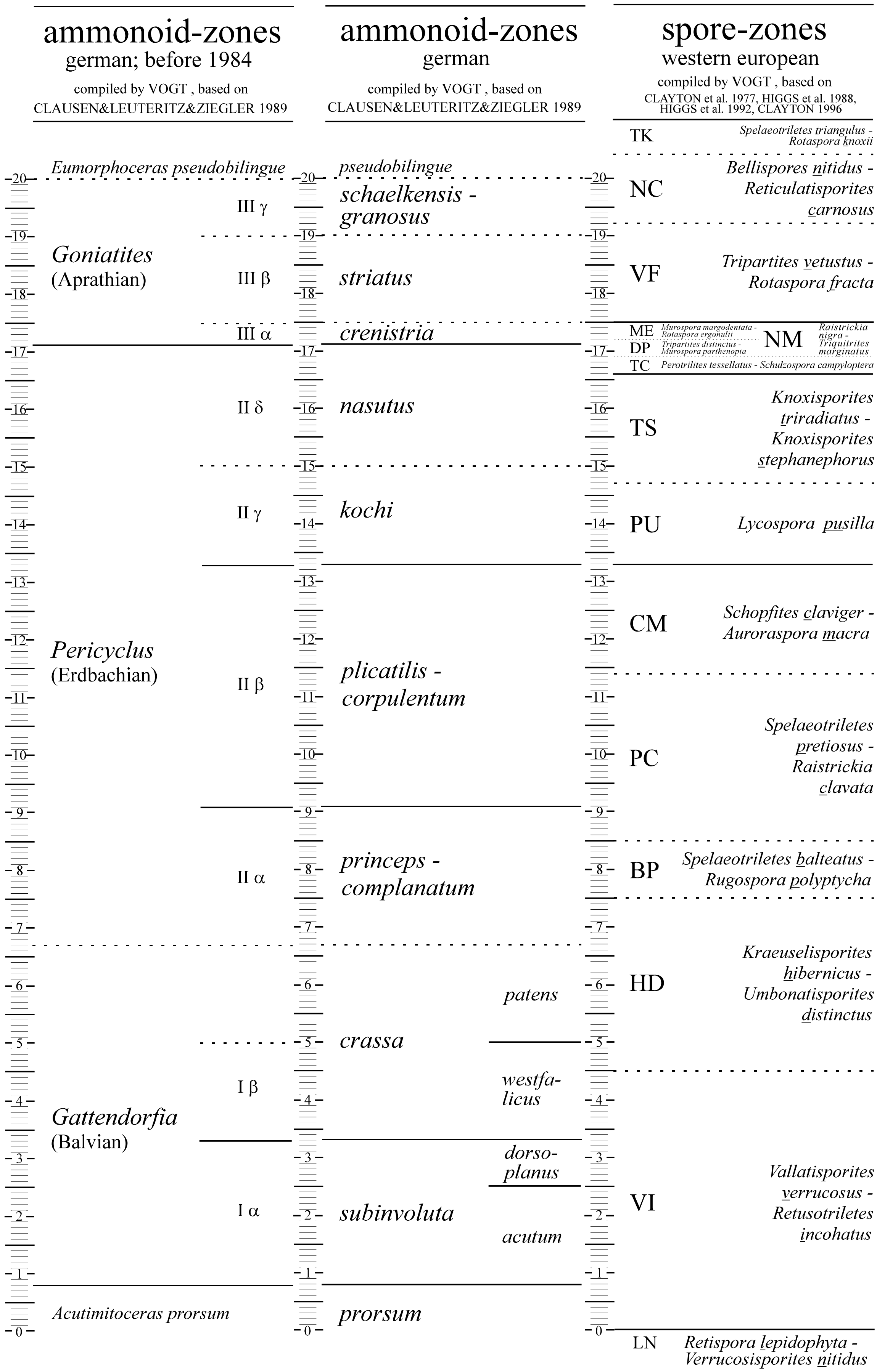
ammonoid-zones
german; before 1984
compiled by VOGT , based on
CLAUSEN&LEUTERITZ&ZIEGLER 1989
ammonoid-zones
german
compiled by VOGT , based on
CLAUSEN&LEUTERITZ&ZIEGLER 1989
spore-zones
western european
compiled by VOGT , based on
CLAYTON et al. 1977, HIGGS et al. 1988, HIGGS et al. 1992, CLAYTON 1996
Eumorphoceras pseudobilingue
Goniatites (Aprathian)
III γ
III β
III α
Pericyclus (Erdbachian)
II δ
II γ
II β
II α
Gattendorfia (Balvian)
I β
I α
Acutimitoceras prorsum
pseudobilingue
schaelkensis - granosus
striatus
crenistria
nasutus
kochi
plicatilis - corpulentum
princeps - complanatum
crassa
patens
westfalicus
dorsoplanus
subinvoluta
acutum
prorsum
TK Spelaeotriletes triangulus - Rotaspora knoxii
NC Bellispores nitidus - Reticulatisporites carnosus
VF Tripartites vetustus - Rotaspora fracta
ME Murospora margodentata - Rotaspora ergonulii
DP Tripartites distinctus - Murospora parthenopia
NM Raistrickia nigra - Triquitrites marginatus
TC Perotrilites tessellatus - Schulzospora campyloptera
TS Knoxisporites triradiatus - Knoxisporites stephanephorus
PU Lycospora pusilla
CM Schopfites claviger - Auroraspora macra
PC Spelaeotriletes pretiosus - Raistrickia clavata
BP Spelaeotriletes balteatus - Rugospora polyptycha
HD Kraeuselisporites hibernicus - Umbonatisporites distinctus
VI Vallatisporites verrucosus - Retusotriletes incohatus
LN Retispora lepidophyta - Verrucosisporites nitidus
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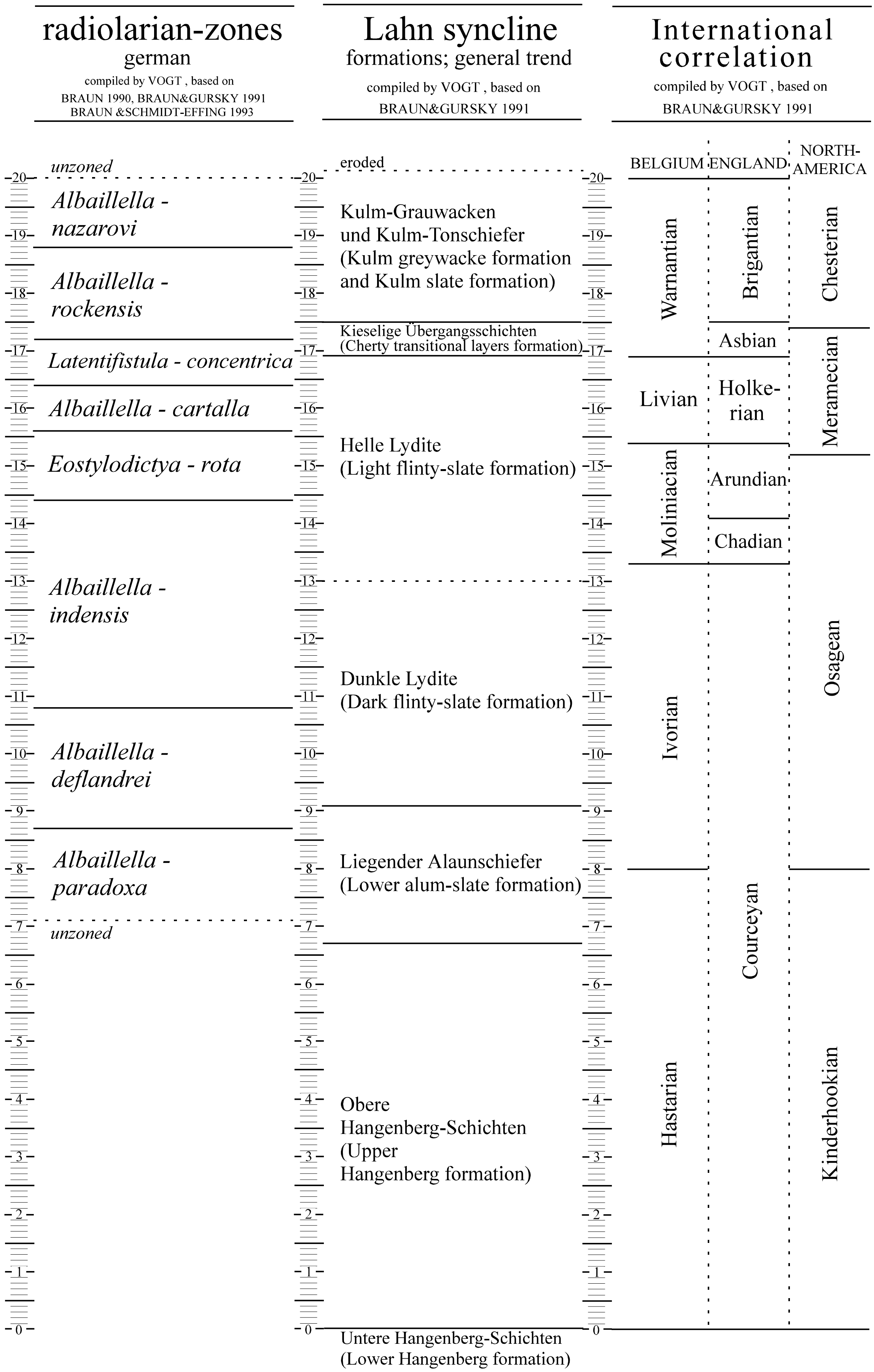
radiolarian-zones
german
compiled by VOGT , based on
BRAUN 1990, BRAUN&GURSKY 1991
BRAUN &SCHMIDT-EFFING 1993
Lahn syncline
formations; general trend
compiled by VOGT , based on
BRAUN&GURSKY 1991
International correlation
compiled by VOGT , based on
BRAUN&GURSKY 1991
BELGIUM
ENGLAND
NORTH-AMERICA
unzoned
Albaillella - nazarovi
Albaillella - rockensis
Latentifistula - concentrica
Albaillella - cartalla
Eostylodictya - rota
Albaillella - indensis
Albaillella - deflandrei
Albaillella - paradoxa
unzoned
eroded
Kulm-Grauwacken und Kulm-Tonschiefer (Kulm greywacke formation and Kulm slate formation)
Kieselige Übergangsschichten (Cherty transitional layers formation)
Helle Lydite (Light flinty-slate formation)
Dunkle Lydite (Dark flinty-slate formation)
Liegender Alaunschiefer (Lower alum-slate formation)
Obere Hangenberg-Schichten (Upper Hangenberg formation)
Untere Hangenberg-Schichten (Lower Hangenberg formation)
Warnantian
Livian
Moliniacian
Ivorian
Hastarian
Brigantian
Asbian
Holke-rian
Arundian
Chadian
Courceyan
Chesterian
Meramecian
Osagean
Kinderhookian
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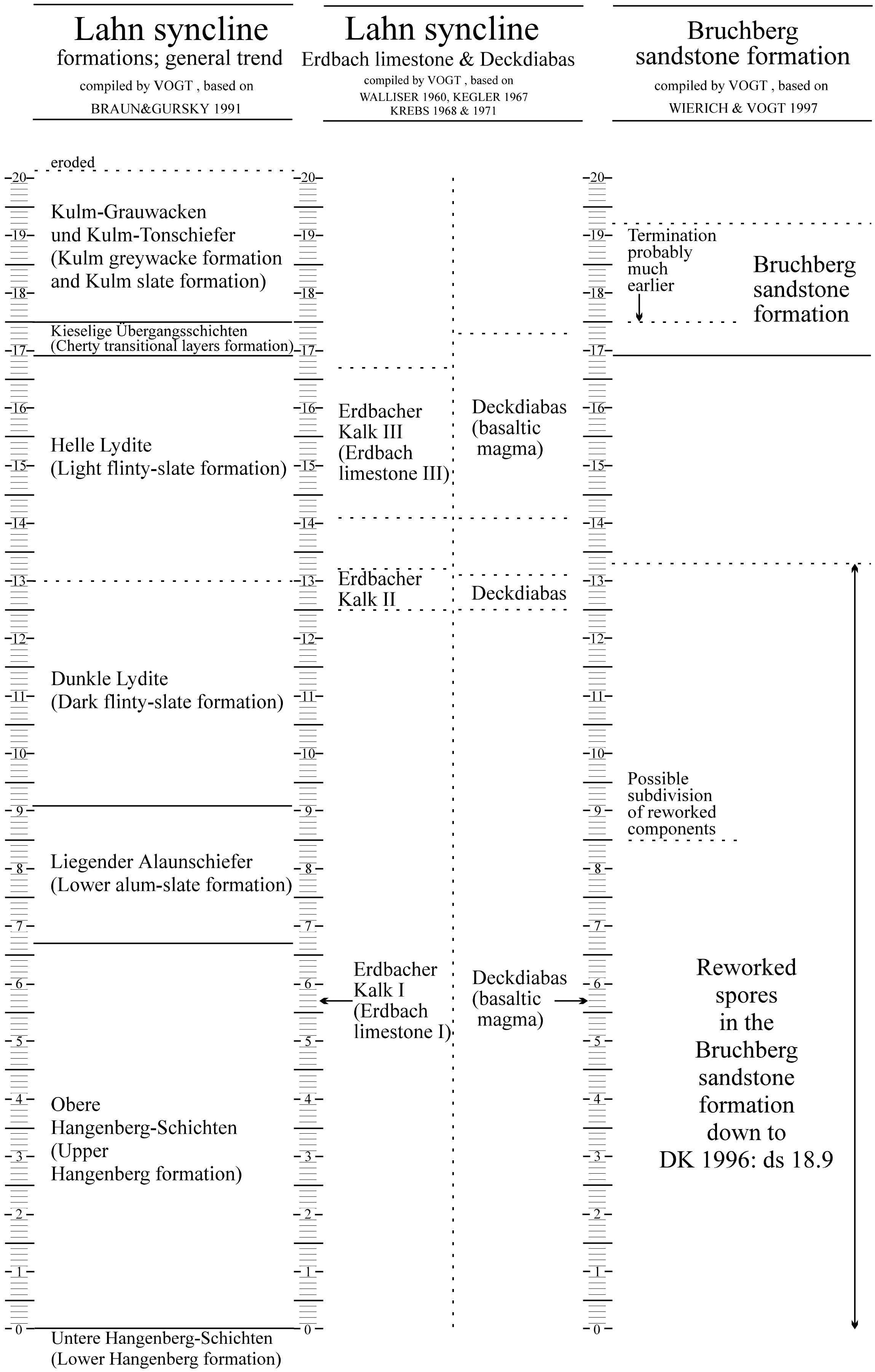

Lahn syncline
formations; general trend
compiled by VOGT , based on
BRAUN&GURSKY 1991
Lahn syncline
Erdbach limestone & Deckdiabas
compiled by VOGT , based on
WALLISER 1960, KEGLER 1967
KREBS 1968 & 1971
Bruchberg
sandstone formation
compiled by VOGT , based on
WIERICH & VOGT 1997
eroded
Kulm-Grauwacken
und Kulm-Tonschiefer
(Kulm greywacke formation
and Kulm slate formation)
Kieselige Übergangsschichten
(Cherty transitional layers formation)
Helle Lydite
(Light flinty-slate formation)
Dunkle Lydite
(Dark flinty-slate formation)
Liegender Alaunschiefer
(Lower alum-slate formation)
Obere
Hangenberg-Schichten
(Upper
Hangenberg formation)
Untere Hangenberg-Schichten
(Lower Hangenberg formation)
Erdbacher
Kalk III
(Erdbach
limestone III)
Deckdiabas
(basaltic
magma)
Erdbacher
Kalk II
Deckdiabas
Erdbacher
Kalk I
(Erdbach
limestone I)
Deckdiabas
(basaltic
magma)
Termination
probably
much
earlier
Bruchberg
sandstone
formation
Possible
subdivision
of reworked
components
Reworked
spores
in the
Bruchberg
sandstone
formation
down to
DK 1996: ds 18.9
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C 2

The technique of applied argument analysis (adopted from FISHER 1993)

C 2.1 Introduction

This method applies to reasoning in natural language, especially in written texts. It is important to note, that - by using this method -we are solely interested in finding out the truth about things rather than in scoring points off the author whose text is analysed. Hence, a basic principle has to be applied during the analytical process: "In general when trying to decide whether a passage contains reasoning one should adopt the Principle of Charity. This says that if interpreting as reasoning a passage which is not obviously reasoning yields only bad arguments, assume it is not reasoning." (FISHER 1993: 17f).

The extraction of an author's intended arguments from a text is often complicated and very time-consuming. It's *not* the intention to copy in parts and thereby summarise a text but to understand the author's intentions and therefore finding out the truth about things. This is far from being a trivial procedure since it needs knowledge about the topics offered in a text and imagination. Everybody who, stante pede, declares the whole procedure of argument analysis to be unnecessary and the analyser to be a copist of others texts (and ideas), should be forced by oneself to undertake such an analysis in order to find out how much valuable work it is. One cannot discuss and evaluate what one does not fully understand.

"We begin by describing how to recognise contexts in which reasoning is taking place (i.e. we say what 'the linguistic clues' are). We then describe how to uncover and display the structure of a piece of reasoning (whether it is a 'chain' of reasons etc.). Finally we explain, as far as possible, how to decide whether the reasoning is correct or incorrect. [...].

All the arguments we study in [the examples in this work] are arguments which have *actually been used* by someone with a view to *convincing* others about some matter. They are *real* arguments – not the 'made-up' kind with which logicians usually deal." (FISHER 1993: 15).

"If we are to focus attention on reasoning we must first describe how to distinguish contexts in which reasoning is taking place. (...) reasoning or arguing a case consists in giving grounds or *reasons* for *conclusions*, in order to *support, justify, establish, prove* or *demonstrate* the conclusion. (The author is trying to convince the audience by means of reasoning.) In natural languages it is not always easy to tell when an argument is being presented [...], but all arguments have a conclusion and in English a conclusion is often signalled by the presence of one of the following words or phrases, which we call 'conclusion indicators':

Conclusion indicators
therefore...; so...; hence...; thus...; consequently...; which proves that...; justifies the belief that...; I conclude that...; ...which implies that...; ...which allows us to...; infer that...; it follows that...; ...establishes the fact that...; ...demonstrates that... [...]

Every argument also includes grounds or *reasons* for its conclusion. A reason is generally presented as being *true* and as being *a reason for* some conclusion. [...] Words and phrases which are used in English to signal the presence of reasons – and which we shall call 'reason indicators' – include the following:

Reason indicators
because...; for...; since...; follows from the fact that...; the reason being...; firstly, ...secondly, ...(etc.); may be inferred from the fact that... [...]

Reasons are generally presented as being true. But sometimes also reasons are used which "are *not* presented as being true but which are 'supposed for the sake of the argument'. [...]

It is important to note that "we are not saying that *whenever* these words or phrases are used a reason [or conclusion] is present, but that they commonly *indicate* the presence of a reason [or conclusion]. They serve as markers which enable us, with the aid of a little judgement, to locate [conclusions and] reasons. [...] Of course, conclusions [and reasons] are sometimes presented with no conclusion [or reason] indicator at all; instead the context shows that a conclusion is being presented. [...]

It will be convenient to have a phrase to refer to both reason and conclusion indicators so we shall call them both **'inference indicators'** or **'argument indicators'**." (FISHER 1993: 16f).

"The contexts in which we are interested are those in which an author or speaker presents some claim, the conclusion, as being supported or justified by other claims, the reasons. So whether certain claims are to be counted as conclusions or reasons depends solely on the author's apparent intentions [...]
Sometimes reasoning takes place without the use of inference indicators to signal the presence of reasons and conclusions. Sometimes it is difficult to decide whether reasoning is taking place in such cases." (FISHER 1993: 17).
"The conclusion is sometimes omitted from an argument. [...] The context usually makes the intended conclusion clear. Similarly, reasons are sometimes omitted from arguments even though they are being assumed as part of the argument." (FISHER 1993: 18).
"It follows immediately from [the foregoing] paragraphs [...] that the dividing line between argument and non-argument is not sharp. It is often absolutely clear that a passage expresses an argument. Similarly it is often quite certain that a passage does *not* contain reasoning. But equally, it is often quite unclear whether it does or not." (FISHER 1993: 18).

In order to explore the structure of reasoning presented in a text we have to consider some conventions and apply a **basic terminology**.

"If some claim, R, is presented as being a reason for accepting some conclusion, C, we shall write like this: **R → C** where the arrow is to be read as 'therefore' or some idiomatically appropriate synonym." (FISHER 1993: 19).

If more than one reason is presented, the reasons may be delivered in two principal ways: a) reasons (R_1 + R_2 + ... + Rn) that *jointly* (only together) support the conclusion C; or b) reasons ($R_1 \vee R_2 \vee ... \vee$ Rn) which - each - *independently* support the conclusion C.

The **'Main Conclusion' MC** of a text (if there exists only one) is supported by **'Basic Reasons' R** (e.g.: R_1 + R_2 + ... + Rn). Also **'Intermediate Conclusions' C** may be presented in the course of the text, which may , e.g., support the establishment of a basic reason but do not directly assert MC. Reasons that do not act as basic reasons for MC but support only an intermediate conclusion C are noted in the following way: R_a + R_b + R_c + ... + Rn **('Additional Reasons').**

If a reason R or a conclusion C is omitted from the text and therefore had to be *inferred* by the analyser it is noted as follows: ***inf*R** or ***inf*C** **('Inferred Reason** or **Conclusion')**.

Suppositional or hypothetical reasons or conclusions are marked: **sR** or **sC**. Formally exist slight but significant differences between assumptions, presumptions, propositions, hypotheses and suppositions:

Assumption: a) a fact or statement taken for granted, b) the supposition that something is true. The use of the phrase "assume" may imply either reasonable grounds for supposing or a deliberate purpose in taking as definite something that is not actually settled or determined.

Presumption: a conclusion reached on strong grounds of belief in the way, that something is supposed to be true but not vigorously proved. A 'presumption' implies greater confidence in supposing without (or no sufficient) proof or justification than an 'assumption'.

Proposition: an expression in language - offered for consideration or acceptance - of something that can be either true or false (proposal).

Hypothesis: something not proved but assumed to be true for purposes of argument or further investigation. If a hypothesis is employed in order to suppose something 'for the sake of the argument', the words 'hypothesis' and 'supposition' become interchangeable.

Supposition: something that is supposed (taken as true or as a fact or as believed/guessed). In many contexts 'assumption' and 'supposition' are interchangeable words, although the use of the first may imply a somewhat greater conviction than the latter.

In order to simplify our argumentation and notation all reasoning which includes medium or highly speculative parts is presented as **'Suppositional Reasoning'**.

The text-analysis should be conducted in the following way:

A Read through the text and mark all inference indicators (underline with stippled line or encircle them).

B Underline all obvious conclusions (C).

C Bracket all obvious reasons ⟨R⟩.

D Identify the main conclusion MC.

E Identify the basic reasons R_1, R_2, ... Rn presented in the text for accepting MC.

F Identify additional reasons R_a, R_b, ... Rn in support of intermediate conclusions.

G Identify omitted reasons or conclusions which are, nevertheless, obvious from the context.

H Group all correlated reasons and conclusions together in a structured way (e.g.: $R_a + R_b \rightarrow C_1$).

I Evaluate the revealed argumentation. Ask the 'Assertibility Question' (AQ, FISHER 1993:22): "What argument or evidence would justify me in asserting the conclusion C (What would I have to know or believe to be justified in accepting C?)"

J Summarise the 'convincing' arguments.
[A general remark about what is "convincing" has to be stated. All scientists are prisoners of their time (as any arbitrary person anyway). This implies: what we accept as convincing is an essential part of the paradigm which we obey at the time. This is a very important observation since it generally discloses that our present-day considerations and conclusions may be judged false in the course of later explorations. Therefore, it is most important to present our newly explored DATA and FACTS in a clear and well structured manner in order to enable succeeding scientists to use our data - rather than allowing for burial under the dust of time our then false conclusions and declaring our data as unreliable or not worth to be considered.]

At this time, we have outlined the main aspects of the argument analysis due to Alec FISHER (1993) - with some appropriate adjustments - but much more could be said. Since this is not suitable in this study, I will refer to FISHER's original textbook for further information. Nevertheless, what we have learned by now is sufficient to undertake a thorough evaluation of a scientific text. A text-example which deals with the a) existence of a Giessen-Harz Nappe, b) its spatial distribution and c) the age correlation of its units is presented afterwards and the whole analysis is outlined in the following steps:

Step I: Plain text.
Step II: Identification and structure of arguments (points A - F, see above).
Step III: Extraction of arguments (points G + H).
Step IV: Evaluation of the arguments (point I).
Step V: Synopsis of convincing arguments (point J).

The proper knowledge about the Giessen (- Harz ?) nappe and its characteristics is essential for this study, since I also detected parts of that nappe structure in the area of the 'Gaudernbach layers'.

C 2.2 Example I: a text from Wolfgang FRANKE (1995: 38): Chapt. III.B.1 Stratigraphy.- in: DALLMEYER et al. (ed.): Pre-Permian geology of Central and Eastern Europe

C 2.2.1 Step I: Plain text

([...] = reference to text-figures or other chapters)

Giessen-Harz Nappe

This unit is exposed [...] at the southeastern margin of the Rhenish Massif, possibly in the southern Kellerwald Mts., in the Werra Mts., and in the Harz Mts. (S Harz and Selke nappes).

At its base, there are tectonic slices of metabasalt with the geochemical fingerprints of MOR-type basalts [...]. It is relevant for the tectonic interpretation of these rocks, that the metabasalts in the parautochthon uniformly reveal the characteristics of intraplate volcanics. In a few cases, the basalts are overlain, without any tectonic disconformity, by condensed shales and bedded cherts with conodonts and radiolarians. In one section, the Late Lower Devonian (Emsian) through Early Frasnian is contained within only 4 m of pelitic sediments. In another locality, the cherts overlying the metabasalt have yielded Eifelian conodonts (Birkelbach et al. 1988). Hence, the metabasalts must be of pre-Eifelian or pre-Late Emsian age. Presumably, the metabasalts of the Giessen-Harz nappe were extruded during the Early Devonian.

The main part of the Giessen-Harz nappe consists of graywacke turbidites and intercalated shales. The oldest graywackes are of Early Frasnian age in the Giessen area. Frasnian in the southern Kellerwald (Jahnke and Paul 1968), Middle Frasnian in the Werra Mts. (Wittig 1968), and Early Famennian in the South Harz nappe (e. g. Walliser and Alberti 1983). In most of these areas, graywacke sedimentation can be shown to extent higher up into the Famennian; near Giessen, an Early Carboniferous age is possible for the southern part of the graywacke nappe (Dörr 1990).

Near Giessen, the graywackes occur as a thin tectonic klippe with a maximum thickness of 200 m only. However, drillings in the southern Harz Mts. have encountered approx. 2000 m of Devonian greywackes (Schust et al. 1991). Besides, the grade of metamorphism in the southern part of the Rhenish Massif (Hunsrück - Taunus) requires an overburden of 5-12 km (Oncken 1988), part of which is probably provided by the Giessen-Harz Nappe.

It is important to note that an almost identical sequence of lithologies exists in S Cornwall. Even the composition of the graywackes in both areas is more or less identical. However, the English sequences complement the German record, in that they also contain a unit with peridotites, gabbros and sheeted dikes of Devonian age (Lizard complex, see Floyd et al. 1990 for a review).

C 2.2.2 Step II: Identification and structure of arguments

On the next page reasons, conclusions and inference indicators are outlined.

	MC	Giessen-Harz Nappe
	R_1	⟨This unit is exposed at the southeastern margin of the Rhenish Massif,⟩
	sR_2	possibly ⟨in the southern Kellerwald Mts., in the Werra Mts., and in the
		Harz Mts. (S Harz and Selke nappes).⟩
	R_a	⟨At ist base, there are tectonic slices of metabasalt with the geochemical
($infR_3$ =)	C_1	fingerprints of MOR-type basalts⟩ [...]. It is relevant for the tectonic
	R_b	interpretation of these rocks, that ⟨the metabasalts in the parautochthon
	R_c	uniformly reveal the characteristics of intraplate volcanics.⟩⟨In a few cases,
		the basalts are overlain, without any tectonic disconformity, by condensed
	R_d	shales and bedded cherts with conodonts and radiolarians.⟩⟨In one section,
		the Late Lower Devonian (Emsian) through Early Frasnian is contained
	R_e	within only 4 m of pelitic sediments.⟩⟨In another locality, the cherts
		overlying the metabasalt have yielded Eifelian conodonts (Birkelbach et al.
(R_f =)	C_2	1988).⟩ Hence, the metabasalts must be of pre-Eifelian or pre-Late Emsian
	sC_3	age. Presumably, the metabasalts of the Giessen-Harz nappe were extruded
		during the Early Devonian.
		The main part of the Giessen-Harz nappe consists of graywacke turbidites
	R_g	and intercalated shales. ⟨The oldest graywackes are of Early Frasnian age in
		the Giessen area, Frasnian in the southern Kellerwald (Jahnke and Paul
		1968), Middle Frasnian in the Werra Mts. (Wittig 1968), and Early
	R_h	Famennian in the South Harz nappe (e. g. Walliser and Alberti 1983).⟩⟨In
		most of these areas, graywacke sedimentation can be shown to extent
	R_i	higher up into the Famennian;⟩⟨near Giessen, an Early Carboniferous age is
$infC_4 \leftarrow R_g + R_h + R_i$		possible for the southern part of the graywacke nappe (Dörr 1990).⟩
	R_j	⟨Near Giessen, the graywackes occur as a thin tectonic klippe with a
	R_k	maximum thickness of 200 m only.⟩ However, ⟨drillings in the southern
		Harz Mts. have encountered approx. 2000 m of Devonian greywackes
	sR_l	(Schust et al. 1991).⟩ Besides, ⟨the grade of metamorphism in the southern
		part of the Rhenish Massif (Hunsrück - Taunus) requires an overburden of
		5-12 km (Oncken 1988),⟩ part of which is probably provided by the
$infC_5 \leftarrow R_j + R_k + sR_l$		Giessen-Harz Nappe.
	R_m	It is important to note that ⟨an almost identical sequence of lithologies
$R_m+R_n \rightarrow infC_6 \rightarrow infR_o$	R_n	exists in S Cornwall.⟩Even ⟨the composition of the graywackes in both
	C_7	areas is more or less identical.⟩However, the English sequences
	R_p	complement the German record, in that ⟨they also contain a unit with
		peridotites, gabbros and sheeted dikes of Devonian age (Lizard complex,
		see Floyd et al. 1990 for a review).⟩

C 2.2.3 Step III: Extraction of arguments

The analysis reveals that this short and "easy to read" text inhabits a complex structure of reasoning. The main conclusion is obvious, esp. since it is presented as headline. But the positioning and structure of intermediate and additional conclusions, together with the "presence" of some inferred conclusions (which are omitted/prohibited from the text) and the use of suppositional reasoning, do not easily show how the author deals with what he seems to accept as "truth".

The main conclusion MC is: "[The] Giessen-Harz nappe [exists]". It contains one structural ("nappe") and two geographical ("Giessen" and "Harz") elements. By accepting this main conclusion as "true" the author gives us some more detailed information about:

- the age-range covered by these lithologies,
- lithologies incorporated in the nappe,
- thickness and spatial distribution of the nappe and
- correlation with "almost identical" units in S England.

Since MC is:

MC "[The] Giessen-Harz nappe [exists]",

we next have to discover what immediate reasons the author presented in the text for accepting MC.

The first reason R_1 is:

R_1 "This unit is exposed [...] at the southeastern margin of the Rhenish Massif."

The town Giessen is situated there, hence the geographical characterization is convincing. Apart from that, ample evidence is available in favor of the existence of the Giessen nappe.

The second reason sR_2 is not presented in a straightforward manner, the supposition indicator "possibly" is used, which shows us the author has some doubts about the truth of that part of the reasoning:

sR_2 "possibly in the southern Kellerwald Mts., in the Werra Mts., and in the Harz Mts. (S Harz and Selke nappes)."

It is not clear whether the phrase "possibly" is only related to the part concerning the "southern Kellerwald Mts." or the whole reason. Since this second reason starts with a supposition it is marked as suppositonal reason sR_2. By accepting this reason we may infer that something which exists around Giessen also exists along a line Kellerwald Mts., Werra Mts. and Harz Mts.

By now we have got the reasons $R_1 + sR_2$ which account for the geographical elements in the conclusion MC. The arguments for accepting the "nappe"-nature of the described rocks are, unfortunately, not that obviously presented. They contain at least 4 additional reasons (R_a - R_d) which add up to the -partly inferred- intermediate conclusion C_1, which also acts as inferred main reason *inf*R_3 for accepting the nappe:

Since

R_a The structure has a *base* with *tectonic slices* of metabasalts "with the geochemical fingerprints of MOR-type basalts";

and

R_b "The metabasalts in the parautochthon uniformly reveal the characteristics of intraplate volcanics." [The "parautochthon" is not part of the proposed nappe-structure, which itself may be regarded as "allochthon" (with MOR-type metabasalts).]

and

R_c "In a few cases, the [MOR-type] basalts are overlain, without any tectonic disconformity, by condensed shales and bedded cherts with conodonts and radiolarians." Both, condensed shales and bedded cherts in the vicinity of such metabasalts may indicate a different development in contrast to e. g. the "normal" Devonian Lahn-syncline sedimentation;

and

R_d "In one section, the Late Lower Devonian (Emsian) through Early Frasnian is contained within only 4 m of pelitic sediments." If this is true, it is a strong argument for a completely different depositional environment in the proposed nappe - in comparison to the "normal" development with the production of at least several tens of metres sediment pile;

the author concludes, that

C_1 "the tectonic interpretation of these rocks [reveals: a nappe-structure exists.]"

Next, this intermediate conclusion C_1 is used as inferred reason *inf*R_3 in favor of the authors argumentation:

infR_3 $= C_1$

The structure of this reasoning is therefore: $R_a + R_b + R_c + R_d \rightarrow C_1 = inf R_3$

With that knowledge now we are able to complete the structure of reasoning used for the establishment of the main conclusion MC:

$$\mathbf{MC \leftarrow R_1 + sR_2 + (\textit{inf}R_3 = C_1)}$$

Apart from establishing the main conclusion MC, some additional - but not essential - information about the "Giessen-Harz nappe" is presented by the author.

a) The first additional information deals with the age-correlation for the MOR-type metabasalts:

R_e "In another locality, the cherts overlying the metabasalt have yielded Eifelian conodonts (Birkelbach et al. 1988)."

By accepting this reason the author concludes:

C_2 "Hence, the metabasalts must be of pre-Eifelian or pre-Late Emsian age."

R_f Next, he treats this intermediate conclusion C_2 as reason R_f for a further - now suppositional - conclusion:

sC_3 "Presumably, the metabasalts of the Giessen-Harz nappe were extruded during the Early Devonian."

Therefore the structure of this reasoning is:

$$\mathbf{sC_3 \leftarrow (R_f = C_2) \leftarrow R_e}$$

b) The second additional information deals with the age-range of the graywacke turbidites which - together with intercalated shales - form "the main part of the Giessen-Harz Nappe":

R_g "The oldest graywackes are of Early Frasnian age in the Giessen area, Frasnian in the southern Kellerwald (Jahnke and Paul 1968), Middle Frasnian in the Werra Mts. (Wittig 1968), and Early Famennian in the South Harz nappe (e. g. Walliser and Alberti 1983)."

and

R_h "In most of these areas, graywacke sedimentation can be shown to extent higher up into the Famennian"

and

R_i "near Giessen, an Early Carboniferous age is possible for the southern part of the graywacke nappe (Dörr 1990)."

The conclusion is omitted from the text, but by adding up all three reasons the following inferred intermediate conclusion *inf*C_4 is obvious:

infC_4 The graywacke sedimentation lasted from Early Frasnian to a time "higher up" in the Famennian and - possibly - up to the Early Carboniferous.

Therefore the structure of this reasoning is:

$$\boldsymbol{inf}\mathbf{C_4 \leftarrow R_g + R_h + R_i}$$

c) The third additional information deals with the thickness of the graywacke and spatial distribution of the Giessen-Harz nappe:

R_j "Near Giessen, the graywackes occur as a thin tectonic klippe with a maximum thickness of 200m only."

and

R_k "drillings in the southern Harz Mts. have encountered approx. 2000 m of Devonian greywackes (Schust et al. 1991)."

and

sR_l "the grade of metamorphism in the southern part of the Rhenish Massif (Hunsrück – Taunus) requires an overburden of 5-12 km (Oncken 1988), part of which is probably provided by the Giessen-Harz Nappe." The suppositional part of this reason is indicated by the phrase "is probably provided".

The conclusion is omitted from the text, but by adding up all three reasons the following inferred intermediate conclusion *inf*C_5 seems obvious:

infC_5 Devonian greywackes of the Giessen-Harz Nappe yield a thickness of up to 2000m. By accepting this information and the fact that near Giessen the greywacke is eroded down to approx. 200m, one can conclude that several tens of kilometres south of Giessen (in the Hunsrück-Taunus area) the required (now eroded) overburden in order to explain the grade of metamorphism there, may have been provided by parts of the Giessen-Harz Nappe. In this way we can extend the spatial distribution of the nappe farther to the south.

The structure of this reasoning is:

$$\boldsymbol{inf}\mathbf{C_5} \leftarrow \mathbf{R_i + R_k + sR_l}$$

d) The fourth additional information deals with the correlation between the Giessen-Harz Nappe and an "almost identical" unit in S England:

R_m "an almost identical sequence of lithologies exists in S Cornwall."

and

R_n "the composition of the graywackes in both areas is more or less identical."

The intermediate conclusion is omitted from the text, but by adding up all three reasons the following inferred intermediate conclusion *inf*C_6 is obvious:

infC_6 A whole sequence and also an important component of this sequence in S Cornwall is "more or less identical" to the lithologies encountered in the Giessen-Harz Nappe.

The structure of the reasoning is:

$\boldsymbol{inf}\mathbf{C_6} \leftarrow \mathbf{R_m + R_n}$

$inf C_6$ can be used as inferred additional reason $inf R_o$ in favor of the authors argumentation:

$inf R_o$ = $inf C_6$

and

R_p "they [the English sequences] also contain a unit with peridotites, gabbros and sheeted dikes of Devonian age (Lizard complex, see Floyd et al. 1990 for a review).

the author concludes:

C_7 Hence, "the English sequences complement the German record"; i. e. peridotites, gabbros and sheeted dikes could be expected also within the Giessen-Harz Nappe (but are nowadays eroded or not yet detected).

The structure of this reasoning is:

$$\mathbf{C_7 \leftarrow R_p + (\mathit{inf}R_o = \mathit{inf}C_6)}$$

The analysis is now complete and we are therefore able to show the whole structure of the reasoning employed by Wolfgang FRANKE in the text:

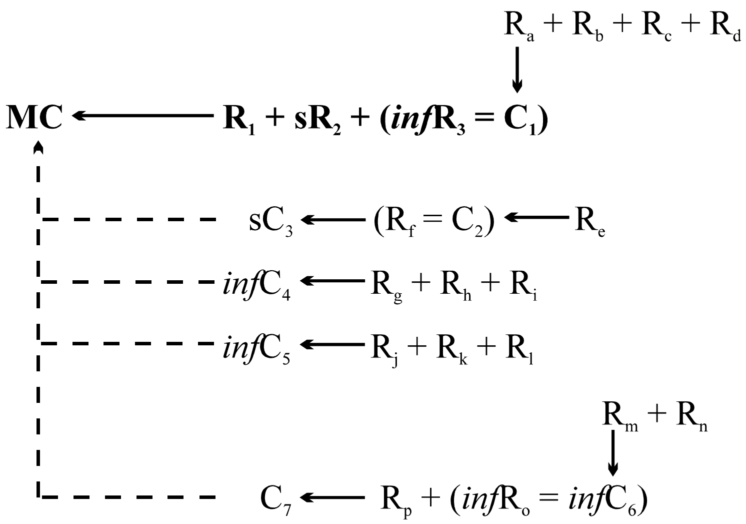


Fig. C 2.1: Diagrammatic presentation of the structure of the reasoning employed by Wolfgang FRANKE in the analysed text.

From this it is obvious that the author uses a very complex structure of reasoning with the following components:

- 1 main conclusion (MC), asserted by 3 main reasons (R_1 – R_3) of which one has a suppositional and another an inferred character;
- 7 intermediate/additional conclusions (C), of which one is suppositional and 3 inferred;
- 16 additional reasons (R_a – R_p) of which 1 is inferred and 2 also act as intermediate conclusion.

The reasoning is incorporated in a relatively short text of 27 lines (150mm broad; incl. headline) and 384 words. From a statistical viewpoint **nearly every 2nd line a reason and approx. every 3rd line a conclusion was employed**. This is not surprising since the text represents a summary within a review article. But - in order to be enabled to distinguish between the known and well established facts and the speculative part of the reasoning - it is necessary to use a well structured and straight presentation of arguments. **In this text the reader is intended to infer a lot of omitted reasons and conclusions.** Also some additional, but somewhat arbitrary, information which do not assert MC but show some of its proposed attributes is presented. As a concequence, the reader is either forced a) to accept as true what is presented or b) has to employ a lot of thorough, time-consuming evaluation in order to reveal the suppositional or maybe even contradictory arguments.

C 2.2.4 Step IV: Evaluation of the arguments

In step III the argument structure and the omitted conclusions had been revealed. In this step we try to evaluate the arguments presented by the author. The main conclusion of the article is:

"[The] Giessen-Harz nappe [exists]".

Different kinds of reasons have been presented by FRANKE in order to assert this main conclusion. Hereafter they are listed in order of appearance and shortly discussed.

R_1 *"This unit is exposed [...] at the southeastern margin of the Rhenish Massif."*

Evidence in favor of the existence of the Giessen nappe is summarised in DÖRR (1990) and e.g. SCHÖNENBERG & NEUGEBAUER (1988: 70+94) or FRANKE et al. (1996: 29). At this time no alternative concepts are in discussion.

sR_2 *"possibly in the southern Kellerwald Mts., in the Werra Mts., and in the Harz Mts. (S Harz and Selke nappes)."*

Nappe structures in the Kellerwald Mts. had been ruled out by nearly all scientists who worked *in* this area (e.g. STOPPEL 1961, MEISCHNER 1991, MEISCHNER 1996: 26 in FRANKE et al. 1996). But: in this study the Bruchberg sandstone (= Kellerwald quartzite) in the middle Lahn syncline is interpreted as being a part of the Giessen Nappe; since the Kellerwald quartzite in the Kellerwald Mts. had always been acknowledged as part of the parautochthonous units, the discussion about the tectonic implacement of the Bruchberg sandstone should be revived.

SCHMID (1991) proposed the existence of a Werra nappe in the "Unterwerra" Mts. and presented petrographic and tectonic data as well as results of illite-crystallinity measurements. It would take a separate publication in order to evaluate the presented arguments. At this place it may only be mentioned that some of the reasons are not unequivocally to be regarded as true - e.g. the results of the illite-crystallinity measurements are not significant at a statistical level (compare SCHMID 1991: 55). However, the existence of a Werra nappe remains "possible".

The occurrence of nappes in the eastern Harz Mts. had also been proposed. At this time it is not matter of debate *if* nappes exist, but only *which* units have to be considered as nappes. WACHENDORF et al. (1996: 131f) summarise characteristic features and arguments in favour of a "Ostharz" nappe.

The connection of all the above mentioned (proposed or established) nappe structures to a "Giessen - Harz Nappe" represents a stimulating hypothesis, but remains up to this day a highly speculative topic.

R_a ,R_b The structure has a base with tectonic slices of metabasalts "with the geochemical fingerprints of MOR-type basalts". "The metabasalts in the parautochthon uniformly reveal the characteristics of intraplate volcanics."

The mentioned "base" of the nappe structure with tectonic slices of metabasalts had only been convincingly described in the Giessen area (e.g. BIRKELBACH et al. 1988: 67, DÖRR 1990: 33ff). Equivalent metabasalts from the Harz Mts. had been taken from rock units in still questionable tectonic settings (PLATEN et al. 1989a: 42, b: 365).

Several geochemical analyses of these metabasalts had been undertaken, e.g. by WEDEPOHL et al (1983), GRÖSSER & DÖRR (1986), PLATEN (1991). Most research was restricted to the analysis of Rare Earth Elements (REE), since the major element characteristics, which are normally also needed in order to typify a basaltic rock, are overprinted by the chemical changes during diagenesis and metamorphism. Main results of this research are presented in diagram C 2.2. It can be shown that two geochemically different groups of metabasalts occur within the Rhenohercynian zone. The first group - which includes most of the metabasalts - may be interpreted as former intra-plate basalts (compare WEDEPOHL et al. 1983, PLATEN et al. 1989a: 42, b: 365). Due to crustal contamination and fractional crystallisation the REE - patterns show an enrichment esp. in light REE and a progressive fractionation towards the less mobile heavy REE. Several factors may influence these patterns (WILSON 1989: 17 (after GREEN 1980)):

Garnet and possibly hornblende readily accomodate heavy REE and so strongly fractionate light REE. Sphene has the opposite effect accomodating the light REE. Clinopyroxene fractionates the REE but only slightly. Eu is strongly fractionated into feldspars and Eu anomalies may reflect feldspar involvement.

"Intuitively, we should expect the greatest degrees of crustal contamination in regions with high rates of crustal extension, as these are associated with higher magma production rates, which will induce higher geothermal gradients in the crust." (WILSON 1989: 358).

The second observed group of metabasalts show REE patterns which scatter in and around the borderlines between a N-type and a P-type MORB. "Typical N-type MORB have unfractionated heavy REE abundances and are strongly depleted in light REE. Primitive basalts have REE concentrations of 10x chondrite or less, whereas extremely differentiated basalts may contain up to 50x chondrite. Fractional crystallisation involving olivine, plagioclase, clinopyroxene and spinel increases the total REE content of more evolved MORB, but does not produce any significant inter-element fractionations." (WILSON 1989: 139). If we assume the REE patterns as sufficient evidence in order to make the following statement, the interpretation as former MOR basalts for the observed magmatic rocks is generally confirmed; but a restriction to N- or T-type MORB's (PLATEN et al. 1989a: 42, b: 365), which is solely based on these observations, is not reliable. However, FLOYD (1995: 71) presents additional geochemical data apparently sufficient for the characterization of metabasalts from the Giessen nappe as N-type (to T-type) MORB's and compares these readings with approx. equivalent data from SW-England (Cornwall).

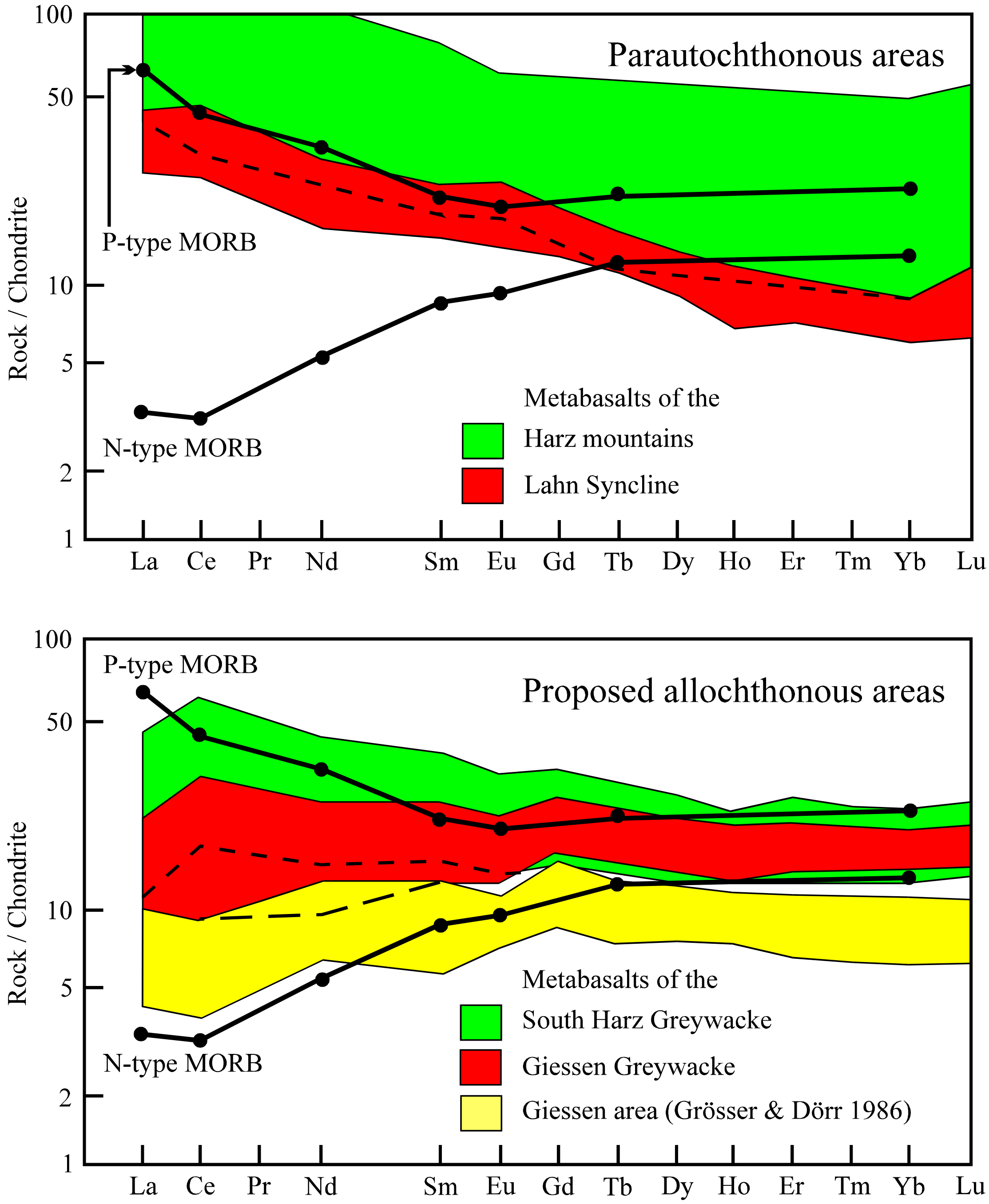


Fig. C 2.2: Chondrite-normalised REE patterns for metabasaltic rocks or metabasaltic components within greywacke units of the Rhenohercynian. The upper diagram shows the patterns for the parautochthonous areas with characteristics of intra-plate basalts; whereas the lower diagram displays the patterns for the proposed allochthonous areas which scatter in or around the displayed MORB field. Only the *range* for several samples from a distinct area is displayed. Data from PLATEN (1991 in FRANKE et al. 1996: fig. 6) and GRÖSSER & DÖRR (1986). PLATEN also analysed two samples from the Werra Greywacke: the sample from the parautochthonous unit shows a pattern which lies within the range of the metabasalts from the Harz Mts.; the sample from the proposed allochthonous part displays a pattern which lies within the range of the metabasalts from the Giessen Greywacke. Note that the data of GRÖSSER & DÖRR (1986) show a significantly different (but subparallel) pattern to the one presented by PLATEN (1991) for the Giessen Greywacke, although the samples had been taken in the same area.
For comparison: the thick lines represent the range of REE patterns displayed by basalts from normal and plume ridge segments along the Mid-Atlantic Ridge. P-type MORB from 71°33'N; N-type MORB from 66°51'N (data from SCHILLING et al. 1983 in WILSON 1989: 139).

R_c *"In a few cases, the [MOR-type] basalts are overlain, without any tectonic disconformity, by condensed shales and bedded cherts with conodonts and radiolarians."*

Generally, condensed shales and bedded cherts occuring together with such metabasalts indicate a significantly different facies development in contrast to e. g. the "normal" Devonian Lahn-syncline sedimentation.

No specific locations are named, hence it is very difficult to decide which places the author had in mind. In BIRKELBACH et al. (1988: 66f) and BIRKELBACH (1986: diploma-thesis) a ca. 1m thick effusive diabas is described from the Atzbach spring near Atzbach (E 3470680 N 5607155), which is overlain by flinty cherts of Eifelian age without apparent disconformity. The effusive character of this metabasalt is proposed because of the lack of any contact rim on top of the diabas. But: is there really a *concordant* succession metabasalt/flinty slate observable? This question is not to be answered without further and more detailed *published* information. The diabas is remarkably tectonised and partly sheared into slices and this is true also for the slates.

R_d *"In one section, the Late Lower Devonian (Emsian) through Early Frasnian is contained within only 4 m of pelitic sediments."*

Due to FRANKE et al. (1996: 52) the mentioned sedimentary succession is to be found in a small old quarry located near a barbeque hut in the forest northern and uphill of the village Salzböden and was intensively described in the diploma-thesis of MICHEL (1984). But no detailed data (esp. fossil lists!) have been published. Therefore, we have to *believe* that:

- a *concordant* succession with
- a *continuous* fossil record

was observed – or have to visit the quarry.

$infR_3$ *$= C_1$ "the tectonic interpretation of these rocks [reveals: a nappe-structure exists.]"*

If it is true that condensed basinal marine sediments together with MOR-type metabasalts occur within the lithological units of proposed allochthonous origin, then this facies must be considered significantly different from the parautochthonous lithologies with intra-plate metabasalts and partly thick columns of shelf- or shelf-derived sediments.

The analysed text of FRANKE contains two independent parts:

1) the establishment of the main conclusion MC: "[The] Giessen-Harz nappe [exists]", which is discussed above; and
2) the presentation of additional information about several units of the nappe.

The first additional information deals with the age-correlation for the MOR-type metabasalts:

R_e *"In another locality, the cherts overlying the metabasalt have yielded Eifelian conodonts (Birkelbach et al. 1988)."*

Again, the author probably talks about the situation in the quarry at the Atzbach spring near Atzbach (compare comments on R_c; BIRKELBACH et al. (1988: 66f) and BIRKELBACH (1986: diploma-thesis)). There a ca. 1m thick effusive diabas is overlain by flinty cherts with intercalated slates of Eifelian age. The conodont *Polygnathus trigonicus* BISCHOFF & ZIEGLER 1957 had been found there, probably by BIRKELBACH. Due to WEDDIGE (1977: 322) this conodont has a stratigraphic range from the upper *costatus*- to the lower *ensensis* - zone, which correlates to: DK 1996: ca. dm 2.7 — 7.2 (middle — upper Eifelian).

It is important to mention, that the metabasalt from *this* quarry had *not* been geochemically analysed; hence, it can't be said this metabasalt has MORB chemism - it could also be e.g. an intra-plate basalt. Only "in similar rocks in the immediate vicinity GRÖSSER & DÖRR (1986) have encountered basalts which show a trace element spectrum of recent mid-ocean ridges" (BIRKELBACH et al. 1986: 67).

R_f = C_2 *"Hence, the metabasalts must be of pre-Eifelian or pre-Late Emsian age."*

Or they are even older if a concordant succession within a condensed section is taken for granted. They could not be younger since the diabas shows convincing upside/down criteria (decompression vesicles; BIRKELBACH et al. 1986: 67).

sC_3 *"Presumably, the metabasalts of the Giessen-Harz nappe were extruded during the Early Devonian."*

Why? No additional evidence is presented in favor of this temporal restriction. Therefore, this statement is regarded to be entirely speculative.

The second additional information deals with the age-range of the graywacke turbidites which - together with intercalated shales - form "the main part of the Giessen-Harz Nappe":

R_g *"The oldest graywackes are of Early Frasnian age in the Giessen area, Frasnian in the southern Kellerwald (Jahnke and Paul 1968), Middle Frasnian in the Werra Mts. (Wittig 1968), and Early Famennian in the South Harz nappe (e. g. Walliser and Alberti 1983)."*

The fossil evidence for these different sites is of variable quality; generally, only relatively sparse faunas had been recovered. In the actual study it will be shown (chapt. C 5) that pelitic intercalations in the greywackes contain palynofloras of Frasnian and Early Famennian age, but also reworked lower Frasnian/Middle Devonian and late Early Devonian palynomorphs. We have to ask whether the greywacke sedimentation, which can accumulate great amounts of sediments in a relatively short time interval (tubidity currents), should have lasted for several million years unchanged - or if these different age correlations are the product of chance, depending on what assemblage of reworked fossils had been encountered.

In the Giessen area several stratigraphic data from banded slates intercalating the greywackes had been obtained by different authors. A short summary of the results is listed in DÖRR (1990: 29 -31). Due to this listing various locations yielded middle to upper Adorfian (Frasnian) ages and one location an early Nehdenian age.

JAHNKE & PAUL (1968) summarised several diploma-theses dealing with areas in the southern Kellerwald. The greywackes from this area yielded conodont faunas indicating an Upper Devonian age for these rocks: partly they had been dated into the Adorfian, partly into the Wocklumian. A temporal restriction to the Frasnian (as mentioned above) is therefore not tolerable - at least not by quoting this source. But it is possible that the greywackes belong to different units of an overthrust- (or even nappe-) structure. The proposed late Famennian (Wocklumian) greywackes could contain *reworked* conodonts and therefore could also be of younger (Lower Carboniferous?) age.

The rare conodont fauna from the Werra Greywacke, obtained by WITTIG (1968) from several, partly calcareous, greywacke-samples, only permits a stratigraphic correlation ranging from upper Adorfian to Nehdenian. I inspected several of the mentioned outcrops during my diploma-work in this area (VOGT 1992), but could no more find any calcareous greywackes or conodonts on bedding planes.

In a review article WACHENDORF et al. (1995: 128) place the *onset* of the greywacke sedimentation in the South Harz nappe into the middle Famennian.

Tab. C 2.1: Comparison of published age correlations for Upper Devonian greywackes in the Rhenohercynian

Published age correlations for Upper Devonian greywackes in the Rhenohercynian		
Region	**FRANKE (1995)**	**above mentioned authors**
Giessen area	Early Frasnian	Middle — upper Frasnian Early Nehdenian
Southern Kellerwald	Frasnian	Upper Devonian (Adorfian and Wocklumian)
Werra mountains	Middle Frasnian	upper Adorfian — Nehdenian
South Harz nappe	Early Famennian	Middle Famennian (or younger)

Anyway, since from all the above named locations always *components of a greywacke-turbidite sequence* had been dated, only the relative maximum age had been determined in this way. We can not be sure if we really dated the *oldest* greywackes, or - by chance - the greywackes with the *oldest reworked* fossils. At locations with insufficient knowledge about the tectonic development we are not even sure if the dated slates are really intercalations within the greywackes or only represent small schuppen within a thrust structure.

R_h "In most of these areas, graywacke sedimentation can be shown to extent higher up into the Famennian"

If something *can be shown*, fossil evidence can be put forward in order to assert the argumentation. In reason R_g only the presumably *oldest* greywackes from different areas had been named. In R_h the possible stratigraphic range is stated. This statement is confirmed by results of the above (in R_g) mentioned authors and by results presented in the actual study in chapter C 5.

R_i "near Giessen, an Early Carboniferous age is possible for the southern part of the graywacke nappe (Dörr 1990)."

"Due to DABER (in HENNINGSEN 1961) the plant remnants [found in the 'younger' Giessen greywacke] undoubtedly belong to the Lower Carboniferous. A more detailed correlation is, however, not possible. Conodonts from the lowermost part of the Adorf stage (ENGEL et al. 1983a) from the Younger Greywacke [Jüngere Grauwacke] may induce doubts on the stratigraphic position of the plant remnants. However, the conodonts had been recovered from calcareous greywackes; and the obtained data are not in accordance with the stratigraphic results from the Krofdorfer Schichten. Fossiliferous limestone components in these calcareous greywackes (corals, styliolins, ostracods, etc.) indicate, that these conodonts are reworked and therefore only show a maximum age." (DÖRR 1990: 32).

Due to the above mentioned quotation an Early Carboniferous age is not even possible but probable.

$infC_4$ The graywacke sedimentation lasted from Early Frasnian to a time "higher up" in the Famennian and - possibly - up to the Early Carboniferous.

The former analysis revealed two distinct groups of stratigraphic correlation for the greywackes. The first, well established, group yielded an age range from the Frasnian to the early Nehdenian. The second group show an age somewhere within the Lower Carboniferous (possibly with reworked Wocklumian components). There, at least, exists an evidence-gap for the time between middle/late Nehdenian and Dasbergian. Hence, a concordant sedimentary succession cannot be assumed (at this time).

The third additional information about the Giessen-Harz nappe deals with its spatial distribution and the thickness of the greywacke units.

R_j "Near Giessen, the graywackes occur as a thin tectonic klippe with a maximum thickness of 200m only."

Maybe even less than 200m thickness is possible, since no proper control on the extent of folding and internal thrusting exists (or is published at least).

R_k *"drillings in the southern Harz Mts. have encountered approx. 2000 m of Devonian greywackes (Schust et al. 1991)."*

Again, this is only a maximum estimate, since no satisfying data about the extent of folding and internal thrusting have been published.

sR_l *"the grade of metamorphism in the southern part of the Rhenish Massif (Hunsrück – Taunus) requires an overburden of 5-12 km (Oncken 1988), part of which is probably provided by the Giessen-Harz Nappe."*

"The anchimetamorphic to greenschist facies metamorphism [...] during the peak of kinematic motion indicate - obviously triggered by tectonic stacking - a synkinematic overburden of the schuppen-structure of ca. 12 - 22 km [...]. It is thinkable that a connection exists with the transport of a nappe system, to which the 'Giessen greywacke' belongs, to the north (comp. ENGEL et al. 1983a)." (ONCKEN 1989: 149).

ONCKEN requires an overburden of 5 - 12 km or 12 - 22 km - and it is possible (maybe even probable) that part of which is provided by the Giessen nappe and maybe even by a proposed Giessen-Harz- nappe - or something else which has been eroded meanwhile.

$infC_5$ *Devonian greywackes of the Giessen-Harz Nappe yield a thickness of up to 2000m. By accepting this information and the fact that near Giessen the greywacke is eroded down to approx. 200m, one can conclude that several tens of kilometres south of Giessen (in the Hunsrück-Taunus area) the required (now eroded) overburden in order to explain the grade of metamorphism there, may have been provided by parts of the Giessen-Harz Nappe. In this way we can extend the spatial distribution of the nappe farther to the south.*

Bearing in mind the discussions in the foregoing paragraphs this conclusion summarises only maximum estimates for thickness and spatial distribution for distinct areas. Much more detailed work is necessary in order to satisfyingly assert the conclusion.

The fourth additional information about the proposed Giessen - Harz nappe deals with the correlation between this nappe and an "almost identical" unit in S England.

R_m, R_n *"an almost identical sequence of lithologies exists in S Cornwall." and "the composition of the graywackes in both areas is more or less identical."*

$infC_6$ *A whole sequence and also an important component of this sequence in S Cornwall is "more or less identical" to the lithologies encountered in the Giessen-Harz Nappe.* ($infR_o = infC_6$)

The provenance, geochemistry and depositional environment of Rhenohercynian synorogenic greywackes from the Giessen nappe and the Gramscatho group had been intensively studied by FLOYD et al. (1990 and 1991). If the statements in these publications are regarded to be true, then the above told argumentation is also verified.

R_p *"they [the English sequences] also contain a unit with peridotites, gabbros and sheeted dikes of Devonian age (Lizard complex, see Floyd et al. 1990 for a review).*

Indeed, they do (see also DUNNING 1992: 541 ff) and they are convincingly proposed to represent parts of a former ophiolite complex. But this complex and the Devonian greywackes are separated by thrust sheets. The connection of this unit to a uniform Gramscatho group remains a possible or even probable, but not inescapable hypothesis.

C_7 *Hence, "the English sequences complement the German record"; i. e. peridotites, gabbros and sheeted dikes could be expected also within the Giessen-Harz Nappe (but are nowadays eroded or not yet detected).*

At least, if we assume the proposals in paragraphs R_m - R_p to be true, this conclusion is sanctioned, but remains speculative. Further research is needed on this topic.

C 2.2.5 Step V: Synopsis of convincing arguments

1) The Giessen nappe exists.
2) So far, only thrust, but no nappe structures have been detected in the Kellerwald Mts.
3) The occurrence of nappe structures in the Werra Mts. is possible.
4) The East Harz nappe exists.
5) The connection of the above mentioned nappes to a uniform Giessen - Harz nappe structure is not sufficiently proven and represents a hypothesis.
6) Small occurrences of metabasalts with REE patterns indicative for MOR basalts have been encountered in the Giessen nappe. They are significantly different from metabasalts with REE patterns indicating an intra-plate setting. No direct dating on these geochemically analysed metabasalts had been undertaken; all fossil evidence was collected from slates or flinty slates at proposed "similar" tectonostratigraphic settings. Due to these correlations the MOR basalts could be of middle to upper Eifelian age or older.
7) Two distinct groups of stratigraphic correlation for the greywackes have been revealed. The first, well established, group yielded an age range from the Frasnian to the early Nehdenian. The second group show an age somewhere within the Lower Carboniferous (possibly with reworked Wocklumian components). There, at least, exists an evidence-gap for the time between middle/late Nehdenian and Dasbergian. Hence, a concordant sedimentary succession cannot be assumed at this time.
8) The greywackes of the Gramscatho group in Cornwall are petrographically, geochemically and in respect to their tectonic setting similar to the Upper Devonian greywackes from the German Rhenohercynian.

C 2.3 Example II: Comparison of two texts from TAIT et al. (1997) and MEISSNER et al. (1994), dealing with palaeogeographic reconstructions for the position of continents during the Palaeozoic

Both texts were published in the Geologische Rundschau and deal with similar topics. They are far too long in order to apply the method of argument analysis in a reasonable time in full. But I propose a quick technique for a short but thorough evaluation:

1) mark all words/phrases/passages which indicate suppositional reasoning;
2) observe how much and what sort of "true" evidence is left (if at all), i. e. how much non-suppositional reasoning is presented;
3) detect and summarise the - as being doubtlessly "true" presented - reasons and conclusions;
4) evaluate these "true" reasons and conclusions;
5) integrate the presented suppositional reasoning (point 1) into your discussion.

The rationale for this approach is: when we are able to distinguish between the suppositional and the properly established part of the argumentation we will quickly be enabled to extract the "true" reasons, hence, we will be able to detect and discuss properly established conclusions rather than hypothetical suggestive conclusions.

The points 2 to 4 cover the general method of argument analysis as described before (see example I). The successful solution for point 5 relies on the skills and background knowledge of the analyser. But the expected results for both texts are of no importance in this part of the study (some details are presented in chapter 7), therefore, I will describe in more detail only point 1 for both texts.

C 2.3.1 Example IIa: TAIT, J. A., BACHTADSE, V., FRANKE, W., SOFFEL, H. C. (1997): Geodynamic evolution of the European Variscan fold belt: palaeomagnetic and geological constraints

The following words/ phrases, which indicate suppositional reasoning, were extracted from the text:

a degree of; are believed; assumed; becomes apparent; considerably; have been interpreted; implied; in good agreement; in most; indicated; is not considered; is possible; is thought; it has been argued; many geologists; might reflect; more likely / unlikely; must have been; one possible interpretation; positive support; possibly; preferred; probably; related to; reliable / unreliable; similar; suggested; the more conservative, and preferred (in contrast to "more complex"); would be expected.

The text contains 94 such suggestive phrases or words within ca. 790 lines (85 mm broad), which allows us to deduce that -statistically - **every 8th line such a suggestive reason or conclusion was employed**.

In addition, 26 times the use of words and phrases indicative for "strong" support without presenting further evidence was detected:

certainly; clearly / clear; enormous; essentially; fairly; leaves no doubt; little evidence; strong support; too narrow.

Although more complex in their presentation, the following failing conclusions are attributed to the latter group, therefore represent some sort of suppositional reasoning:

"Palaeomagnetic data [...] are *in agreement* with this scenario and *demonstrate* ..." (p.588). For the sake of the argument we accept the reason that "data [...] are *in agreement* with this scenario", but the data may be well *in agreement* with other (not mentioned) scenarios, therefore cannot "*demonstrate*" the truth of the scenario itself.

"It *has* since *been shown*, however, that these data are the result of remagnetisation and incomplete separation of palaeomagnetic vectors, *as suggested by* ..." (p. 589). If something *has been shown*, then *evidence* (e. g. new sampling at the original locality and new measurements) in support of the conclusion must have been put forward, not *suggestions*. From the larger context, however, we may infer that the new evidence had been presented elsewhere by TAIT and her collegues in the course of their own investigations in the Bohemian massif, but this is not an inescapable assumption.

"... and only two pole positions [...] *are believed to represent* primary magnetisations. The resulting palaeolatitudes [...] *indicate* ..." (p. 593). Again, the authors are not sure about the nature of data obtained, they "*are believed to represent*" something. Only if, for the sake of the argument, they state the primary supposition as true, then it *indicates* something; if it is false, something else - or nothing is *indicated*.

C 2.3.2 Example IIb: MEISSNER, R., SADOWIAK, P., THOMAS, S. A., BABEL working group (1994): East Avalonia, the third partner in the Caledonian collisions: evidence from deep seismic reflection data

The following words/ phrases, which indicate suppositional reasoning, were extracted from the text:

alternatively, or in addition; apparent; appears; considered; has been attributed; indicated; it has been, and will be, considered in all our ...; look roughly; may belong; may even have; may have; may have arrived; may represent; might show; most geologists; most workers agree; much debated; much more often; must have aquired; must have occurred; must represent; possibly; probably; related to; reminds the observer; seems to be; similar; sometimes only; strongly; suggested; suspected; uncertain, but rather large; unusually; we ... attribute; we have tentatively attributed; which may be.

The text contains 79 such suggestive phrases or words within ca. 510 lines (85 mm broad), which allows us to deduce that -statistically - **every 7th line such a suggestive reason or conclusion was employed**.

In addition, 14 times the use of words and phrases indicative for "strong" support without presenting further evidence was detected:

certainly; clear; dramatic; famous; fundamental; mild; poor / poorly; sporadically; typical.

C 2.3.3 Results of the text-analyses

From this analysis it is *obvious* that both texts deal with highly speculative topics. Therefore, we are not allowed to use the presented results without a high grade of *precaution*.

Another important aspect is that of the personal, subjective, impression one gets by reading a text. So far no "objective" tools exist in order to make judgements about when a text is a) nearly not (lowly), b) medium, or c) highly speculative. One such a tool could be the criterion "every 1st (or: 2nd, 3rd, ...) line a speculative word or phrase is presented", e. g.:

Tab. C 2.2: Possible criteria for the judgement on scientific texts.

Criterion	Judgement	Reliability of presented results
"every 1.-10. line a speculation"	highly speculative text	strong precaution!
"every 11.-20. line a speculation"	medium speculative text	in many parts reliable
"more than every 20. line a speculation"	lowly speculative text	almost reliable.

These criteria are dependent on letter width and height, line length and also the analysed language (compare e. g. relatively short english and quite long finnish words) and are - therefore - only reliable within certain limits.

At last a very important aspect has to be noted: a medium or highly speculative text is not automatically a bad or unscientific text - at least not if judged solely on its "speculative" nature. It is essential for the progress in geosciences that such hypothetical but thriving, vivid, encouraging texts will be continuously presented. But also it is important that every reader without too much effort is enabled to recognize its nature.

C 3

Annotated register of former (1918-1997) biostratigraphic results from the analysed region

Numerous biostratigraphic data are available from the middle Lahn-syncline, especially from the area of the "Gaudernbacher Schichten (G. layers)". But the quality of these data sets is highly variable. It depends on:

- the state of preservation of the fossils found,
- the number of described individual species,
- their diagnostic relevance for exact time correlation,
- the ability of the then working scientist to properly identify the fossils found,
- the often highly insufficient description of the sample location and lithology,
- new interpretations of old observations or ideas,
- the methods applied for the collection of data (e.g. random or layer-related collection),
- ignorance of succeeding scientists (missing will to initially accept "old" observations or determinations),
- a.s.o.

Therefore it is necessary to find monomethodic means of presenting all these data in a single scheme which will allow for a reproducible correlation of these different data sets (see appendix F 1 for all detailed results).

THE APPLIED SCHEME: can be used in a data-processing programme and is structured in the following way:

Sample:
New labelling by VOGT (original labelling by the author of the quoted publication).
Quotation:
Author (year), page & position on page.
Gauss-Kruger-coordinates:
Original coordinates (Eastings and Northings) by the author of the quoted publication [in brackets if derived by VOGT].
Location:
Original description by the author of the quoted publication.
Lithology:
Original description by the author of the quoted publication.
The term "calcareous nodules" (Kalkknollen, Kalkknoten) is used for originally thin (turbiditic) layers of calcareous debris which separated into nodules during diagenesis and compaction.
Stratigraphic correlation:
Original correlation by the author of the quoted publication.

Fossils:

Kind, preservation, determination by the author of the quoted publication or other mentioned scientists.

Original description by the author of the quoted publication: *Genus species* AUTHOR YEAR

[known lifetime of the species; from (base of) zone A — to (top of) zone B.
The term "— **in** zone B" is used, where the known lifetime of the species terminates **within** zone B]

Since old listings are often incomplete and/or revisions for the species had been undertaken meanwhile, they are updated as far as possible. This additional information is regarded as a *proposal* for the reader in order to get extra data about the stratigraphic range of the species on a general level; this does *not* replace a thorough inspection by a specialist:

[*additional informaton by* VOGT *is always presented in angular brackets*]

If known, collection, number and site of the original fossils are attached. SMF = Senckenberg Museum Frankfurt. All other fossils are expected to be found (if not lost during the last world war) in Berlin (former collection of the Preussische Geologische Landesanstalt, now deposited at the Humboldt University in Berlin), Wiesbaden (Geologisches Landesamt), Giessen (Institut für Lithosphärenforschung), Frankfurt (SMF) or Marburg (Institut für Geologie und Paläontologie).

Mostly original names attributed by former authors are listed. Where possible, useful updates by VOGT are attached. Remember: it is not the aim of this study to undertake palaeontological revisions for the different mentioned fossil groups (brachiopods, ammonoids, etc.). This is work for specialised palaeontologists. Therefore, if a non-specialist is generally not enabled to make proper determinations for the fossils mentioned by former authors, it is *of no use* to find out:

a) what fate the then collected fossil samples had suffered or

b) where they are found nowadays or

c) have a look on these fossils *just for the sake of having done it*.

In this case, the only goal can be to find out if and how we can use and update the *presented* data - in order to be enabled to make statements about the time-span covered by the fossil assemblage described by the respective authors. In doing so, we take the fossil determination by the author to be "true" (in using the method of argument analysis described in chapter C 2) unless striking contradictions occur.

Nevertheless, additional problems occur: old fossil lists are often incomplete in that only genus and species names are presented but not the author of or the publication with the first description. But without this information one cannot - or only with very time-consuming additional research - find the original work in which a species was first described and therefore will not get the neccessary information about the proposed stratigraphic range of a species.

For several of the mentioned species numerous revisions have been carried out meanwhile. Due to an increasing knowledge about a species and its stratigraphic range several new choices for revised interpretations have to be taken into account. As far as possible I added this additional information for the species on old fossil lists, but CLEARLY marked (angular brackets) my additions and any other changes. Therefore, these changes have to be regarded as PROPOSAL (= additional help) for specialised scientists who are interested in further research on the actual species.

Remarks (always by VOGT if not otherwise stated):

Revised stratigraphic correlation. Always related to conodont-stratigraphy for standardisation where possible. For the Devonian system also the coordinates in the Devonian correlation chart (DK) for 1996 (WEDIGGE 1996) of the German Subcommission on Devonian Stratigraphy are used (e.g. DK1996: di 6.3 — 7.0). For the Carboniferous system no equivalent correlation chart to the Devonian one existed. In order to maintain a monomethodic correlation a new correlation chart for the Lower Carboniferous (LCC 2003; chapt. C 1) was compiled. This new correlation chart is standardised on conodont stratigraphy mainly presented by CLAUSEN, LEUTERITZ & ZIEGLER 1989 (e.g. LCC 2003: ci 6.3 — 7.0).

The numeric coordinates (down to a fraction of 1 mm) are decided in the following ways:

a) The known stratigraphic range for each species is listed. Based on these data the smallest time span common to all determinable species from a sample site is deduced. This new time span covers the highly probable max. time of deposition for the sediments at the sample location; it is not known whether the whole time range or only a fraction somewhere within represents the depositional time.

b) If the known stratigraphic range of a species starts with the beginning of zone A (e.g. *inversus*, DK 1996: di 14.3) and terminates with the end of zone B (e.g. *serotinus*, DK1996: di 18.8), then the easily readable coordinates are transferred into the sample description list (e.g. DK1996: di 14.3 — 18.8).

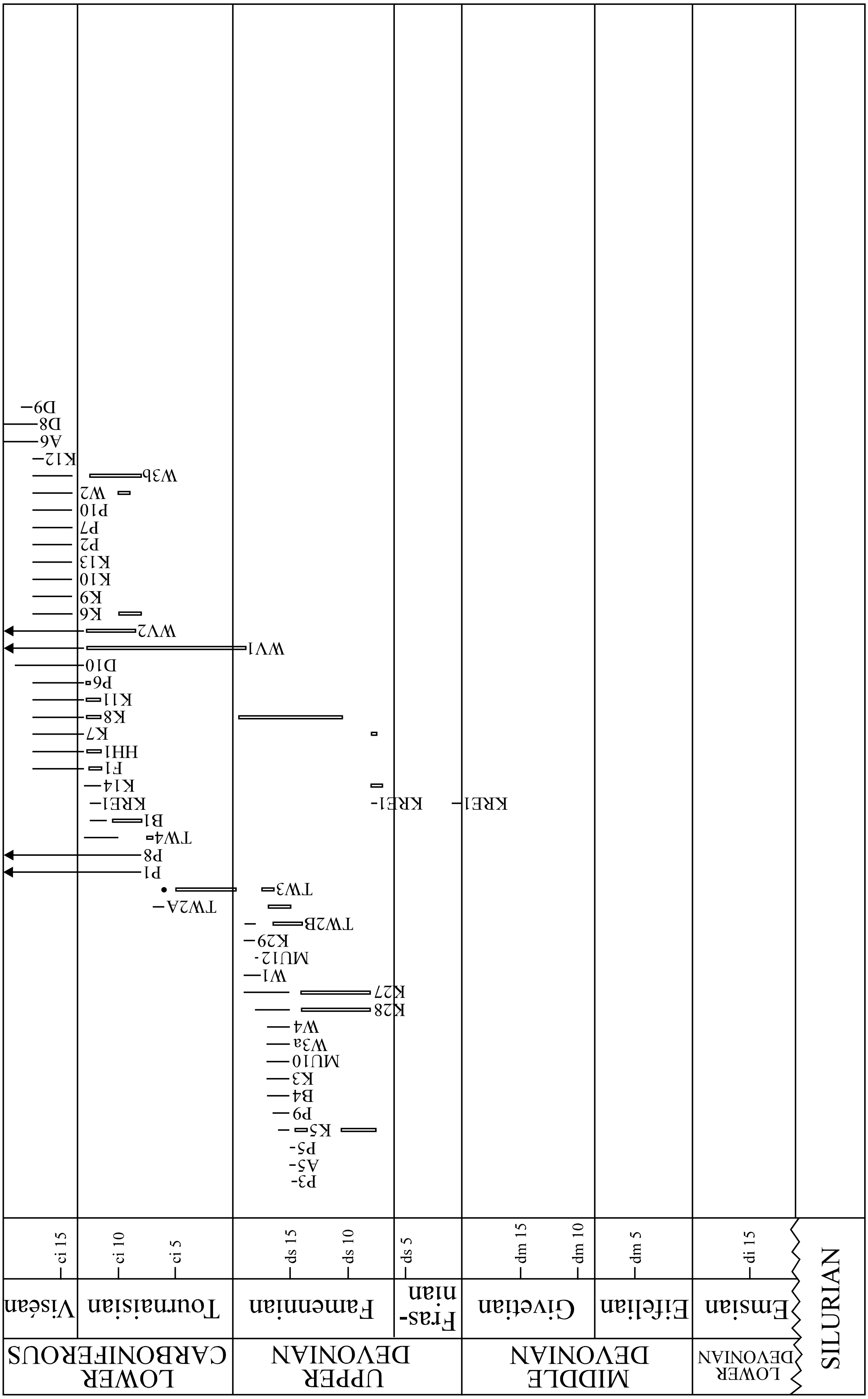
c) It is more difficult to deduce the coordinates for the stratigraphic ranges of species which start and/or terminate somewhere within a zone. In a first step the maximum recorded stratigraphic range is determined from literature data. A possible result is as follows: *"Icriodus" cornutus* SANNEMANN 1955 [in middle *triangularis* — latest *crepida*]. The middle *triangularis* zone ranges from ca. ds 6.8 — 7.5, therefore covers ca. 7 mm. Due to KÖNIGSHOF & PIECHA (1991) the species has its onset ca. in the middle of the zone (= factor 0.5). Hence, 7 mm are multiplied by 0.5 which results in 3.5 (rounded 4) mm. The onset of *"I." cornutus* therefore has the following coordinate: DK1996: ds 6.8 + 0.4 = ds 7.2. I'm aware this purely mathematical approach produces some problems. They especially arise from the different interpretations of different authors what "in the middle" or "near the top" of a single zone really means. But by accepting the presented statements of the stratigraphers as "true" and using them for a pure mathematical subdivision, the whole procedure becomes reproducible, therefore transparent, prepared for later correction and hence: scientific.

Presumable sedimentary environment:

<u>Short</u> interpretation by VOGT, based on original lithologic description and new inspection/revision - if not otherwise stated.

NEXT TWO PAGES:

Fig. C 3.1: Synopsis of the revised stratigraphic results from the analysed region (for detailed data see appendix F 1). Solid bars or points: least spans of possible lifetime ranges covered by the faunal and/or floral evidence for each sample. Open bars: least spans of possible lifetime ranges for reworked species ("ghost fauna/flora").


SILURIAN
LOWER DEVONIAN
MIDDLE DEVONIAN
UPPER DEVONIAN
LOWER CARBONIFEROUS
Emsian
Eifelian
Givetian
Fras-nian
Famennian
Tournaisian
Viséan
di 15
dm 5
dm 10
dm 15
ds 5
ds 10
ds 15
ci 5
ci 10
ci 15
P3
A5
P5
K5
P9
B4
K3
MU10
W3a
W4
K28
K27
W1
MU12
K29
TW2B
TW3
TW2A
P1
P8
TW4
B1
KRE1
K14
F1
HH1
K7
K8
K11
P6
D10
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P10
W2
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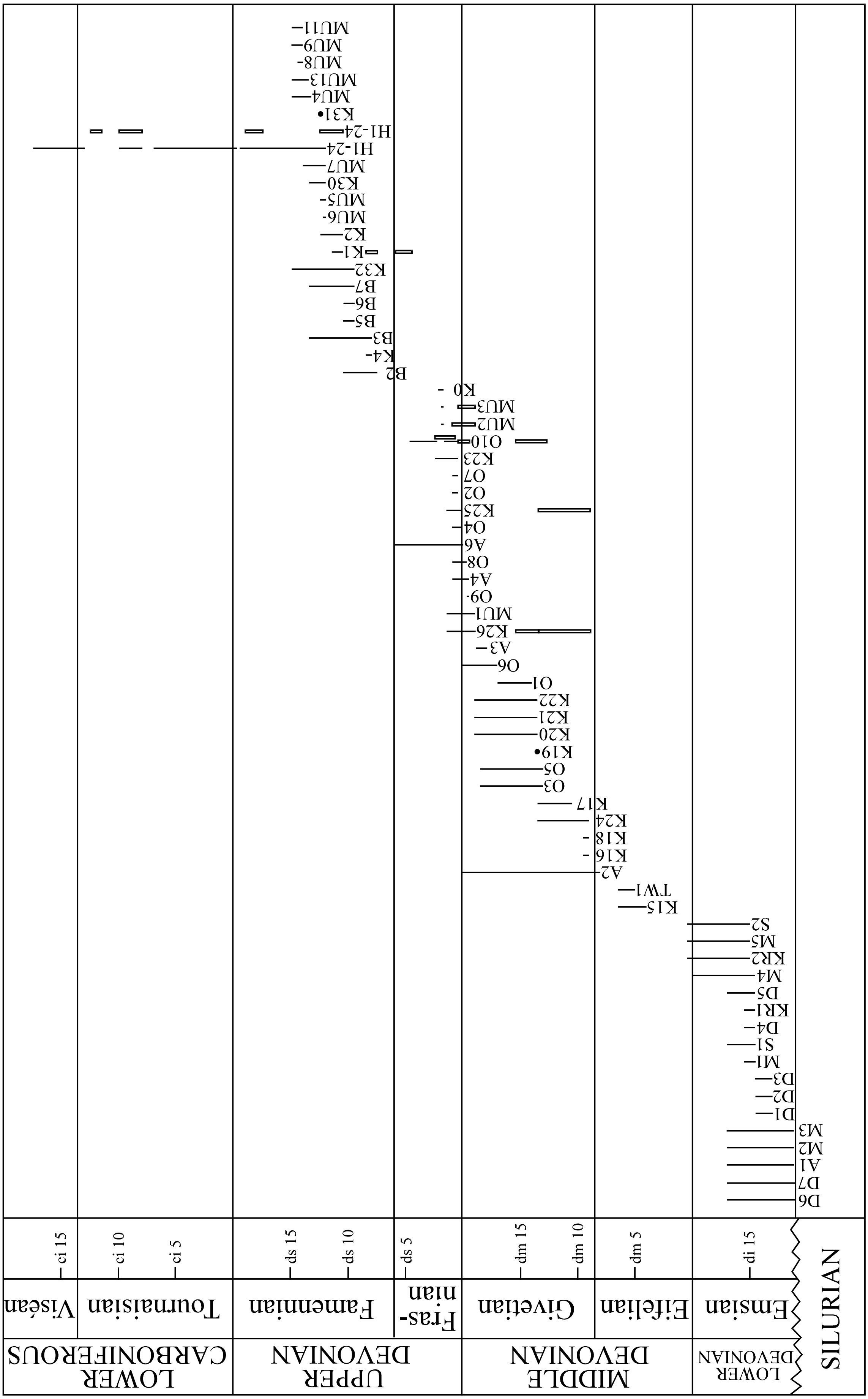
K12
A6
D8
D9


LOWER CARBONIFEROUS
UPPER DEVONIAN
MIDDLE DEVONIAN
LOWER DEVONIAN
SILURIAN
Viséan
Tournaisian
Famennian
Fras-nian
Givetian
Eifelian
Emsian
ci 15
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C 4

Factors influencing the fate of palaeozoic palynomorphs (spores, acritarchs etc.)

Acritarchs, pollen and spores are organic fossils that are regularly recorded in great abundance over long stratigraphical intervals in the palaeozoic. Optical analysis for colour, transparency and reflectance of these fossils may be used in palaeotemperature analysis. Other regularly recorded, but less abundant organic fossils include graptolites, chitinozoans, scolecodonts. Conodonts and other phosphatic fossils contain traces of organic material within the inorganic phosphate. Bacteria, algae, fungi, protists, chitinous foraminifera and chitinic material from arthropods can be used to obtain supplementary data (DORNING 1986).

Acritarchs build a main constituent of the marine microflora. The majority of acritarchs is believed to be algal cysts of the Pyrrhophyta or Chlorophyta. Unaltered acritarchs are colourless to pale yellow. Alteration and colour change due to increased temperature takes place through increasingly dark browns to grey or black (DORNING 1986).

Spores are produced by terrestrial plants (e.g. pteridophytes). From the Late Ordovician to Recent in non-marine and nearshore environments spores and plant fragments are regularly recorded. Unaltered land plant material is often pale yellow to brown. Alteration due to increased temperature takes place through dark browns to black (DORNING 1986).

When organic material is deposited in sediments, in addition to microbial and chemical degradation, there exist three main physicochemical factors that cause alteration (BROOKS 1971):

temperature, time, pressure.

If no oxidation is employed during processing (which could lighten the colour of organic material) optical analysis to deduce palaeotemperatures from the organic material can be undertaken with standard palynological processing. But the obtained data have to be handled "cum grano salis" since marine organic fossils (e.g. acritarchs) often show more consistent results than material from land plants (e.g. spores). This is mostly due to exposure of terrestrial material to variable oxidation and bacterial degradation prior to final deposition. The effect is most striking in samples with unaltered to moderately altered organic material, whereas high thermal alteration material is little affected by weathering (DORNING 1986).

The original concentration of spores and pollen in a sediment may be influenced by:
flotation, sorting, mixing, resettling and aquatic and aerial reworking, bioturbation, grain size and material of host sediment (esp. behaviour during diagenesis), pore water chemistry, fresh/seawater supply, climatic conditions etc. The resulting alterations lead to qualitative and quantitative change in the analysis of the recoverable spores and pollen from a sediment (TRAVERSE 1988).

Modern and fossil spore walls of gymnosperms, angiosperm, pteridosperms, fungi and algae are in majority composed of sporopollenin. Chemical analysis of organic material from sediments up to 3.4 to 3.7 billion years old show strong affinities to sporopollenin of recent spore exines (BROOKS 1971).

For palaeontological and biostratigraphical investigation it is important to understand what sort of organic material is to become fossilised and inasmuch alteration effects have to be evaluated. Therefore the general architecture of spores has to be outlined. They consist of an inner hemisphaere which carries the cytoplasma with genetic material in the plant to be propagated, and of a cover of wall material. This is split up in two parts: the inner wall -intine- the majority of which is cellulose whilst the outer wall - exine - is mainly sporopollenin. Size and structure of spores from different plants - even from the same species - and also the proportion of sporopollenin (exine) compared to the amount of cellulose (intine) in the spore wall show significant ability of variation. The most interesting differences and consequences are (BROOKS 1971):

a) The wall content of selective pollen and spores vary from ca. 32 % to ca. < 2 %.
b) There exist different relationships between sporopollenin (exine) and cellulose (intine) content of spore/pollen walls from different plant species. It ranges from ca. 27 % sporopollenin and 3 % cellulose (ratio ca. 9.3) to ca. 4 % sporopollenin and 7 % cellulose (ratio ca. 0.6). It is believed high ratios of sporopollenin to cellulose (e.g. selaginellales, *Lycopodium*) are characteristic for early types of plants in the terrestrial evolutionary sequence - with an evolutionary trend to low ratios and relatively higher cellulose (intine) content (e.g. angiosperms).
c) Some spores and pollen loose their original shape under increased temperature condition whilst others retain their shape more or less. One explanation is this is due to varying thick-/thinness of the (original shaped) exine. But close examination shows single spore and pollen species with small amounts of sporopollenin in their wall retain their morphology, whilst other species containing larger amounts of sporopollenin become amorphous.
d) Considering the wide range of fossil and recent plant species, sporopollenin shows only minor variations in stoichimetry (of the molecular species: molecular formula ca. $C_{90}H_{82-158}O_{11-44}$) and architectural variation of the exines.

When a spore fails to reach its intended destination it soon perishes, leaving only the extraordinarily resistant outer wall of the exine, consisting of sporopollenin, as the only remnant in the sediment. However, this is only true if there were no oxidizing conditions at time and site of deposition (BROOKS 1971). And the outer morphology of the spore/pollen is only retained if the wall thickness and/or structure is significant enough to uphold the whole structure; otherwise the spore/pollen will become amorphous. But even if the original morphology and size is retained after first chemical and microbiological attack, temperature and pressure increase due to further sediment accumulation and basin development will implement additional constraints on the so far surviving plant material. These may lead to distortion and/or progressive shrinking of some spore/pollen species (ROBERT 1988). It will at any rate lead to metamorphic changes in the organic material which causes alteration of optical properties (opacification, reflectance).

Reconstruction of the fate of the organic material will become more complicated, if ascending hydrothermal fluids occur in the spore/pollen host rock. If the pores of the sediment are still open, the fluids will inevitably destroy the organic material. A chance to survive is only given if pores had become closed by diagenetic processes or where pore flow is minor (e.g. in mudstones). In this case ascending hydrothermal fluids can only invade the sediment laterally along intrusion zones of joints and faults. Considering this, hydrothermal fluids may in single samples bring about differently altered spores and pollen (similar effects had been reported by BENDER & KÖNIGSHOF (1994) for conodont alteration). A good indicator for hydrothermal impregnation are pyrite spore-pseudomorphs, where pyrite grew as thin layer/plate within the flattened spore cavity and/or cingulum. Later (or contemporaneously?), when the organic cover became destroyed, only the sheet-like, round-shaped, sometimes cingulum-bearing, pyrite pseudomorph was left.

C 4.1 Classification of different stages of alteration

Devonian to Lower Carboniferous spores and acritarchs from most lithologies of the area covered by the former "Gaudernbach layers" show uniform state of preservation: spores are rare, acritarchs as well. Most organic matter show clear evidence of pre- or syn- or postdepositional biodegradation. Therefore statistical population-analysis of species and their distribution through time and space is impossible. In order to gain at least some information of pre- or syndepositional conditions a systematic classification procedure for the organic and inorganic material of the processed samples was employed. Since a quantitative analysis would have neither been sufficient nor effectively employable, a qualitative evaluation scheme with four classes was used:

class 1:	++	good; very frequent
class 2:	+	medium; frequent
class 3:	o	slightly insufficient; rare
class 4:	?	occurrence questionable.

Phytoclasts (miospores, megaspores, wood, cuticular fragments, etc.) and heavy minerals (e. g. pyrite) have been evaluated for palynofacies determination and special attention has been focussed on the state of preservation.

For each analysed sample the following parameters were determined:

Tab. C 4.1: Parameters determined during analysis of palynofacies and state of preservation.

Lithology	F = flinty slate; P = pelite; PF = pelite - flinty slate succession; PU = silty pelite; UP = pelitic silt; PT = tuff-bearing pelite; PS = pelite - sand succession; PG = pelite - greywacke succession
Kerogen flakes	Amount after HF-treatment. The more kerogen flakes the more organic material was present in the sample
calcareous	Calcareous sample? *Calcite* growth normally destroys palynomorphs
EC	Metamorphically altered *even cut* , but not oxidised, phytoclasts
PO	*Partly oxidised* metamorphically altered phytoclasts
PO+PY	*Partly oxidised* and *pyritised* metamorphically altered phytoclasts
AC	*Acritarchs* and prasinophycean algae
SP	*Spores*
CH	*Chitinozoans*
RA	*Radiolarians* in pyrite and/or organic preservation
SC	*Scolecodonts*
PO	*Partly oxidised* metamorphically altered palynomorphs
PO+PY	*Partly oxidised* and *pyritised* metamorphically altered palynomorphs
PY	Completely *pyritised* metamorphically altered palynomorphs
PS	Pyrite spore-*pseudomorphs*, where pyrite grew as thin layer within the flattened spore cavity and or cingulum. Later (or contemporaneously?), when the organic cover became destroyed, only the sheet-like, round-shaped, sometimes cingulum-bearing pyrite pseudomorph was left.
reworked	Are reworked palynomorphs present in the sample?
Heavy minerals	Zircone, rutile, turmaline, etc - apart from pyrite
euhedral	Euhedral (octahedral or cubic) single, sometimes simply twinned, pyrite crystals
complex aggregates	Complex, non-framboidal, aggregates/clusters of pyrite crystals
single framboid	Single "spheres" of framboidal pyrite
2-cluster	Chain of 2 "spheres" of framboidal pyrite
3-cluster	Chain of 3 "spheres" of framboidal pyrite
4-cluster	Chain of 4 "spheres" of framboidal pyrite
cluster of > 4	Chain of > 4 "spheres" of framboidal pyrite
TAI	Observed *thermal alteration index*. Due to postdepositional oxidation (weathering, ascending hydrothermal fluids) sometimes erraneous tendencies towards lower TAI-values were observed.
Stratigr. correlation achieved	Was there any sufficient stratigraphic correlation achievable and of what quality is it?

NEXT FOUR PAGES:

Tab. C 4.2: Synopsis of obtained results during analysis of palynofacies and state of preservation from HF-processed samples.

Sample		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	18	19	20	21	22	23	24	25	26	32	38	46	47	48
Lithology		F	PF	P	FP	P	P	PF	P	P	P	P	PU	PU	PU	P	PS	P	PF	PF	P	P	PU	PS	PT	PU	PU	P	P	P
Weight [g]		44	53	65	55	38	62	45	55	94	80	181	78	115	113	82	66	55	76	62	63	106	99	77	76	47	32	36	54	50
Kerogen flakes		o	+	++	o	+	+	+	++	+	++	++	++	+	+	+	+	+	o	++	++	+	++	++	++	++	+	+	++	+
calcareous																						+			o	o				
Phyto-clasts	**EC**	o	+	+	o	o		+	+	++	+	+	+				+			o		+		+		o	o		+	
	PO		+	+	o	+	+	+	+	+	++	++	+	+			++	o	+	+	o	+	o	+	o	o	++	o	o	+
	PO+PY	o					+				+	+		o					o	+	o	+	o				o	+		
Palyno-morphs	**AC**	+	+	+	+		+	+	+	+	++	+					o			o		o		o		?	+	o	+	
	SP		+	+	?	o	o	+	+	o	o	o		?			+	o		o		+	?	+	?		+	?	o	
	CH		o	o				o	o	o							o									?				
	RA	+			+		+															o								
	SC									o										?										
Preser-vation of palyno-morphs	**PO**		+	++	o		+	+	+	+	+	o					+			o		+		+			+		+	o
	PO+PY	o	o	+	+	o	o	o	+		+	+					+	+		+			o		o		+	o	o	+
	PY					+	+																			o	o	+		
	PS	o	o	o	o	+	o	o	o	o				?			o	o		o		o	o	+				++		+
	rewor-ked		o	o	+			o	o	o	?	?					o			?		+		+		?	?	+		
Heavy minerals				o		o	o	o	o	o			++	o	o	+	+	+		o	o	+	++		+	o	+	++	o	o
Pyrite	**euhedral**														o	o		o			o		+		+	o			o	
	complex aggre-gates						+											o					o		o	+	o	o		
Framboi-dal pyrite	**single framboid**		o			o	+	o		o	o	o					+	+			+				+	++		o	o	
	2-cluster																				o					+				
	3-cluster																				o					o				
	4-cluster									o																o				
	cluster of >4																									+				
TAI		5	3-5	4-5	5	3-4	3-4	5	4-5	5	4-5	4-5	5	5			5	5	5	4-5	5	3-4	5	3-4	5	4-5	4-5	5	4-5	5
Stratigr. correlation achieved		++	++	o	o	o	+		++	o	+	o					+			+		o		++			+		+	

Sample		49	51	57	67	69	70	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	91	92	147	159	161
Lithology		P	PT	P	P	PU	PU	P	PU	P	P	P	P	P	P	P	P	P	P	P	PF	P	P	P	P	P	P	PF	P	P
Weight [g]		51	49	87	84	42	115	39	38	36	45	77	41	44	52	69	85	96	101	72	48	47	75	75	46	55	44	78	63	53
Kerogen flakes		+	o	+	++	+	+	+	++	+	++	+	+	+	o	o	o	o	++	+	+	+	+	o	o	+	o	++	+	+
calcareous																														
Phyto-clasts	EC	++	o	o	++	+	o			+	+	o	o	+	o		o		o			o	o					+		
	PO	+	o	+	+	+	o	+	+	+	+	o	+	+	+		+	o	+	o	++	+	+	+			+	+	o	o
	PO+PY		o		o		+	o	+				o		+	o	+	o	o	o	+	o	o	+	+	o	+	o	o	+
Palyno-morphs	AC	+	+	o	+	+		o	o	+	+	+	+	o	?	o	?	?	+	+	?	+	+	o	?	?	?	o	?	?
	SP	+	o	+	+	o	o	o	o	o	o	?	o	o		+		?	o	o	?	o	+	o	?	?	?	+	?	o
	CH					o													?	?		o								
	RA																													
	SC																													
Preser-vation of palyno-morphs	PO	+	o	+	+	o			o	o	+	o	o	+					+			o	o					+		
	PO+PY		o	+	o	+	+	+	+	o	o	o	+	+	+	+	+	+	+	+	+	+	+	+	+	o	o		o	o
	PY		+		o	+	+	o	o						+	+	+			o	+	+	o	+	+	o	o		o	+
	PS	o	o	o	o	o		o		o	o	o	o	+		o		o	o	o	o	o	+	+	+			+		
	rewor-ked		+	o	?	+					+		+			?			+	+		o						+		
Heavy minerals		o	++	o	o	o	o	o	o	o											o		o	o	+	o	o		o	o
Pyrite	euhedral				o	+	+	+	o							+	o					o	o	o	+	o			+	+
	complex aggre-gates		o		+	o	+	+	o				o			+	o					o	o	o	+	+	o		+	+
Framboi-dal pyrite	single framboid			o	+	+	++	+	+							+			o		o	+	o	o	o	+	o		+	+
	2-cluster				o	o	o	o	o							+						o	o	o	o	o			o	o
	3-cluster				o	o	o									+						o		o	o	o			o	o
	4-cluster				o	o	o		o							+						o		o	o	o				
	cluster of >4				o	o	o									+						o		o	o	o				
TAI		5	5	4-5	5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5		4-5			4-5	4-5		4-5	4-5	5				3-4		
Stratigr. correlation achieved		+	o	+	+	+	+	o	+	o	++		+	o					++	+		o	+	o				++		

Sample		162	164	174	177	179	181	186	191	197	203	210	215	217	219	221	222	223	225	227	231	242	246	255	258	259	264	268	271	275
Lithology		P	P	P	P	UP	P	P	P	PU	P	PU	P	P	P	P	PU	P	PU	P	PU	P	P	P	PG	P	P	PF	P	P
Weight [g]		49	55	51	47	55	68	42	46	45	52	68	62	50	72	79	60	69	53	52	53	51	48	52	45	44	47	39	52	37
Kerogen flakes		+	+	+	+	+	+	+	+	+	+	++	++	++	++	++	++	++	++	+	o	+	+	+	++	+	++	++	++	++
calcareous													o	o					o		o	o							o	
Phyto-clasts	**EC**											+										+	+		+	+				+
	PO	o	o	+	+	+	o	+	+	o	o	o				+	o	+	o	++		o	o	o	+	+	o	+	o	+
	PO+PY	o	o	+	+	+	o	+	+	+	o	o	o	o	+	o	o	o	+	+	+	o	o	o	o		o	o	o	o
Palyno-morphs	**AC**	o	?	?	o	o		?	?	?		o				?				+	o	+	+	+	+	o	?		o	+
	SP	o	?	o	o	o				?		+				+		?	o	+	o	o		?	o	+	?	+	o	+
	CH																					+	?		o	+			o	
	RA											+											?						o	
	SC																													
Preser-vation of palyno-morphs	**PO**															+						o				+				+
	PO+PY	o	o	+	o	o						+				o				+	+	+	+	+	+	+	o	o	o	+
	PY	o	o	o	o	o						+							+	o	o	o	+	+	o		o		o	
	PS																	o		o	o	o	+	+	o	o	o	o		o
	rewor-ked	o			o	?						?				+						o	+			o			o	?
Heavy minerals		o	o	o	o	o	o	+	o	o	o	+	+	+	+	++	+	o	o	o		o	+	o	+	+	o	o		o
Pyrite	**euhedral**	+	+	+	+	+	o	+	+	+	++	+	o	o	o			o	+		++		+		+			o	o	
	complex aggre-gates	+	+	+	+	+	o	+	+	+	+	+	+	+	+			o	++				+		o				o	
Framboi-dal pyrite	**single framboid**	+	+	+	+	+	o	o	++		+	++	++	++	+				++	++	+		++	++	o	o	o		o	
	2-cluster	o	o	o	o	o			+			o	o	o	o				+	+			+							
	3-cluster	o	o	o	o	o			o			+	o	o	o				+	+			o							
	4-cluster								o			o	o	o	o				+	+			o							
	cluster of >4								o			o	o	o	o				+	+	o		o							
TAI		3-5		4-5	4-5							3-4				3-4				4-5	5		5		4-5	3-5		4-5	5	4-5
Stratigr. correlation achieved		o		o	o							++				++				+	o	o	o		o	+		o	o	++

Sample		282	283	285	292	294	295	297	SYNOPSIS OF OBTAINED RESULTS																				
Lithology		PG	PG	PT	PF	P	P	P	RSC	10 samples: ++					20 samples: +					23 samples: o					41 samples: none				
Weight [g]		49	45	36	39	45	55	47	ECA	++	+	o	?	Σ	++	+	o	?	Σ	++	+	o	?	Σ	++	+	o	?	Σ
Kerogen flakes		++	++	++	++	o	+	++		8	1	1		**10**	8	12			**20**	6	13	4		**23**	13	20	8		**41**
calcareous														**0**					**0**		1	3		**4**			5		**5**
Phyto-clasts	**EC**	o	o		o	o	o	o			7	2		**9**	2	5	9		**16**	1	6	6		**13**		2	5		**7**
	PO	+	+	o	+	+	o	+			8	1		**9**	4	13	1		**18**	1	14	7		**22**	1	10	19		**30**
	PO+PY	+	o	o		+	+	o				6		**6**		7	7		**14**		7	9		**16**		14	18		**32**
Palyno-morphs	**AC**	+	+	?	+		o	+			6	3	1	**10**	1	13	5		**19**		11	9		**20**		3	3	16	**22**
	SP	?	+	?	o			o			7	2		**9**		9	10	1	**20**		3	17	1	**21**		1	3	17	**21**
	CH	o	o					o				2	1	**3**		1	5	1	**7**		1	5	1	**7**			1	1	**2**
	RA				o						2			**2**		1			**1**		1	3	1	**5**					**0**
	SC	o	o											**0**			2	1	**3**			1		**1**					**0**
Preser-vation of palyno-morphs	**PO**	+		o							8			**8**		10	5		**15**	1	3	6		**10**		1	2		**3**
	PO+PY	+	+	o	+		+	+			4	4		**8**		16	3		**19**		13	7		**20**		9	12		**21**
	PY			+	o		o				1			**1**		3	6		**9**		5	10		**15**		10	7		**17**
	PS	o	o	o	+		+	o			2	6		**8**		1	14		**15**		5	12		**17**	1	3	10	1	**15**
	rewor-ked	o	o	+				o			5	2	2	**9**		3	6	1	**10**		2	5		**7**		1		5	**6**
Heavy minerals		+	+	++	o	++	+	o		1	1	2		**4**		5	12		**17**	1	4	12		**17**	5	9	21		**35**
Pyrite	**euhedral**		o								1			**1**		2	5		**7**	1	6	4		**11**	1	12	12		**25**
	complex aggre-gates		o	o		o					1			**1**		3	6		**9**		5	5		**10**	1	15	10		**26**
Framboi-dal pyrite	**single framboid**		+		o	++	o	o		1	1	1		**3**	2	6	6		**14**	1	6	8		**15**	7	11	8		**26**
	2-cluster		o			o						1		**1**		1	6		**7**		1	6		**7**		4	11		**15**
	3-cluster		o			o					1			**1**		1	4		**5**			6		**6**		2	13		**15**
	4-cluster		o			o						1		**1**		1	5		**6**			4		**4**		2	8		**10**
	cluster of >4		o			o						1		**1**		1	4		**5**			4		**4**		3	7		**10**
TAI		5	3-5		5	4-5	5	4-5		RSC = Rating of achieved stratigraphic correlation for all samples																			
Stratigr. correlation achieved		+	+		o		o	+		ECA = Evaluation category per sample & actual counting parameter Σ = Sum for each evaluated parameter & category																			

Apart from the valuable results for the palynofacies analysis, which are separately discussed for each sample in appendix F 2, two interesting general trends are observable:

a) The moderate occurrence of partly oxidised metamorphically altered phytoclasts is not a limiting factor for a good stratigraphic correlation itself, but the more partly oxidised *and* pyritised metamorphically altered phytoclasts are present, the less probable is a good correlation.

b) An increasing amount of pyrite-bearing samples is observable when less stratigraphic correlation is achievable; however: the occurrence of pyrite in any form is not a limiting factor for a good stratigraphic correlation itself (since pyrite is also present in some *good* samples), but only on a statistical level. The reasons for this are numerous and partly described in chapter C 10.

These results are summarised in the following diagram:

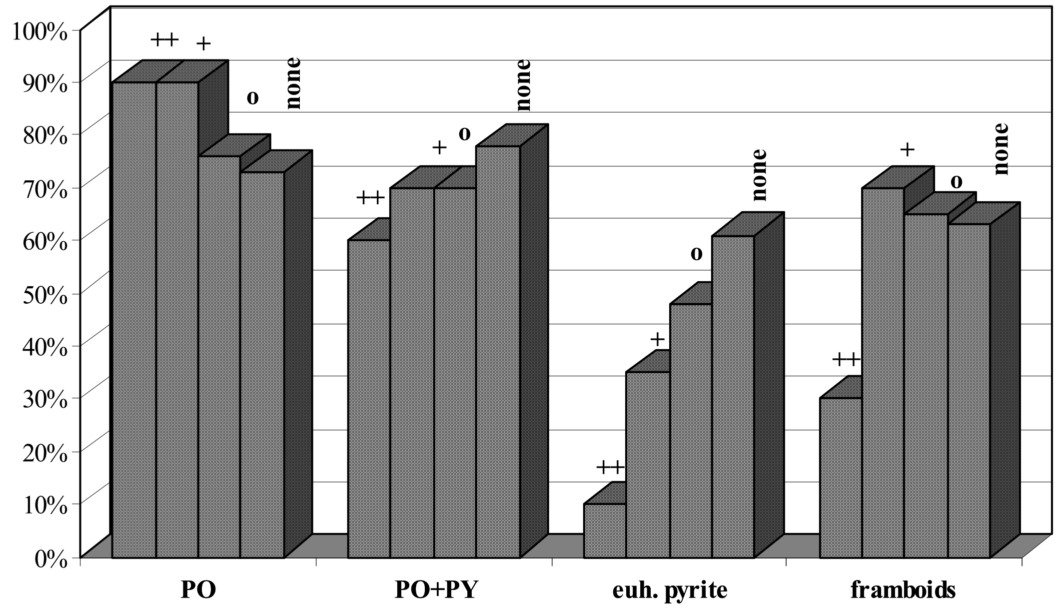


Fig. C 4.1: Comparison between pyrite content (euhedral and framboidal pyrite) and preservation of microfloras (PO = partly oxidised phytoclasts; PO+PY = partly oxidised and pyritised phytoclasts). The columns show the percentual amount of samples which bear pyrite or a special state of preservation for each counting category. The 4 counting categories consist of samples where:

++	= *good*	(100% = 10 samples),
+	= *medium*	(100% = 20 samples),
o	= *slightly insufficient*	(100% = 23 samples),
none	= no	(100% = 41 samples)

stratigraphic correlation was achieved. Note, that an increasing amount of pyrite-bearing samples is observable when less stratigraphic correlation is achievable; however: the occurrence of pyrite in any form is not a limiting factor for a good stratigraphic correlation itself (since pyrite is also present in some *good* samples) but only on a statistical level.

C 5 New biostratigraphic results

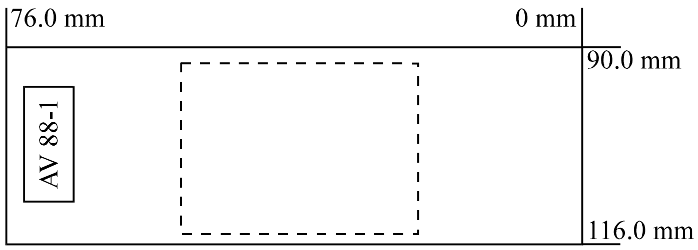
116 biostratigraphic data sets from the analysed area (mostly formerly "Gaudernbach layers"), obtained by different researchers in the last 100 years, are compiled in chapter C 3, fig. C 3.1 and appendix F 1. All important macrofossil (brachiopods, ammonoids, trilobites etc.) bearing lithologies - as well as most important limestone bearing units in the search for conodonts had been sampled by these researchers. With the achieved data a relatively complete stratigraphic correlation for lithologic units from Emsian to Viséan times seemed to be possible - apart from sparse data sets for the Eifelian and Frasnian. However, new findings of Bruchberg sandstones (e. g. WIERICH & VOGT 1997), debris flow sediments and greywacke (this study) as well as proposed Upper Devonian "fossil-free" dark slates which should represent a "special" (deep-marine) facies provoked new questions or remained as unsolved problems.
To overcome this, some new calcareous samples (search for conodonts) and also flinty slates (search for radiolarians) were collected (see tab. C 5.1).

Tab. C 5.1: Treatments with 10 - 12 % formic acid (search for conodonts) or 5 % HF (search for radiolarians). + = good, O = medium, — = no / none. C = conodonts, E = echinoderms (trochites, spines, test-remnants), F = fishes (teeth), R = radiolarians, S= sponge (spicules), T = tentaculites.

Sample	Treatment	analysed mass (g)	Solution successful ?	recovered fossils	stratigraphic correlation achieved ?
AV 1	HF	< 50	+	R, S, C	+
AV 4	HF	< 50	+	—	—
AV 26	formic acid	860	—	—	—
AV 52	HF	< 50	+	C, R	—
AV 53	HF	< 50	+	C, R	—
AV 234	formic acid	1980	O	—	—
AV 244	formic acid	630	—	—	—
AV 245	formic acid	820	—	—	—
AV 246	formic acid	1520	O	—	—
AV 247	formic acid	750	—	—	—
AV 248	formic acid	800	—	—	—
AV 254	formic acid	790	—	—	—
AV 255	formic acid	1540	O	? C	—
AV 260	formic acid	900	—	—	—
AV 262	formic acid	950	O	C, E	—
AV 263	formic acid	560	—	—	—
AV 270	formic acid	900	—	—	—
AV 271	formic acid	1850	O	? T	—
AV 278	formic acid	900	O	C, F	O
AV 280	formic acid	980	+	C, E	+
AV 285	formic acid	600	—	—	—
AV 289	formic acid	900	—	—	—
AV 290	HF	< 50	+	S, C, R, ?E	O
AV 295	formic acid	1490	O	—	—
AV 299	formic acid	890	O	E	—

As we can see in tab. C 5.1 the obtained results proved to be disappointing. Most of the interesting limestone bearing lithologic units had been sampled, e. g., by BISCHOFF & ZIEGLER (1958), WALLISER (1960), KEGLER (1967a-c), MUNK (1981) and OETKEN (1996).
At this stage, the only promising technique to be tested was the palynostratigraphy. The obtained results are presented in appendix F 2.

Most effort was employed in properly documenting the achieved results. This is, because the preservation of most recovered fossils is generally medium to low (compare chapter C 4). Determinations have been undertaken during microscopy, not from photomicrographs (It is estimated that up to 50% of the additional information gainable during T/R - microscopy (combined transmitted/reflected light microscopy) is lost on a photograph). For all fossils mentioned coordinates on the actual slides are given:



Each slide has an AV-label on it, for coordinate-reference always on the "left" side. The fossil / object coordinates on the slide are correlated to the above displayed scheme.

All mentioned fossils are fully or nearly opaque - if not otherwise stated. Due to enhanced thermal alteration chemical procedures to lighten the altered fossils (e. g. with SCHULZ's solution) had not been successful. **Species determinations have been undertaken in order to gain biostratigraphic results - not for palaeontological analyses.** In general, all fossils from the analysed area should not (or with great precaution) be used for comparing palaeontological studies. A great extent of experience in describing metamorphically altered palynological objects is necessary in order to make species determinations. However, the palynologist is often "called on to work with poorly or very poorly preserved specimens where they are the only, or among the few, fossils present. [...] Often, after a 'foothold' is attained to suggest the approximate age level, even execrable, badly preserved, corroded, and carbonised 'wreck' specimens [...] can be identified." (TRAVERSE 1988: 436).

In the following paragraphs some explaining remarks to the applied scheme (compare also introduction to chapter C 3) are given:

Stratigraphic correlation: original palynostratigraphic correlation. Related to conodont-stratigraphy for standardisation where possible. For the Devonian system also the coordinates in the Devonian correlation chart (DK) for 1996 (WEDIGGE 1996) of the German Subcommission on Devonian Stratigraphy are used (e.g. DK1996: di 6.3 — 7.0). For the Carboniferous system no equivalent correlation chart to the

Devonian one exists. In order to maintain a monomethodic correlation, a new correlation chart for the Lower Carboniferous (LCC; chapter C 1) was compiled. This new correlation chart is standardised on conodont stratigraphy mainly presented by CLAUSEN, LEUTERITZ & ZIEGLER 1989 (e.g. LCC 2003: ci 6.3 — 7.0).

The procedures for determining the numeric stratigraphic coordinates are presented in chapter 3.

Fossils: kind, preservation, determination by VOGT or other named scientists.

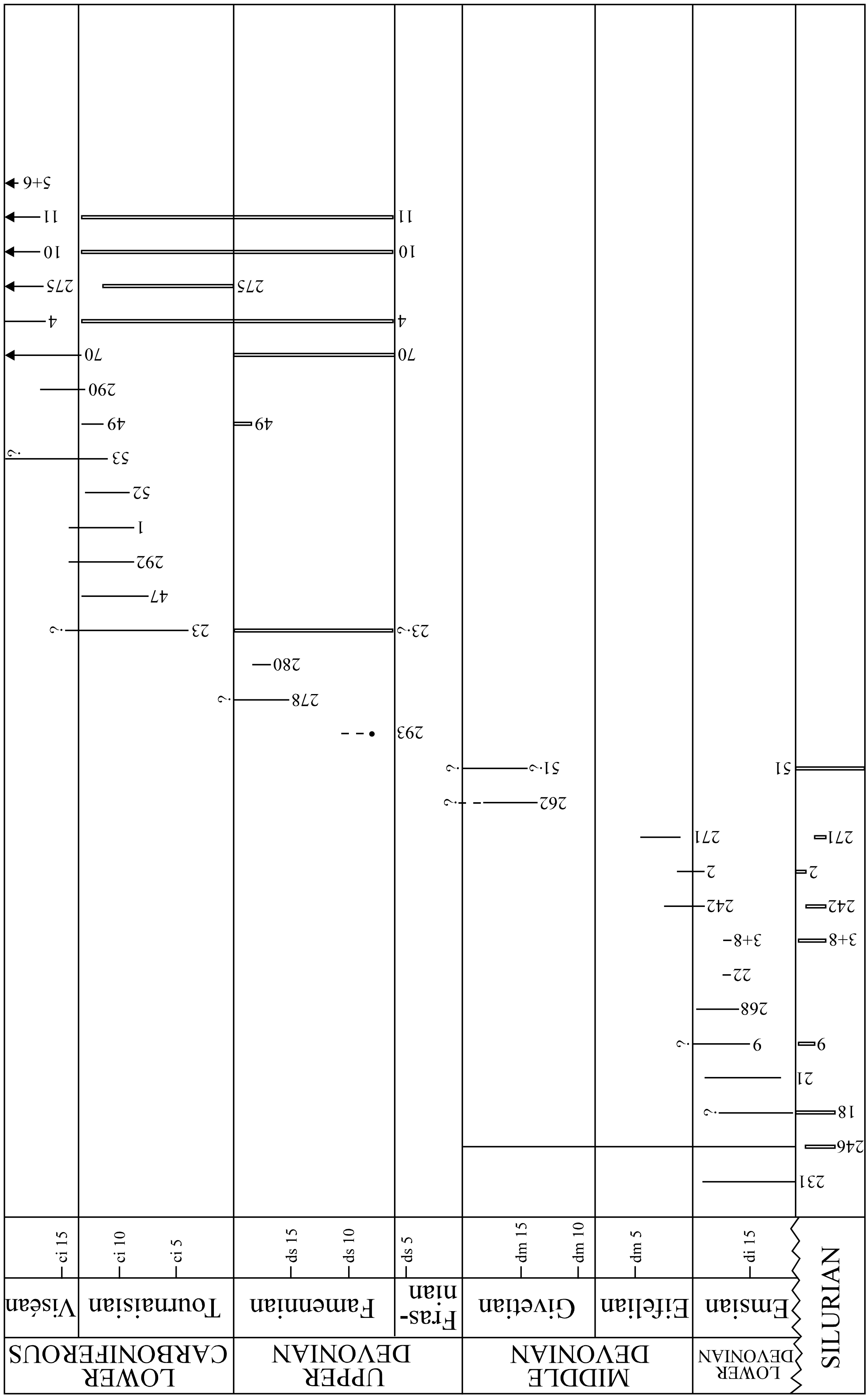
Genus (old genus) spezies (FIRST DESCRIBED BY) REVISED BY [known lifetime; from (base of) zone A — to (top of) zone B. The term "— in zone B" is used, where known lifetime of spezies terminates within zone B]

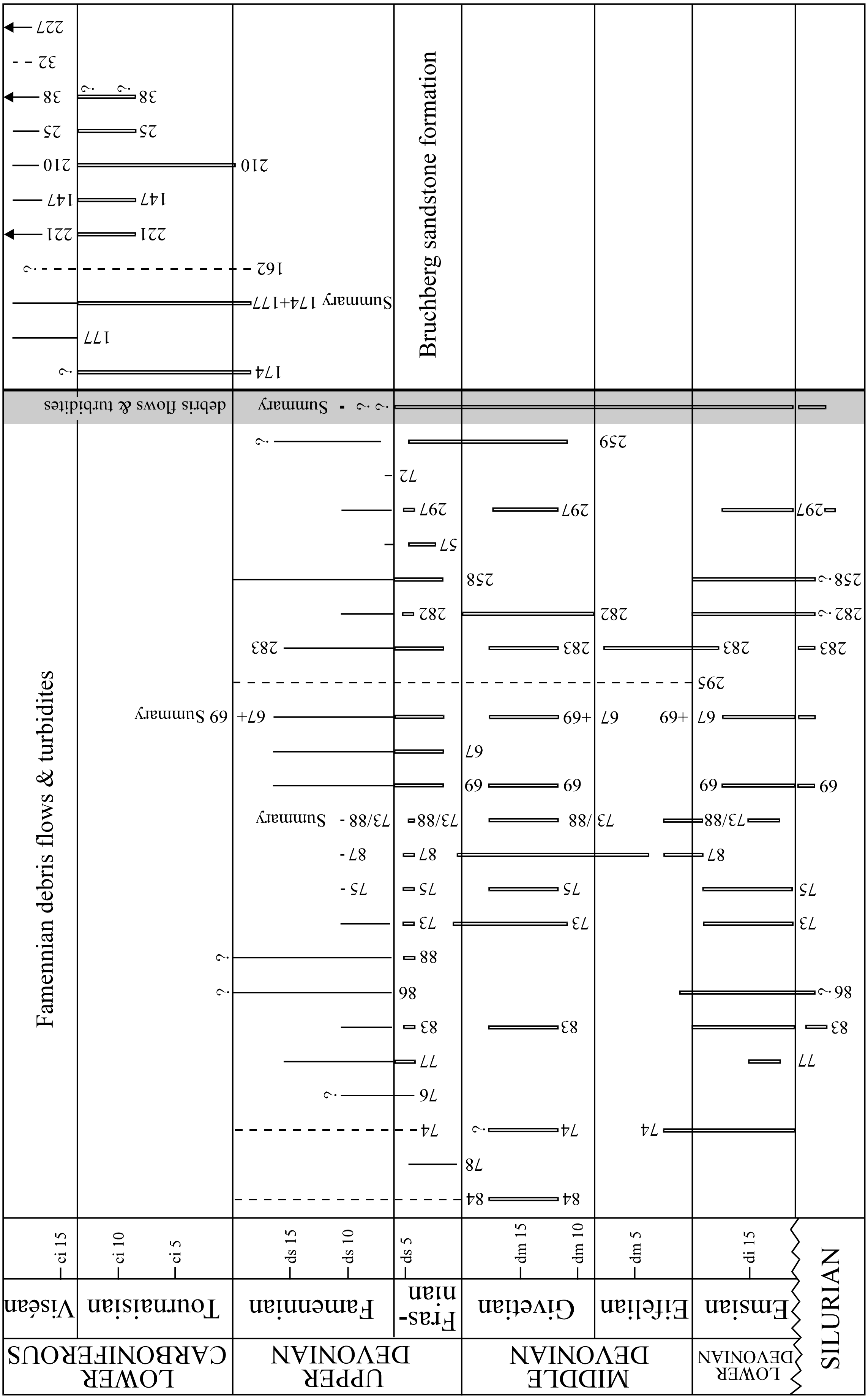
Mainly the following literature was used for species determinations and stratigraphic background information:

AL-AMERI (1983), ARBIZU et al. (1995), ASHRAF & UTESCHER (1991), AVCHIMOVITCH et al. (1988), AVCHIMOVITCH et al. (1993), BALME (1962, 1995), BARSS (1967), BECKER et al. (1974), BECKMANN (1953), BELKA (1985, 1990), BENDER et al. (1971), BISCHOFF & ZIEGLER (1958), BLESS & STREEL (1976), BRAUN (1990), BRAUN & SCHMIDT-EFFING (1993), BUTTERWORTH & WILLIAMS (1958), CASTANIER et al. (1994), CLAUSEN & LEUTERITZ & ZIEGLER (1989), CLAYTON (1985, 1995, 1996), CLAYTON et al. (1977), CLAYTON et al. (1990), COLEMAN & CLAYTON (1987), COMBAZ et al. (1967), COQUEL et al. (1995), CUI-LING & WEI-PING (1996), DOWNIE (1984), DREESEN & SANDBERG & ZIEGLER (1986), EDWARDS (1968), GAO (1986), HACQUEBARD (1957), HARTKOPF-FRÖDER & STREEL (1994), HASHEMI & PLAYFORD (1998), HIGGS, MCPHILEMY et al. (1988), HIGGS & CLAYTON & KEEGAN (1988), HIGGS et al. (1992), HIGGS & STREEL (1984), HOFFMEISTER et al. (1955), HUYSKEN et al. (1992), JARDINE et al. (1971), JUX (1975), KAISER (1970, 1971), KEDO (1963), KLAPPER et al. (1993), KÖNIGSHOF & PIECHA (1991), LACHKAR et al. (1993), LANE & SANDBERG & ZIEGLER (1980), LE HERISSE et al. (1997), LI-CHANG (1994a+b), LOVE (1960), LUBER & WALTZ (1938, 1941), MARTIN (1968, 1981, 1982, 1984), MCGREGOR (1960), MCGREGOR & CAMFIELD (1976, 1982), MCGREGOR & PLAYFORD (1992), MCNESTRY (1988), MOON-ZOO (1983), MÜLLER (1956), NAUMOVA (1953), NEVES (1961), PAPROTH et al. (1983), PARIS (1981), PEPPERS & HARVEY (1997), PLAYFORD (1962, 1963, 1971, 1977, 1990), PLAYFORD & MCGREGOR (1993), REITZ (1989, 1994), REITZ et al. (1995), RICHARDSON (1965), RICHARDSON & MCGREGOR (1986), RIEGEL (1993), RODRIGUEZ (1977), SANDBERG & ZIEGLER et al. (1992), SCHMIDT-EFFING (1988), SCHULTZ (1968), SCHULZ (1997, = WINDISCH 1998), SMITH & BUTTERWORTH (1967), SMITH (1996), SOMERS (1971), STEEMANS (1989, 1995), SULLIVAN (1968), SULLIVAN & MARSHALL (1966), TAUGOURDEAU-LANTZ (1971), TCHIBRIKOVA (1962), TRAVERSE (1988), TURNAU (1975, 1978), TURNER et al. (1989), URBAN (1972), URBAN & KLINE (1970), URBAN & NEWPORT (1973), UTTING (1987), WICANDER (1974), WICANDER & PLAYFORD (1985), WICANDER & WOOD (1997), WIERICH & VOGT (1997), WINDISCH (1998 = SCHULZ 1997), XIAO-RONG (1994), YI (1996), ZIEGLER (1958a+b, 1962, 1965), ZIEGLER & LANE (1987), ZIEGLER & SANDBERG (1990).

NEXT TWO PAGES:

Fig. C 5.1: Synopsis of the new stratigraphic results (AV-samples) from the analysed region. Solid bars/points: least spans of possible stratigraphic ranges covered by the faunal and/or floral evidence for each sample. Open bars: least spans of possible lifetime ranges for reworked species ("ghost fauna/flora").


LOWER CARBONIFEROUS
Viséan
Tournaisian
UPPER DEVONIAN
Famennian
Fras-nian
MIDDLE DEVONIAN
Givetian
Eifelian
LOWER DEVONIAN
Emsian
SILURIAN
ci 15
ci 10
ci 5
ds 15
ds 10
ds 5
dm 15
dm 10
dm 5
di 15
5+6
11
10
275
4
70
290
49
53
52
1
292
47
23
280
278
293
51
262
271
2
242
3+8
22
268
9
21
18
246
231


SILURIAN
LOWER DEVONIAN
MIDDLE DEVONIAN
UPPER DEVONIAN
LOWER CARBONIFEROUS
Emsian
Eifelian
Givetian
Fras-nian
Famennian
Tournaisian
Viséan
di 15
dm 5
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dm 15
ds 5
ds 10
ds 15
ci 5
ci 10
ci 15
Famennian debris flows & turbidites
Bruchberg sandstone formation
debris flows & turbidites
Summary
Summary 174+177
Summary 67+69
73/88 Summary

C 6 Reconstruction of particle size distributions from thin sections

In 1953 MÜNZNER & SCHNEIDERHÖHN presented a new procedure for estimating the grain size and weight distribution within a clastic sediment by counting lengths of passed by grains along distinct observation lines in thin section ("Sehnenschnittverfahren" (line cut procedure)). The major advantage of this procedure in comparison to other methods (e. g. KRUMBEIN 1935 + 1938, FRIEDMAN 1958, SMITH 1966) is: there is no need to count the biggest visible diameter or grain area but to count only lengths of grain-proportions lying directly on the counting line. On the other hand a minimum of >1000 counts are necessary to minimise chance hits and get a statistically consistant result.

In spite of the advantages the procedure was not very often used, mostly due to relatively time-consuming calculations. Nowadays, by using personal computers and spreadsheet programs, this problem no longer exists. However, other problems remain. BURGER & SKALA (1973) developed a Monte Carlo model to reconstruct particle size distributions from thin section based on similar assumptions and statistical model as MÜNZNER & SCHNEIDERHÖHN. They found that in parts insufficient calculations had been undertaken, the expected grain size distribution due to the statistical model (p. 464, tab. 3: $E(n_i)$-data) were especially erraneous. Nevertheless, with further investigation and new calculation of original data BURGER & SKALA were able to *demonstrate the general validity of the 'line cut procedure'* within defined limits (spheroidal grains, ideal statistic distribution of grain classes, equal specific physical properties of all grains).

Detailed methodological descriptions for the 'line cut procedure' are given in MÜNZNER & SCHNEIDERHÖHN (1953), therefore only the resulting equations are presented:

(1)

$$P'_i = \frac{100\, d_i}{d_1+d_2+...+d_k}$$

with

(2)

$$d_i = \frac{(n'_i / (a_i-a_{i-1})) - 3\,(a_i+a_{i-1})\,(d_{i+1}+d_{i+2}+...+d_k)}{a_i + 2\, a_{i-1}}$$

whereby:

P'_i = estimated value (%) for each frequency distribution class of grains
d_i = auxiliary parameter for simplification of equation (1)
a_i = maximum value for each frequency distribution class
a_{i-1} = maximum value for each next lower frequency distribution class
n'_i = number of 'line cut' counts for each frequency distribution class

Equation (2) is a recurrence relation, since it expresses each coefficient in terms of a preceeding one. It only successively allows the calculation of d_i, starting with $d_k = n'_k / (a_k - a_{k-1}) (a_k + 2 a_{k-1})$.

For comparison with results obtained with sieve or sedimentation analysis on grains it is of more interest to determine the percentual proportion of weight-related frequency distributions (W_i) instead of P'_i. Due to MÜNZNER & SCHNEIDERHÖHN (1953: 468) the following calculations have to be undertaken:

(3)

$$W_i = \frac{100\, e_i}{e_1 + e_2 ... + e_k}$$

whereby $e_i = P'_i * w_i$

with $w_i = a_{i-1}^3 + (a_{i-1}^2 * a_i) + (a_{i-1} * a_i^2) + a_i^3$

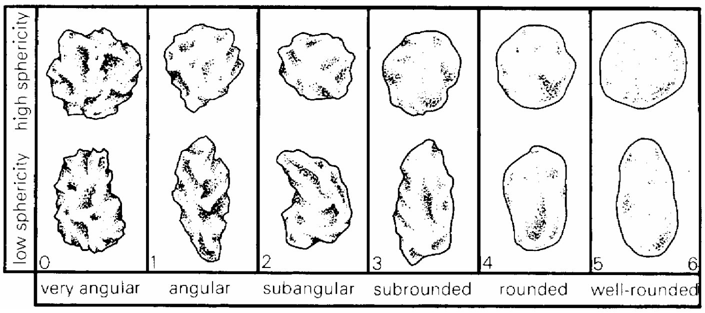
W_i = estimated value (%) for each weight-related frequency distribution class of grains
e_i = expected weight-related value for each frequency distribution class
w_i = weight- related auxiliary parameter for simplification of formula (3)

MÜNZNER & SCHNEIDERHÖHN (1953) used an equivalent of the the german industry norm (DIN 4022) for subdivision of grain size classes. In this system the maximum value for each frequency distribution class is: $a_0 = 0$, $a_1 = 0{,}02 \cdot 10^{½}$, $a_i = a_1 \cdot 10^{(i-1)/4}$ (for $i \geq 1$). Beginning from the first point of change the difference ($\log a_i - \log a_{i-1}$) is constant (=0,25); therefore logarithmic equidistant distribution can be observed. Presentation of results takes place in semi-logarithmic x-y-diagrams.

In order to implement the - on the ratio of 2 or $2^{½}$ based - Φ-scale ($\Phi = -\log_2(d/d_0)$ with d = grain diameter and d_0 = unit diameter 1mm) for easier interpretation and presentation of data, for the following calculations the grain size class distribution method after WENTWORTH (1922) is used. In this geometrical series the maximum value for each frequency distribution class is: $a_i = a_1 \cdot 2^{i-1}$ (for $i \neq 0$), with the starting-point at: a_1 = 1 mm. Here also logarithmic equidistant distribution of grain size classes can be observed: $\log_2 a_i - \log_2 a_{i-1} = 1$.

Once the frequency distribution for the grain size of an analysed sample is obtained, we may need a short description for the sorting of unimodally distributed grains. In general, the less classes are counted and/or the less grain size classes inhabit most of the bulk grain mass, the better sorted the sediment is. The variation index V (= Ungleichförmigkeitszahl U) after the German Industry Norm (DIN 1054 (1976) and DIN 18196 (1988)) is defined as: $V = d_{60} / d_{10}$; with d_{60} = grainsize at 60% of the grain sum distribution (sum-% W_i). Small V-values are characteristic for well sorted grains, larger values are indicative for moderately or poorly sorted grains.

The grade of sorting, roundness and sphericity in a clastic sediment contribute toward the textural maturity of the sediment. Texturally immature sand- or siltstones are generally poorly sorted with angular grains of low to medium sphericity, while texturally supermature clastics are generally well sorted with wellrounded grains of high sphericity. The degree of roundness and sphericity for 100 grains counted along a line on each thin section was estimated by using the following scheme (from TUCKER 1989: 39):



Crucial for a re-interpretation of parts of the "Gaudernbach Layers" are the Viséan Bruchberg sandstone (formerly acknowledged as Upper Devonian quartzite) and the finding of Upper Devonian greywackes at several locations in the analysed area. A thourough description of the Bruchberg sandstone with special focus on petrography and occurrence was published by WIERICH & VOGT in 1997. But also the greywackes need more particular descriptions. Therefore, especially these have been analysed in more detail; the results are presented in this chapter C 6 and in chapter C 7.

Tab. C 6.1: List of samples on which grain size distribution counts (G.S.D.C.) and shape determinations (S.D.) have been untertaken.

Sample	Thin section	Lithology	G.S.D.C	S.D.
AV 44	AV 44-1	Viséan Bruchberg sandstone	X	X
AV 69	AV 69-1	Greywacke within Upper Devonian debris flow	X	X
AV 76	AV 76-B	Greywacke within Upper Devonian debris flow	X	X
AV 257	AV 257-1	Upper Devonian greywacke	X	
AV 257	AV 257-2	Upper Devonian greywacke		X
AV 283	AV 283-1	Upper Devonian greywacke	X	X
AV 301	AV 301-2	Greywacke within Upper Devonian debris flow	X	X

In order to simplify the neccessary calculations a Microsoft Excel spreadsheet for calculating the frequency distribution for each analysed thin section was developed.

ON THE NEXT PAGE:

Fig. C 6.1: Spreadsheet showing the formulas for calculating the frequency distribution for each analysed thin section.

	A	B	C	D	E	F	G	H	I	J
1	**Calculation steps for the reconstruction of particle size distributions from thin sections via line cut procedure**									
2	Sample: AV 44			Thin section: 1		Analyst: Vogt			Date: 15.08.1996	
3	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
4	i	a_i [mm]	$a_i + 2\ a_{i-1}$	$3\ (a_i + a_{i-1})$	n'_i	$n'_i / (a_i - a_{i-1})$	$d_{i+1}+d_{i+2}+...+d_k$	[7] * [4]	d_i=([6]-[8])/[3]	P'_i =100*d_i / ($d_1+d_2+...+d_k$)
5	1	0.0078125	=B5	=3*B5	14	=E5/B5	=G6+I6	=G5*D5	=0 (negat. value)*	=100*I5/I13
6	2	0.015625	=B6+2*B5	=3*(B6+B5)	57	=E6/(B6-B5)	=G7+I7	=G6*D6	=0 (negat. value)	=100*I6/I13
7	3	0.03125	=B7+2*B6	=3*(B7+B6)	259	=E7/(B7-B6)	=G8+I8	=G7*D7	=(F7-H7)/C7	=100*I7/I13
8	4	0.0625	a.s.o.	a.s.o.	283	a.s.o.	a.s.o.	a.s.o.	=(F8-H8)/C8	a.s.o.
9	5	0.125	"	"	267	"	"	"	a.s.o.	"
10	6	0.25	"	"	129	"	"	"	"	"
11	7	0.5	"	"	30	"	=G12+I12	=G11*D11	"	"
12	8	1	=B12+ 2*B11	=3*(B12+B11)	3	=E12/(B12-B11)	set =0	=G12*D12	=(F12-H12)/C12	=100*I12/I13
13					**SUM**				**SUM**	
14									*=(F5-H5)/C5 < 0, the value is set =0	
15										
16	i	a_i [mm]	w_i =	e_i =P'_i * w_i	W_i = 100*e_i / ($e_1+e_2+...+e_k$)		Φ - value	Middle of each class	Sum-% W_i	
17	1	0.0078125	$(B17)^3$	=J5*C17	=100*D17/D25	fine silt	7.5	2EXP-7.5	=E17	
18	2	0.015625	$(B17)^3$+($(B17)^2$*B18)+ (B17*$(B18)^2$)+$(B18)^3$	=J6*C18	=100*D18/D25	medium silt	6.5	2EXP-6.5	=E17+I17	
19	3	0.03125	$(B18)^3$+($(B18)^2$*B19)+ (B18*$(B19)^2$)+$(B19)^3$	=J7*C19	=100*D19/D25	coarse silt	5.5	2EXP-5.5	=E19+I18	
20	4	0.0625	a.s.o.	a.s.o.	a.s.o.	very coarse silt	4.5	2EXP-4.5	a.s.o.	
21	5	0.125	"	"	"	very fine sand	3.5	2EXP-3.5	"	
22	6	0.25	"	"	"	fine sand	2.5	2EXP-2.5	"	
23	7	0.5	"	"	"	medium sand	1.5	2EXP-1.5	"	
24	8	1	$(B23)^3$+($(B23)^2$*B24)+ (B23*$(B24)^2$)+$(B24)^3$	=J12*C24	=100*D24/D25	coarse sand	0.5	2EXP-0.5	=E24+I23	
25				**SUM**						

The obtained results for all analysed greywacke samples are presented in the following two tables.

Tab. C 6.2: Results for the grain size frequency distribution analyses on Upper Devonian greywackes. The variation index V is defined as: V = d_{60} / d_{10}; with d_{60} = grainsize at 60% of the grain sum distribution (sum-% W_i). Small V-values are characteristic for well sorted grains, larger values are indicative for moderately or poorly sorted grains.

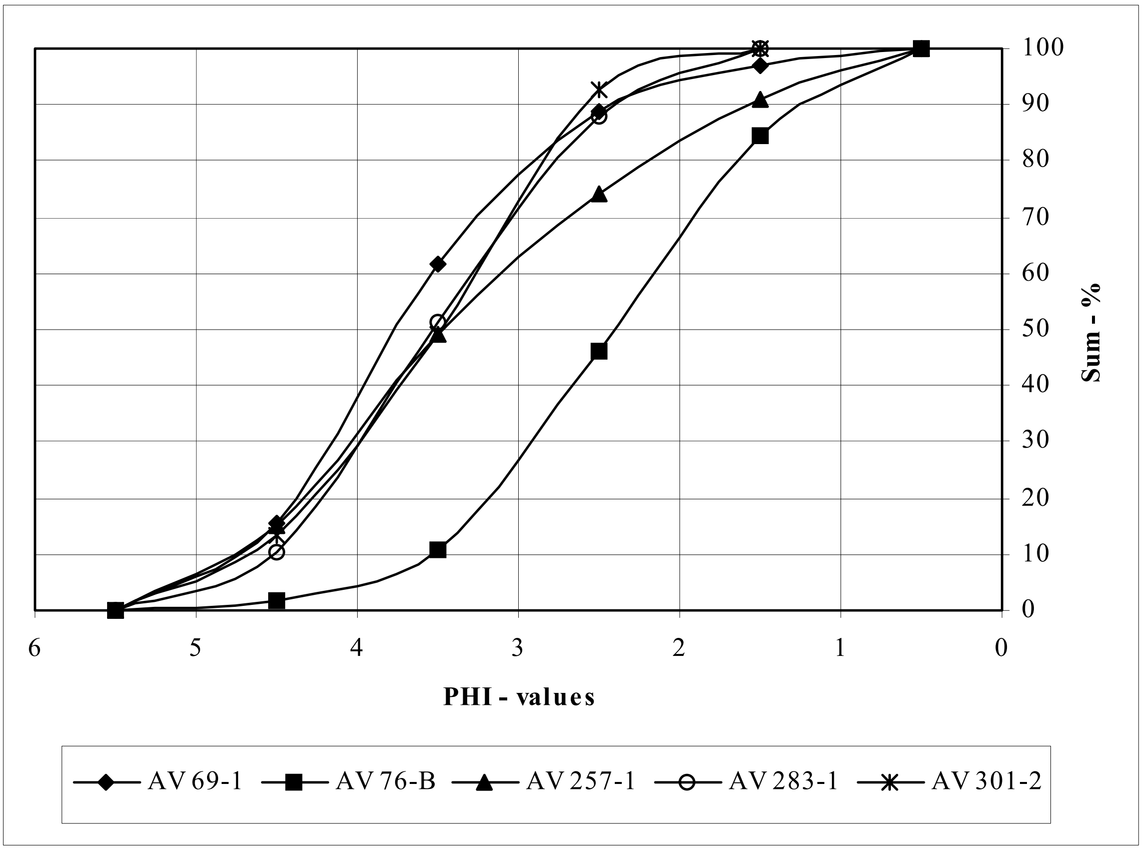
Grain-size	**AV 69-1**			**AV 76-B**			**AV 257-1**			**AV 283-1**		
µm	n'_i	P'_i (%)	W'_i (%)	n'_i	P'_i (%)	W'_i (%)	n'_i	P'_i (%)	W'_i(%)	n'_i	P'_i(%)	W'_i(%)
16-31	142	71.1	0	21	0	0	110	0	0	107	0	0
31-63	436	26.8	15.4	176	50.5	1.8	494	76.3	15.1	398	64	10.2
63-125	403	2	46.3	312	31.7	9	402	21.5	34.1	447	32.3	41.1
125-250	110	0.07	27.4	358	15.6	35.3	145	2	25.1	173	3.6	36.7
250-500	16	< 0.01	7.7	164	2.1	38.3	46	0.16	16.5	26	0.15	12.1
500-1000	3	< 0.01	3.2	30	0.11	15.6	11	0.01	9.1	0	0	0
Total	1110	c. 100	100	1061	c. 100	100	1208	c. 100	100	1151	c. 100	100
V	**2.6**			**2.5**			**3.1**			**2.3**		

Grain-size	**AV 301-2**		
µm	n'_i	P'_i (%)	W'_i (%)
16-31	124	0	0
31-63	413	72.1	13.3
63-125	400	24.2	35.7
125-250	190	3.7	43.8
250-500	15	0.08	7.2
500-1000	0	0	0
Total	1142	c. 100	100
V	**2.6**		

Tab. C 6.3: Results for the grain shape analyses on Upper Devonian greywackes (N = number of counts. HS : LS = relation "high sphericity" : "low sphericity" of grain shapes. M = statistical mean. s = standard deviation. M ± BS = M ± both sided statistical security range for a security value of 99%).

Grain-shape category	**AV 69-1**	**AV 76-B**	**AV 257-1**	**AV 283-1**	**AV 301-2**
	n_i	n_i	n_i	n_i	n_i
0	5	9	14	18	14
1	32	34	37	39	36
2	35	27	37	28	40
3	22	25	17	15	10
4	6	5	5	0	0
5	0	0	0	0	0
6	0	0	0	0	0
N	100	100	100	100	100
HS : LS	1 : 1.6	1 : 1.3	1 : 1.4	1 : 1.6	1 : 1.6
M	1.9	1.8	1.6	1.4	1.5
s	0.99	1.06	1.08	0.95	0.86
M ± BS	1.9 ± 0.3	1.8 ± 0.3	1.6 ± 0.3	1.4 ± 0.3	1.5 ± 0.2

Fig. C 6.2: Grain size distribution in Famennian greywackes. Data achieved via line-cut procedure (Sehnenschnittverfahren sensu MÜNZNER & SCHNEIDERHÖHN 1953); compare tab. C 6.2. In addition to each AV-sample number the number of the counted thin section (e. g. -1) is displayed.



The grainsize of the analysed Famennian greywackes lies mostly in the range coarse silt to coarse sand. The variation index varies between V = 2.3 - 3.1. The shape of grains varies between very angular (0) to subrounded (3), seldom rounded (4); the average values are 1.4 - 1.9. The grains are moderately to poorly sorted with many different components (see chapter C 7) in a mostly silty-pelitic matrix which accounts for ca. 5 - 15 % of the total mass.

Grainsize analyses on samples of Viséan Bruchberg sandstone had been published earlier in WIERICH & VOGT 1997. The grainsize of the analysed samples from the region northern of Limburg lies mostly in the range very fine- to coarse sand. The variation index of sample AV 44 is V = 3.7 (WIERICH & VOGT 1997: 110). The shape of grains varies between very angular (0) to well-rounded (5); mean value: 2.5 (WIERICH & VOGT 1997: 117). The grains are moderately sorted, dominated by quartz, however with many different components (see chapter C 7). The matrix in this grain-supported sediment is mostly silty-pelitic.

C 7 Petrographic analyses

Petrographic analyses have been undertaken on most lithologic units of the analysed area. But the wealth of information obtainable during detailed analysis is in sharp contrast to the very time-consuming analytical procedure. Therefore, only on the more important lithological units more detailed petrographic descriptions of grain-assemblages observable in thin-section have been undertaken. The detailed results for:
- Famennian greywackes ("Giessen greywacke formation")
- Famennian pyroclastic deposits ("Schalstein")
- Viséan Bruchberg sandstone

are presented herein.

VOLL (1969) outlined in his stimulating work the fate of detrital mineral grains under increasing temperature and pressure during regional-/contact-metamorphism (see also VOLL 1980a+b). The knowledge about the developing grain fabrics under these conditions as well as interesting new findings of HENNINGSEN (e. g. 1962, 1963, 1966, 1970) about the composition and origin of Palaeozoic greywackes led to a structured source area analysis based on the description of light minerals. WIERICH & VOGLER (1997) proved its importance in reconstructing the wander path of detrital grains 2.9 Ga through time. WIERICH & VOGT (1997) demonstrated the petrologic uniformity of the sandstones and conglomerates of the Bruchberg sandstone formation along a distance of more than 300km.
By trying to reconstruct the fate of single and/or composite grains from e.g. greywackes or sandstones one can get information about the nature of the source area for the sedimentary components and about the palaeoenvironment. The method in full and its extreme usefulness for the localization and reconstruction of palaeoenvironments of the Devonian is described in WIERICH (1998), which has been published in *Marburger Geowissenschaften*, vol. 1 (WIERICH 1999).
Punctual analyses seldom allow for a decision whether specific clasts are e. g. first-term recycled metamorphite clasts or were shed as parts of former (multiply?) reworked sediments - especially in finer-grained sediments, where "multiclasts" are mostly destroyed. Only research which covers the developments of sedimentary environments for long time-intervals (e. g. for the whole Devonian, WIERICH 1998, 1999) allows for some necessary adjustments.

C 7.1 Famennian greywacke (samples AV 69, 76, 257, 283, 301)

Petrogr. analysis:	VOGT
Age:	Famennian, ca. Latest *crepida*-zone or shortly before, since greywacke components of a debris flow sediment of this age were not yet lithified at the time of redeposition (compare fig. C 7.1); ca. DK1996: ds 10.3 — 10.6 (compare chapter C 5, app. F 2).
Grainsize:	coarse silt to coarse sand. Variation index: V = 2.3 - 3.1 (compare chapter C 6).
Shape of grains:	very angular (0) to subrounded (3), seldom rounded (4); mean values: 1.4 - 1.9 (compare chapter C 6).
Sorting:	moderately to poorly sorted with many different components.
Matrix/groundmass:	mostly silty-pelitic in variable amounts (ca. 5 - 15 % of the total mass)

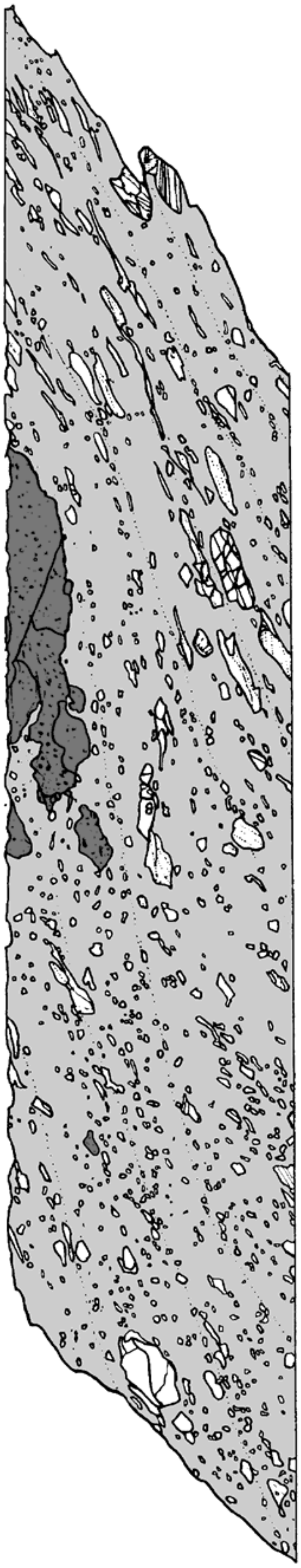
Since all samples show a more or less uniform component spectrum, their lithoclast content is described together:

Fig. C 7.1: Drawing showing the main features of core sample AV 76 (= DK 2010/132, 18.4 - 18.8m; original core diameter: 100mm). Early Famennian debris flow (compare chapters C 5, D 2.4.2.2, fig. D 2.7, appendix F 2).

- - --- - Clay with traces of lamination and/or layering

Clay with fine-silt

Greywacke (coarse-silt to sand)



⇐ Greywacke - component, plastic deformed (note compact but patchy and irregular appearance), i. e. original greywacke layer not yet completely lithefied before debris flow formation.

General remarks:

Note that clay and clay/silt components are small and show small scale intermixing. That's the reason why in most HF-processed debris flow samples several different age correlations have been possible.

Furthermore we should draw special attention to the fact, that these different age correlations had been possible at all. Considering the reworking process and even the conservation of reworked Silurian species, the preservation of palynomorphs in the Giessen nappe samples is quite good and seems to be limited only by the pyrite content. This is in remarkable contrast to the generally bad preservation of Devonian palynomorphs in outcrop samples from proposed autochthonous units.

A. Detritic single mineral grains (ca. 30 - 40%)

a) quartz, angular, monocrystalline, mostly undeformed, with inclusions of:
  aa) euhedral zircone
  ab) apatite
  ac) biotite
  ad) helminthe (chlorite (helminthe) replaced quartz)
b) feldspar:
  ba) albitised alkalifeldspar ("Schachbrettalbit")
  bb) plagioclase, twinned (albite-law)
c) white mica and mostly chloritised biotite
d) heavy minerals:
  da) angular to subrounded rutile
  db) angular to subrounded tourmaline
  dc) subrounded and euhedral zircone, partly with subrounded core

B. Clasts of reworked sedimentary rocks (ca. 20 - 30%)

a) undeformed pelites
b) undeformed siltstones
c) deformed pelites (first cleavage developed)
d) deformed siltstones (first cleavage developed)
e) deformed finegrained sandstones with (in pressure shadows) newly crystallised white mica and deformation lamellae in quartz grains

C. Clasts of magmatic rocks or their derivatives (ca. 5 - 10%)

C 1. Basic volcanites
a) with intersertal texture (e. g. ophitic arrayed plagioclase crystals)
  aa) skeleton-like crystallised plagioclase with interstitial
    aaa) ore
    aab) chlorite
    aac) serpentine
    as devitrification products of former glassy matrix.
  ab) partly fluidal and subparallel arranged in redbrown to blackish matrix
b) euhedral plagioclase phyric volcanite clasts
  ba) with chloritised , formerly glassy, matrix
c) completely serpentinised or chloritised pseudomorphs of mafic minerals

C 2. Intermediate - silicic volcanites
Groundmass coarsened by enhanced quartz-growth. Matrix contains euhedral phenocrysts of:
a) plagioclase
b) quartz
c) biotite
d) albitised alkalifeldspar

C 3. Intermediate - silicic plutonites
Clasts with:
a) quartz and alkalifeldspar
b) quartz and plagioclase
c) euhedral alkalifeldspar crystals; on crystal faces with magmatic accumulation of:
  ca) white mica
  cb) quartz
  cc) zircone
d) quartz and plagioclase and albitised alkalifeldspar ("Schachbrettalbit"), undeformed
  da) and deformed: plagioclase with polysynthetic deformation twins (due to albite law)

e) magmatic rounded and corroded quartz crystals, partly with inclusions of:
  ea) euhedral apatites

eb) resorption-drops of recrystallised former melt

C 4. Hydrothermal and pegmatitic veins

a) polycrystalline quartz with characteristic sheet-like/tabular growth patterns.
b) quartz with cloudy or oriented inclusions of fluids and "dirt"
c) plagioclase with granophyric quartz-plagioclase rims.
d) Probably from pegmatites of 'high-level intrusions' of silicic plutonites or subvolcanites:
da) graphic granite and
db) if the quartz-alkali feldspar intergrowths are confined to smaller crystals (perhaps also in the groundmass of a porphyritic granitoid) - granophyre.

D. Clasts of reworked metamorphic rocks (ca. < 5%)

a) phyllites:
aa) sericit-phyllites
ab) chlorite-sericite-phyllites
b) polyquartz with
ba) well developed subgrain texture and beginning recrystallization (low-grade metamorphism)
bb) coarse and angular sutured subgrain contacts due to strain-induced boundary migration (low to higher-grade metamorphism)
bc) oriented exsolution of small rutile-needles (substitution of Si^{4+} by Ti^{4+} in the quartz crystal is induced under granulite facies conditions; during the following cooling phase starts the oriented exsolution of rutile-needles parallel to all three a-axes of the quartz crystal (VOLL 1969, MASBERG & HOFFER & HOERNES 1992, WIERICH & VOGLER 1997))
c) quartzites (finegrained, during deformation recrystallised quartz; indicators for temperatures > 300°C) with inclusions of heavy minerals
d) gneisses.

C 7.2 Famennian reworked pyroclastics ("Schalstein", sample AV 277)

Petrogr. analysis:	VOGT, with maintenance of WIERICH
Age:	Famennian (late Hembergian — Wocklumian), ca. Early *postera* — ? *praesulcata*-zone (compare AV 278, chapter C 5, appendix F 2); ca. DK1996: ds 15.2 — ?20.0.
Grainsize:	fine- to medium sand.
Shape of grains:	very angular to subrounded.
Sorting:	moderately sorted with many different components.
Matrix/groundmass:	mostly silty-pelitic, with sparitic calcareous cement.

Since all "Schalstein"-samples show a more or less uniform component spectrum, only the lithoclast content of sample AV 277 is described in full:

A. Clasts of magmatic rocks or their derivatives

A 1. Basic volcanites

a) with skeleton-like crystallised plagioclase, ophitic or fluidal arranged in darkbrown matrix with interstitial
aa) ore
ab) chlorite
as devitrification products of former glassy matrix.
b) vesicle-rich basalt-glasses
c) euhedral plagioclase phyric volcanite clasts with chloritised , formerly glassy, matrix

A 2. Intermediate - silicic volcanites

a) clasts of trachyte / rhyodacite with fluidal subparallel arranged feldspars

A 3. Intermediate - silicic plutonites

Clasts with:
a) quartz and plagioclase and albitised alkalifeldspar ("Schachbrettalbit"), undeformed

b) magmatic rounded and corroded quartz crystals, partly with inclusions of:
ba) euhedral apatites
bb) resorption-drops of recrystallised former melt

A 4. Hydrothermal and pegmatitic veins
a) polycrystalline quartz with characteristic sheet-like/tabular growth patterns.
b) quartz with cloudy or oriented inclusions of fluids and "dirt"

B. Detritic single mineral grains

a) quartz, angular, monocrystalline, mostly undeformed, with inclusions of:
aa) apatite
ab) oriented exsolution of small rutile-needles (substitution of Si^{4+} by Ti^{4+} in the quartz crystal is induced under granulite facies conditions; during the following cooling phase starts the oriented exsolution of rutile-needles parallel to all three a-axes of the quartz crystal (VOLL 1969, MASBERG & HOFFER & HOERNES 1992, WIERICH & VOGLER 1997))
ac) resorption-drops of recrystallised former melt
b) quartz, angular, monocrystalline, deformed, undulose with well developed subgrain texture and beginning recrystallization of boundaries (low-grade metamorphism); probably from quartz-veins which developed parallel to the first cleavage and recrystallised during prograde deformation and metamorphism.
c) angular zircone
d) feldspar:
ba) albitised alkalifeldspar ("Schachbrettalbit")
bb) plagioclase, twinned (albite-law)
e) heavy minerals:
ea) angular to subrounded rutile
eb) angular to subrounded tourmaline
ec) subrounded and euhedral zircone, partly with subrounded core

C. Clasts of reworked sedimentary rocks

a) undeformed pelites
b) coarsegrained siltstone, well sorted
b) undeformed silt- to finesandstones, poorly sorted

D. Clasts of reworked metamorphic rocks

a) polyquartz with well developed subgrain texture and beginning recrystallization (low-grade metamorphism).

C 7.3 Viséan Bruchberg sandstone (sample AV 44)

Petrogr. analysis:	WIERICH & VOGT 1997
Age:	Late Viséan, ca. TC — VF-zone (compare AV 147, chapter C 5, appendix F 2); ca. LCC 2003: ci 16.6 — 19.2.
Grainsize:	very fine- to coarse sand. Variation index: V = 3.7 (compare WIERICH & VOGT 1997: 110).
Shape of grains:	very angular (0) to well-rounded (5); mean value: 2.5 (compare WIERICH & VOGT 1997: 117.
Sorting:	moderately sorted with many different components.
Matrix:	mostly silty-pelitic in variable amounts (grain-supported sediment).

Since most Bruchberg sandstone-samples show a more or less uniform component spectrum, only the lithoclast content of sample AV 44 is described (for more information see WIERICH & VOGT 1997):

A. Detritic single mineral grains

a) quartz, angular, monocrystalline, mostly undeformed, with inclusions of:
  aa) euhedral zircone
  ab) apatite
  ac) biotite
  ae) oriented exsolution of small rutile-needles (substitution of Si^{4+} by Ti^{4+} in the quartz crystal is induced under granulite facies conditions; during the following cooling phase starts the oriented exsolution of rutile-needles parallel to all three a-axes of the quartz crystal (VOLL 1969, MASBERG & HOFFER & HOERNES 1992, WIERICH & VOGLER 1997))
  af) fluid inclusions
  ag) resorption-drops of recrystallised former melt (from silicic plutonites)
b) quartz, angular, monocrystalline, deformed, undulose with well developed subgrain texture (grain boundary motion) and beginning recrystallization of boundaries (low-grade metamorphism); probably from quartz-veins which developed parallel to the first cleavage and recrystallised during prograde deformation and metamorphism.
c) quartz, angular, monocrystalline, with trace of rounded diagenetically grown rim (= multiply reworked sediment).
d) feldspar, disaggregated
e) white mica and mostly chloritised biotite
f) heavy minerals:
  fa) angular to subrounded rutile
  fb) angular to subrounded tourmaline
  fc) subrounded and euhedral zircone (partly reddish), partly with subrounded core
  fd) chromite, angular, 0.06mm

B. Clasts of reworked sedimentary rocks

a) undeformed pelites
b) undeformed siltstones
c) chert, partly coarsened by quartz-growth (originated from flinty slates or from silicic volcanites with cryptocrystalline matrix).

C. Clasts of magmatic rocks or their derivatives

C 1. Basic volcanites
a) serpentinite

C 2. Hydrothermal and pegmatitic veins
a) polycrystalline quartz with characteristic sheet-like/tabular growth patterns.
b) quartz with cloudy or oriented inclusions of fluids and "dirt"

D. Clasts of reworked metamorphic rocks

a) quartz-sericite slate
b) polyquartz with
  ba) well developed subgrain texture and beginning recrystallization (low-grade metamorphism)
  bb) coarse and angular sutured subgrain contacts due to strain-induced boundary migration (low to higher-grade metamorphism)
  bc) oriented exsolution of small rutile-needles (substitution of Si^{4+} by Ti^{4+} in the quartz crystal is induced under granulite facies conditions; during the following cooling phase starts the oriented exsolution of rutile-needles parallel to all three a-axes of the quartz crystal (VOLL 1969)
c) quartzites (finegrained, during deformation recrystallised quartz; indicators for temperatures > 300°C) with inclusions of heavy minerals.

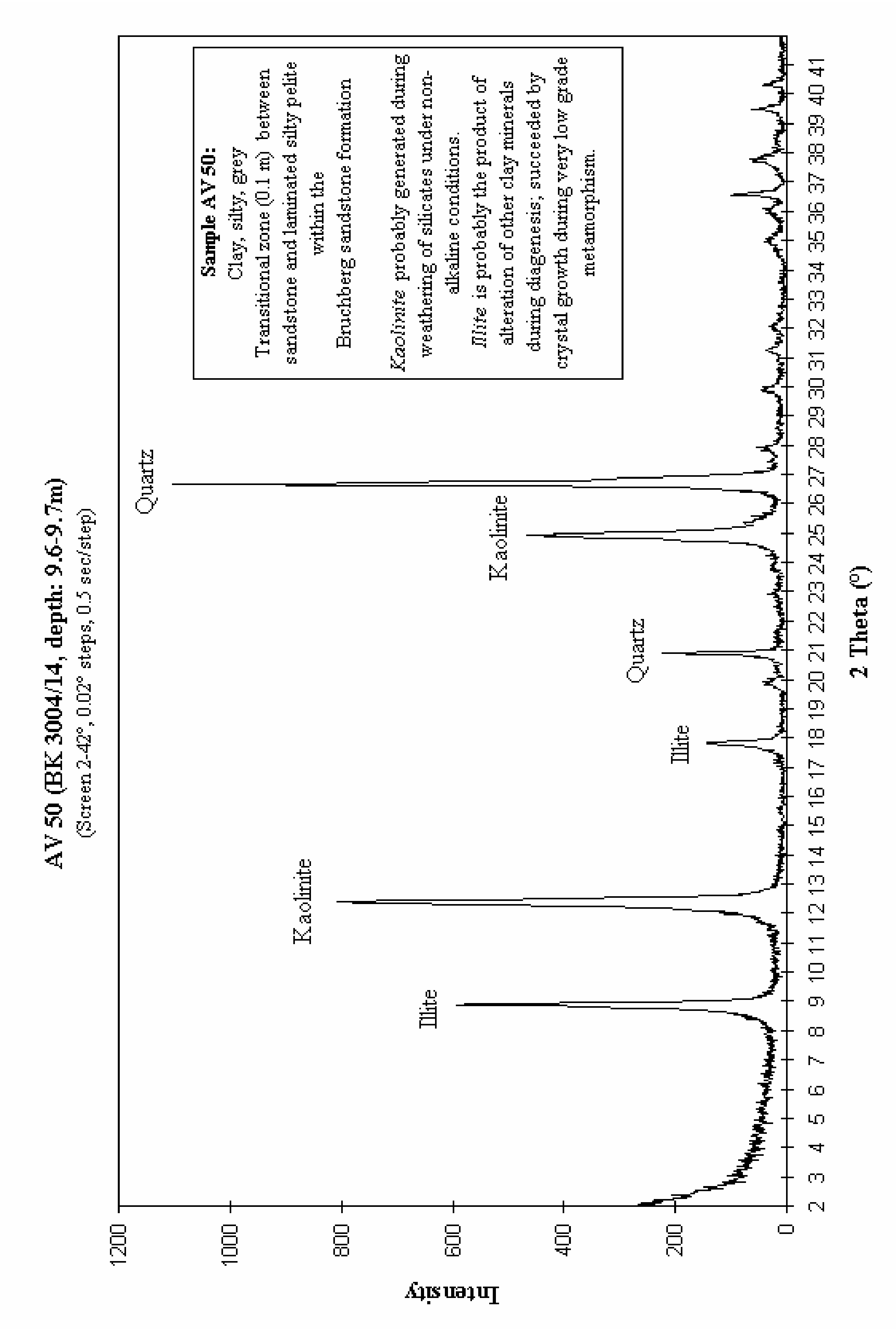


Fig. C 7.2: X-ray diffraction pattern of a weathered clay sample from the Bruchberg sandstone formation (AV 50, from drill site BK 3004/14, depth 9.6-9.7m).

C 8 Cyclic sequences: identification and interpretation

C 8.1 Orbital forcing and cyclic sequences

At least from Upper Devonian to Lower Carboniferous times a basinal environment is observable in the area between Weilburg and Holzheim. In this basinal facies with prevailing low energy conditions and low sediment supply evidence for orbitally driven cyclic sedimentation should be well preserved. But two main conditions are required in order to observe these small cycles: a) outcrops with well preserved pelitic lithologies and b) only minor rock property changes due to folding and faulting. Both preconditions, however, are normally never matched in daylight-outcrops. Either a deep ranging weathering of the pelitic sediments occurs - with subsequent colour changes, varying mineralogy and destruction of e.g. indicative light/dark colour changes; or (/and) intrinsive folding and faulting is observable, which also destroys the mm-scale cyclic structures. In addition to that the region around Limburg especially is infiltrated by great amounts of hydrothermal waters which caused intensive bleaching and disintegration within whole blocks of pelitic or pyroclastic sediment piles during the Tertiary.

The variation of the receipt of solar energy with latitude over the year and therefore the distribution of climatic zones on the Earth is influenced by astronomical parameters. They cause variations in the rate of delivery of all direct solar energy per unit of horizontal Earth surface.

Evidence for the influence of the following astronomical parameters can be detected in sediments under favourable conditions:

a) Sunspot cycle (11.07a, 22.14a)
Big patch-like structures on the Sun surface are called Sun spots. The have an average diameter of 2000 - 50,000km and partly up to more than 100,000km. In the core region (umbra) of such patches the temperature is ca 4500 K, in the transitional region between core and normal Sun surface (penumbra) approx. 5500 K. The Sun spots are always accompanied by strong magnetic fields which cause a lower energy current to the surface and therefore a lower temperature. Several smaller single Sun spots assemble themselves into Sun spot clusters with an average lifetime of 6 days - but can last also up to 100 days at the extreme. The frequency of the spots varies with a period of approx. 11.07 years - the so-called 'Sun-spot-cycle'.

b) precession (19 000a , 23 000a)
The precession is the spinning of the Earth's axis, influenced by the combined effects of the solar and lunar attraction on the equatorial bulge of the Earth. Its absolute period is about 26ka. But the observed average main periods are about 19ka and 23ka (extremes: 14ka and 28ka). This is due to the additional effect induced by the rotation of the elliptical orbit of the Earth. "As a result, the equinoxes, i.e. the position of the Earth in its orbit around the Sun is exactly above the equator and day and night have equal

length (21 March and 23 September), move around the elliptical orbit of the Earth. This leads to regular and predictable changes in the distribution of insolation [= solar radiation that has been received; auth.] over the Earth, and hence changes in the contrast between summer and winter." (DE BOER & SMITH 1994: 2).

The Earth's precession varies through geological time. BERGER & LOUTRE (1994: 20) presented estimated values of the main periods of the palaeoclimatic parameters. With these data I calculated the presumable values for the Earth' precession 340 Ma ago (Tournaisian/Viséan): approx. 17.1ka and 20.3ka.

c) obliquity (41 000a, 54 000a)

The angle of tilt of the Earth's axis with respect to the perpendicular of the ecliptic (= the plane in which the Earth rotates around the Sun). "Obliquity varies between 22 and 24.5° with a mean period of about 41ka [prominent also: 54ka], and it modulates seasonality, especially at high latitudes." (DE BOER & SMITH 1994: 2).

The Earth's obliquity varies through geological time. BERGER & LOUTRE (1994: 20) presented estimated values of the main periods of the palaeoclimatic parameters. With these data I calculated the presumable values for the Earth's obliquity 340 Ma ago (Tournaisian/Viséan): approx. 33.1ka and 41.2ka.

d) eccentricity (100ka; 400ka, 1.3 Ma, 2 Ma)

The path of the Earth around the Sun deviates to some extent from a circular path, it is more like an ellipse with periodically varying eccentricity (from near 0 to 0.06). The average cycle has an average duration of 100ka (prominent also: 99ka and 123ka). At 400ka, 1300ka, 2 Ma occur regular variations of the eccentricity cycles.

Two formations with observable cyclic sequences were detected within the analysed area: a) the Bruchberg sandstone formation and b) the Light flinty slate formation.

C 8.2 Bruchberg sandstone formation

Within the pelitic background sediment of the Bruchberg sandstone formation light-dark changes between different laminae at µm-scale occur. But they are only preserved under favourable conditions; mostly these delicate structures are disturbed by slumping or are superimposed by mm- to m-thick silt/sand-turbidites. A approx. 18cm long core from drilling BK 3004/13 (sample AV 204) shows obvious cyclicity; the results of a detailed analysis are presented herewith.

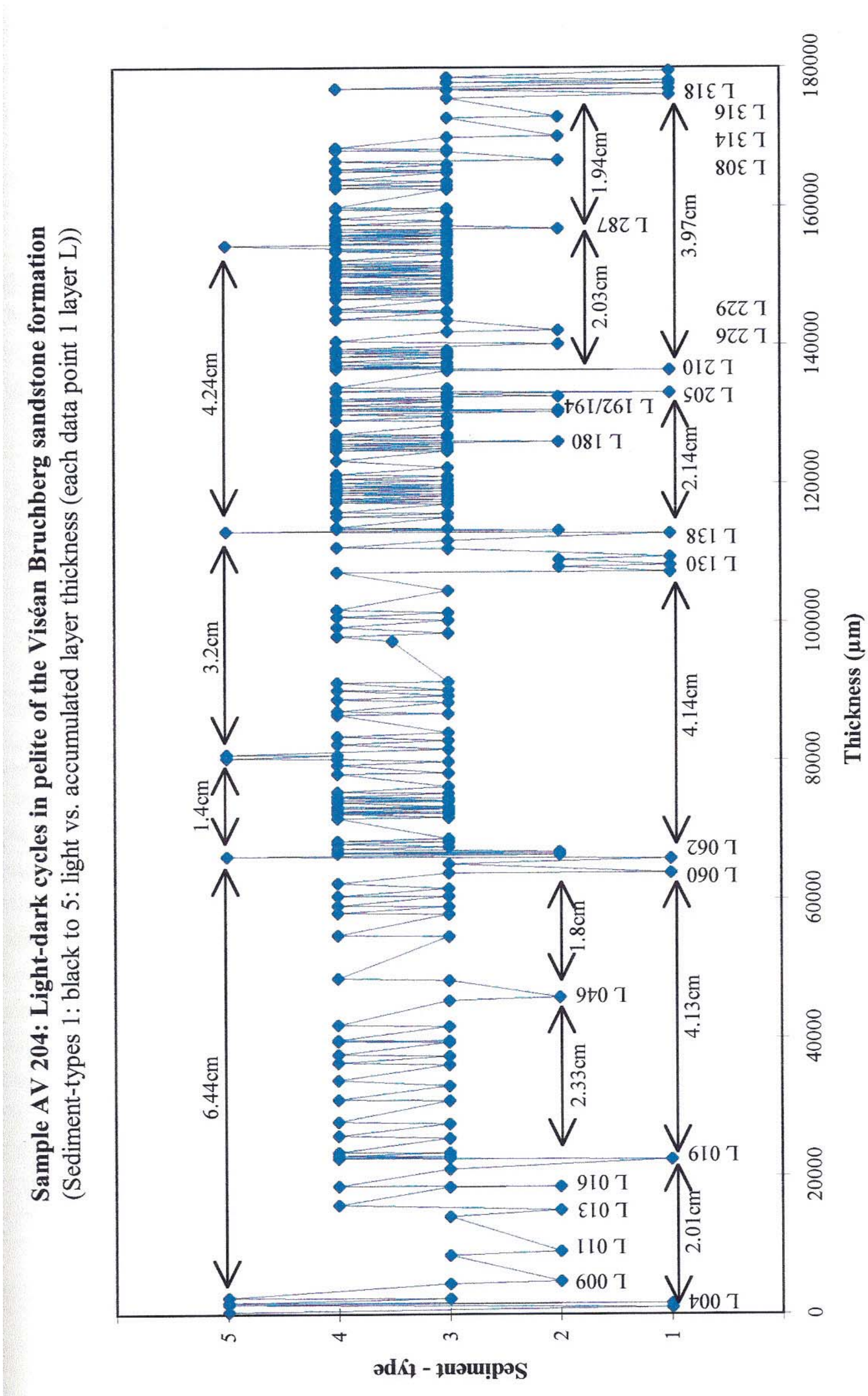


Fig. C 8.1: Results of a detailed analysis of light-dark changes between different laminae at µm-scale within pelites of the Bruchberg sandstone formation (sample AV 204).

All single results are presented in tab. F 4.1 (appendix F 4) and displayed in figure C 8.1. From the latter the most obvious layer intervals which show an apparent cyclicity are derived and shown in tab. C 8.1.

Tab. C 8.1: Layer intervals which show an apparent cyclicity (compare fig. C 8.1); core sample AV 204, drill site BK 3004/13, 21.1-21.3m

Suspected cycle no.	**Layer interval**	**Number of layers**	**thickness [mm] (relative ratio)**	**presumed identifiable cycles in the analysed section**
1	layer-to-layer	2	corrected mean (without layers: 1, 120; 326): 0.532	163 light/dark couplets (= 326 : 2)
Grouped light & dark cycles (from bottom to top) (= light signal)*				
2	L 226 - L 229	3	2	1
3	L 004 - L 009 L 013 - L 016 L 134 - L 138 L 205 - L 210 L 210 - L 226 L 308 - L 314 L 314 - L 316 L 316 - L 318	5 3 4 5 16 6 2 2	3.2 3.4 3.8 3.3 3.7 3.5 2.8 3.2 mean: 3.4	8
4	L 009 - L 011 L 016 - L 019 L 180 - L 192	2 3 12	4.4 4 4.3 mean: 4.2	3
5	L 011 - L 013	2	6	1
6	L 287 - L 308	21	9.9	1
7	*L 063 - L 102 L 140 - L 180 L 229 - L 287	39 40 58	14.0 13.9 14.7 mean: 14.2	3
8	L 004 - L 019 L 019 - L 046 L 046 - L 060 L 138 - L 205 L 210 - L 287 L 287 - L 318	15 27 14 67 77 31	20.1 23.3 18.0 21.4 20.3 19.4 mean: 20.4	6
9	*L 104 - L 139	35	32.0	1
10	L 019 - L 060 L 062 - L 130 *L 139 - L 272 L 210 - L 318	41 68 133 108	41.3 41.4 42.4 39.7 mean: 41.2	4
11	*L 005 - L 063	58	64.4	1

But what is the meaning of the observed apparent cycles? In table C 8.2 possible relationships between time and thickness periodicities are displayed, following the scheme presented in LONGO et al. (1994: 83).

Tab. C 8.2: Relationships between time and thickness periodicities (AV 204).

Orbital forcing (ka)	**Relative ratio (17.1 ka unit)**	**Relative ratio (20.3 ka unit)**	**Relative ratio (33.1 ka unit)**	**Relative ratio (41.2 ka unit)**	**Relative ratio (100 ka unit)**	**Obser-ved periodi-cities (mm)**	**Relative ratio (2 mm unit)**	**Relative ratio (20.4 mm unit)**	**Relative ratio (32 mm unit)**
17.1	1					2	1		
20.3	1.2	1				3.4	1.7		
33.1	1.9	1.6	1			4.2	2.1		
41.2	2.4	2	1.2	1		6	3		
100	5.8	4.9	3	2.4	1	9.9	5		
400	23.4	19.7	12.1	9.7	4	14.2	7.1		
1300	76	64	39.3	31.6	13	20.4	10.2	1	
2000	117	98.5	60.4	48.5	20	32	16	1.6	1
						41.2	20.6	2	1.3
						64.4	32.2	3.2	2
						projected: 2 x 64.4= 128.8	(64.4)		
Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**	**Column 6**	**Column 7**	**Column 8**	**Column 9**	**Column 10**

In table C 8.2 column 1 lists the orbital forcing periodicities predicted for the Lower Carboniferous (approx. Tournaisian/Viséan borderline, 340 Ma ago). Columns 2 and 3 give the relative ratios of the precession periods in units of 17.1 and 20.3ka respectively. Columns 4 and 5 give the relative ratios of the obliquity periods in units of 33.1 and 41.2ka. Column 6 shows the relative ratios of the 100ka unit of the eccentricity period. Column 7 gives the observed periodicities from the core sample AV 204 (expressed in cm), while columns 8 to 10 display the relative ratios of the values in column 7 expressed in units of 2mm (the shortest observed period), 20.4mm and 32mm.

Best fit results between the "relative ratio time series of orbital forcing" and outcrop data have been obtained for the 17.1ka (32mm unit) and 20.3ka (2 and 20.4mm unit) precession orbital cycles.

With these data we are able to estimate the sedimentation rates for the pelitic background sedimentation of the Bruchberg sandstone formation of the middle Lahn-syncline (BSF-MLS):

17.1ka cycle: 32mm ≅ 17.1ka
180.5mm ≅ 96.5ka
sedimentation rate: 180.5mm / 96.5ka = 1.9 mm/ka

20.3ka cycle: a) 2mm ≅ 20.3ka
180.5mm ≅ 1832ka
sedimentation rate: 180.5mm / 1832ka = 0.1 mm/ka

b) 20.4mm ≅ 20.3ka
180.5mm ≅ 179.6ka
sedimentation rate: 180.5mm / 179.6ka = 1.0 mm/ka

Even if we consider the very fine grained background sediment, a sedimentation rate of 0.1 to 1.9 mm/ka for the BSF-MLS seems to be very unlikely, since it would be even smaller than the derived rate for the Tournaisian Light flinty slates. To solve this problem a closer view to the results obtained for the 20.3ka cycle may be helpful: both, the 2mm and the 20.4mm units show a close relation to the relative ratios of the 20.3ka unit. But the derived sedimentation rates vary within an order of magnitude. In my opinion a *fractal behaviour* of the observed "relative ratio time series" is possible, i. e. the 20.3ka signal is expressed at different scales (shows self-similar behaviour). Unfortunately, we can not predict at which order of magnitude we can deduce the most likely sedimentation rates. Therefore a different analytical method is used.

The stratigraphic range of the BSF-MLS is found to cover the equivalent time from LCC 2003: ci 16.9 — 19.2 (probably earlier: 17.5; compare chapter C 1) in the late Viséan. If we assume a total time of 17 Ma (342 — 325 Ma B. P.) and 67mm on the LCC 2003 for the Viséan we can deduce an average time span of 254 ka per mm of the "time ruler". Hence, the BSF deposition would -statistically seen- have lasted 5842ka (1524ka) in the middle Lahn-syncline.

The longest observed concordant bedded pelitic succession within the BSF-MLS is approx. 15m (BK 3004/14). With this reading, which is assumed to be representative, we can infer a sedimentation rate of 2.6 (9.8) mm/ka. This is the minimum guess.

The maximum guess is obtained if we consider the light/dark-cycles in AV 204 to be sunspot cycles (11a, 22a). The average layer thickness is 0.532mm, hence a light/dark-couplet covers (statistically!) 1.064mm which would be equivalent to the 11a or 22a cycles. By considering the whole possible time of deposition for the BSF-MLS we can deduce a maximum layer thickness of 565m (147m) for the 11a cycle or 283m (74m) for the 22a cycle. This is assumed to be true only, if the whole formation would consist of:

a) pelitic background sedimentation, b) constant sedimentation rates, c) light/dark-signals induced by sunspot cycles. The derived sedimentation rates would be:

11a cycle: 565m (147m) ≅ 5842ka (1524ka)
sedimentation rate: 565m / 5842ka (147m / 1524ka) = 9.7 cm/ka

22a cycle: 283m (74m) ≅ 5842 ka (1524 ka)
sedimentation rate: 283m / 5842ka (74m / 1524ka) = 4.8 cm/ka

The analysed 18 cm core (AV 204) would cover approx. 1.9ka or 3.8ka for the 11a or 22a sunspot periodicity cycles respectively. It seems unlikely that the observed precession cycles (17.1 and 20.3ka) could be identified within a 1.9ka covering core sample, the same seems to be true for a 3.8ka covering core. It is assumed that at least a full 17.1ka cycle must be present in the 18cm core sample in order to detect the cycle at all. With this assumption we are forced to deduce a sedimentation rate of approx. 1 cm/ka.

In conclusion, the sedimentation rate for the pelitic background sedimentation of the BSF-MLS lies most probably somewhere within the range: 1.9 mm/ka — 10 mm/ka. Therefore, the 18cm core sample would cover a time span somewhere between 95ka — 18ka. For further discriminations much more information from longer and well preserved core samples and qualitative and quantitative analyses of the clast-spectrum are needed (as exemplified, e. g., in BETZLER, PFEIFFER & SAXENA (2000: 148-150) for Miocene bioclastic carbonate sequences).

C 8.3 Helle Lydite (Light flinty-slate formation)

1248cm compacted sediment, divided by 184 layers (tab. F 4.2, appendix F 4), are preserved at the abandoned quarry south of Eschenau (E 3440890 - N 5588770); with an average layer-thickness of 6.8cm. Most layers are laterally not consistant, e. g. layer L 008 (22cm) shows a diagenetically induced variation in thickness between 15 and 30cm. This phenomenon is well known from flinty slates (e. g. GURSKY 1997: 73), but the accompanying problems are solved by strictly tracing a vertical section without lateral deviations; the obtained results of this study may act as a proof for this assumption. The flinty-slates show a reddish - but mostly surficial - colouration along fault and joint planes. The original rock exhibits a greyish to darkgrey colour. Without climbing tools and -skills it is impossible to trace directly all layers visible at the outcrop. Therefore, the layers have been traced from a photograph and adjusted afterwards on the lower section of the outcrop.

Tab. C 8.3: Number of layers with specific thicknesses (rounded to 1cm) within the Light flinty slates from the abandoned quarry south of Eschenau (E 3440890 - N 5588770)

Layer thickness [cm]	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Number of layers	10	12	26	27	21	12	17	12	5	11	5	1
Layer thickness [cm]	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**22**	**24**	**25**	**34**
Number of layers	7	6	3	1	1	0	2	1	1	1	1	1

All single results are presented in tab. F 4.2 (appendix F 4) and displayed in figure C 8.2. From the latter the most obvious layer intervals which show an apparent cyclicity are derived and shown in tab. C 8.4.

Tab. C 8.4: Layer intervals which show an apparent cyclicity (compare fig. C 8.2); abandoned quarry south of Eschenau (E 3440890 - N 5588770)

Suspected cycle no.	**Layer interval**	**Number of layers**	**thickness [cm]**	**presumed identifiable cycles in the analysed section**
1	L 032 - L 039	7	41	1
2	L 003 - L 012 L 039 - L 059 L 059 - L 075	9 20 16	98 113 100 mean: 104	3
3	L 012 - L 030 L 027 - L 055 L 144 - L 168	18 28 24	155 172 169 mean: 165	3
4	L 055 - L 088 L 121 - L 151	47 30	215 219 mean: 217	2
5	L 077 - L 121	44	278	1
6	L 088 - L 144	56	362	1
7	L 006 - L 088 L 088 - L 168	82 80	567 531 mean: 549	2

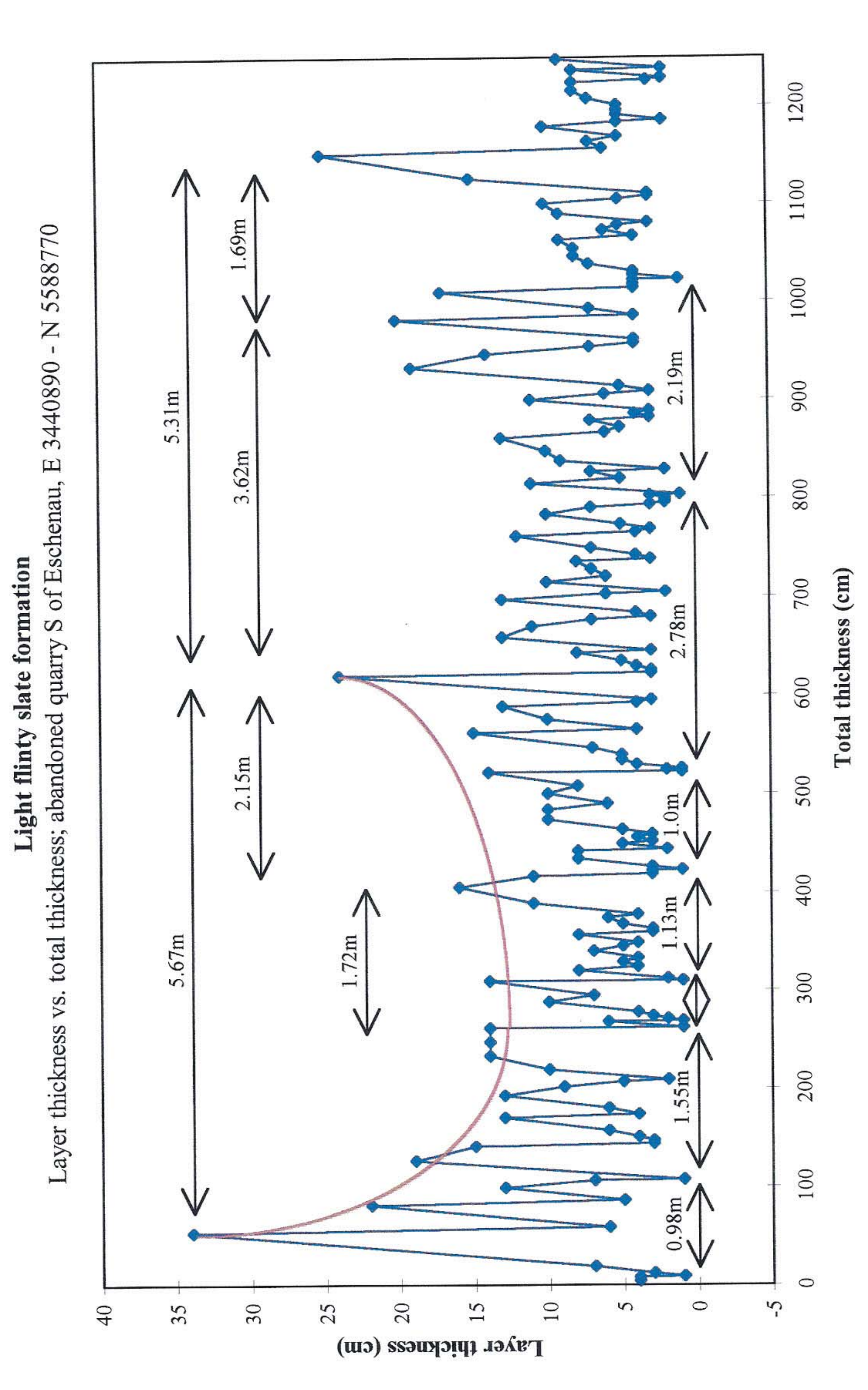


Fig. C 8.2: Results of a detailed analysis of distinctly bedded pelitic layers of the Light flinty slate formation. The red line indicates a probable 1.3 Ma (or 2 Ma) eccentricity cycle.

But what is the meaning of the observed apparent cycles? In table C 8.5 possible relationships between time and thickness periodicities are displayed, following the scheme presented in LONGO et al. (1994: 83).

Tab. C 8.5: Relationships between time and thickness periodicities. See text for details (compare LONGO et al. 1994: 83; Light flinty slates; abandoned quarry south of Eschenau (E 3440890 - N 5588770))

Orbital forcing (ka)	Relative ratio (17.1 ka unit)	Relative ratio (20.3 ka unit)	Relative ratio (33.1 ka unit)	Relative ratio (41.2 ka unit)	Relative ratio (100 ka unit)	Relative ratio (400 ka unit)	Obser-ved perio-dicities (cm)	Relative ratio (41 cm unit)	Relative ratio (104 cm unit)
17.1	1						41	1	
20.3	1.2	1					104	2.5	1
33.1	1.9	1.6	1				165	4	1.6
41.2	2.4	2	1.2	1			217	5.3	2.1
100	5.8	4.9	3	2.4	1		278	6.8	2.7
400	23.4	19.7	12.1	9.7	4	1	362	8.8	3.5
1300	76	64	39.3	31.6	13	3.3	549	13.4	5.3
2000	117	98.5	60.4	48.5	20	5	projected: 5 x 165= 825	(20.1)	
Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**	**Column 6**	**Column 7**	**Column 8**	**Column 9**	**Column 10**

In table C 8.5 column 1 lists the orbital forcing periodicities predicted for the Lower Carboniferous (approx. Tournaisian/Viséan borderline, 340 Ma ago). Columns 2 and 3 give the relative ratios of the precession periods in units of 17.1 and 20.3ka respectively. Columns 4 and 5 give the relative ratios of the obliquity periods in units of 33.1 and 41.2ka. Columns 6 and 7 show the relative ratios of the eccentricity periods in units of 100 and 400ka respectively. Column 8 gives the observed periodicities from the outcrop (expressed in cm), while columns 9 and 10 display the relative ratios of the values in column 8 expressed in units of 41cm (the shortest observed period) and 104cm.

Best fit results between the "relative ratio time series of orbital forcing" and outcrop data have been obtained for the 100ka (41cm unit) and possibly 400ka (104cm unit) eccentricity orbital cycles. Maybe a weak correlation between the 104cm unit and the 20.3ka precession cycle (column 3) is also detectable. In fig. C 8.2 also weak signals for the 1.3 or 2.0 Ma eccentricity cycle seem to be observable.
With these data we are able to estimate the sedimentation rates for the Light flinty slates:

100ka cycle:	41 cm	≅	100ka
	1248 cm	≅	3044ka
	sedimentation rate: 12480mm / 3044ka = 4.1 mm/ka		
400ka cycle:	104cm	≅	400ka
	1248cm	≅	4800ka
	sedimentation rate: 12480mm / 4800ka = 2.6 mm/ka		

GURSKY (1997: 75) mentions an estimated sedimentation rate of 1.8 mm/ka for the Rhenohercynian flinty slates of Lower Carboniferous age. The range of the calculated sedimentation rates, which lies between 2.6 - 4.1 mm/ka, is slightly higher but still in good agreement with GURSKY's guess.

C 9 Colour variations in slates as indicators of paleoenvironment and depositional facies

Various research has been undertaken in order to find reliable relationships between the colour of pelites and/or siltstones and their depositional facies. A good example of present day, actualistic, study was presented by PELLETIER et al. (1968) with correlation of terrigeneous dispersal and present day current systems in the Hudson Bay of Canada. In this intracontinental basinal environment modern clay of predominatly grey to green colour accumulates in deeper and marginal parts of the basin whereas reddish brown clay dominates in the center. This is believed to be a response to slower sedimentation in the center than in the marginal parts of this wide, shallow (max. 257 m deep) sea basin. Depth and dimensions (approx. 1100 x 1000 km) of the Hudson Bay basin are roughly in accordance with estimates for Devonian and Lower Carboniferous distribution of marine paleoenvironments in today middle Europe. Paleogeographic position and tectonic setting, however, was significantly different.

A more relevant model, perhaps, for the depositional environment of Upper Devonian and Lower Carboniferous black shales is presented in STEHLI et al. (1972). In this study shale colour and thickness in a predominatly shaly facies in the Gulfian Cretaceous East Texas Embayment were interpreted together. Black shale is believed to have been deposited in an open ocean in well oxygenated water farthest from source region. The shale is blacker, finer and less permeable basinwards. The colour of the shales show variations from grey (proximal), "more grey than black", "more black than grey" to black (distal) with increasing thickness. This successive colour variation is believed to be indicative of the non-diagenetic origin of shale colour.

Deposition and diagenesis of Upper Devonian red 'pelagic' shales in the Variscan basins of Europe was analysed by FRANKE & PAUL (1980) with sedimentological and geochemical means. According to the authors, the red shales "are restricted to basinal sites without major clastic influx: in areas marginal to turbidite fans, in starved intra-geosynclinal basins, or on the slopes of rises". Into the background sedimentation of red shales intercalations of thin silt layers took place, interpreted as distal or lateral turbidites. The red colouration is attributed to the content of ferric iron in the clay fraction, from which hematite is formed during early diagenesis (compare also EREN & KADIR 1999). In addition, a portion of hematite, minimum 1.5%, is needed to show red colouration at all. The red pigment (hematite) could survive where the organic supply to the sediment was too low in order to consume the available oxygen by degradation of organic matter. Grey-green, green and pale red colouration is believed to be caused mainly by reduction during early diagenesis. Slow sediment accumulation rate and reduced organic influx are assumed to show oligotrophic conditions in the water column, caused by reduced continental afflux from the Caledonian source areas in the Famennian.

The red pigment hematite can

a) build up a seam around clastic grains,

b) show random distribution as pore filling in the sediment or

c) form small concretions (FALKE 1964).

Colour variations of Middle Devonian (Eifelian) slates and siltstones in the Lindlar-Drolshagen region of the western Rhenish Massif were examined by PRESS (1982). "The most important factors during pigment formation are: Eh, ph, supply of detritic iron-bearing minerals, presence of specific cations and anions. The colour of the sediments is influenced by:

- chemical and mineralogical composition (hematite, goethite etc.)
- grainsize of the host sediment
- grade of agglomeration of the iron-oxide crystals
-insertion of foreign ions, e. g. titane in hematite
- Fe_2O_3/FeO-relation in the sediment." PRESS (1982: 121).

A short summary of PRESS' results is displayed in table C 9.1.

Tab. C 9.1: Characteristic properties influencing the colouration of pelitic sediments (PRESS 1982: 121).

Red sediments	Violet sediments	Green sediments	Blue sediments	Black sediments
Fe_2O_3/FeO > 2:1	Fe_2O_3/FeO lower than in red sediments	Fe_2O_3/FeO < 2:1 to FeO > Fe_2O_3	Fe_2O_3/FeO approx. equal to the green sediments	Fe_2O_3/FeO very low
rag-like fabric of very finegrained hematite aggregates	cloudy, opaque to marginal transpa-rent aggregates and pigments; also euhedral hematite plates	chlorite, clay minerals (illite, kaolinite)		organic matter and pyrite present
	insertion of titane in hematite	increase in $CaO+CO_2$ no increase in Fe^{2+}		

C 10 Pyrite occurrence and formation in pelites

Why do we find so much framboidal pyrite in many samples from the analysed region? Is this due to the formerly enhanced injection of iron-bearing hydrothermal fluids into the host rocks (If this is true, why didn't form euhedral pyrite, but framboidal?)? Or caused strongly eutrophic conditions with algal blooms the development of framboids and the destruction of palynoclasts? How do framboids form at all? Are framboids stratigraphically usable? Or are they of importance in palaeofacies-analyses, e.g. as indicators for specific redox-conditions during or shortly after deposition?

In this chapter a short review about the shape, occurrence, chemistry and crystal habit of pyrite framboids is given. It can only act as a small, but concise, overview about the ample literature which has been produced in the last decades on this topic - as well as our own observations.

"Framboids are more or less spheroidal aggregates (mostly from < 1µm to > 100µm) of randomly or nonrandomly distributed, entirely discrete microcrystallites [of pyrite ...]. The term was introduced by RUST (1935) for clusters of tiny pyrite cubes and grains after *framboise* (French for 'raspberry'), because of the external similarity." SCHALLREUTER (1984: 875). "The crystallites of a framboid are normally approximately equidimensional." SCHALLREUTER (1984: 878). Compare fig. C 10.1.

73% of all analysed HF-samples contain free euhedral pyrite as component of the palynospectrum (s. chapter 4). 84% of these pyrite-bearing samples (= 62% of all samples) contain framboidal pyrite, either as single or as polyframboids. All ore minerals - the most prominent in all samples is pyrite - had been analysed by using reflected light microscopy. The detailed results for each sample are listed in chapter 4; some photomicrographs of pyrite framboids and single euhedral crystals are displayed on plate F 2-2 in appendix F 2.2. Even with the use of comparatively simple statistical analyses it was possible to show that the more pyrite is observable, the less organic fossil material is determinable up to species level.

But that doesn't mean all samples with ample framboidal pyrite show poor fossil conservation; some pyrite-bearing samples (e.g. AV 210) also display sufficient fossil preservation. Within this context, "sufficient" means the disaggregation of the palynomorphs is observable at different levels, but only the well preserved palynomorphs can be determined, and only these may lead to an attachment of a sample to a specific biostratigraphic niveau. The search for the latter is very time-consuming and each specimen has to be tested for its completeness and/or if it displays secondary, erroneous, features which had been developed during disaggregation. A further complication is added to this misery: the relatively strong thermal alteration with accompanying opacification of the palynomorphs, which makes determinations via transmitted light microscopy much more difficult or inhibits them at all. Therefore, preliminary determinations from photomicrographs were impossible in most cases and had to be completely undertaken at the microscope, using combined transmitted/reflected light microscopy.

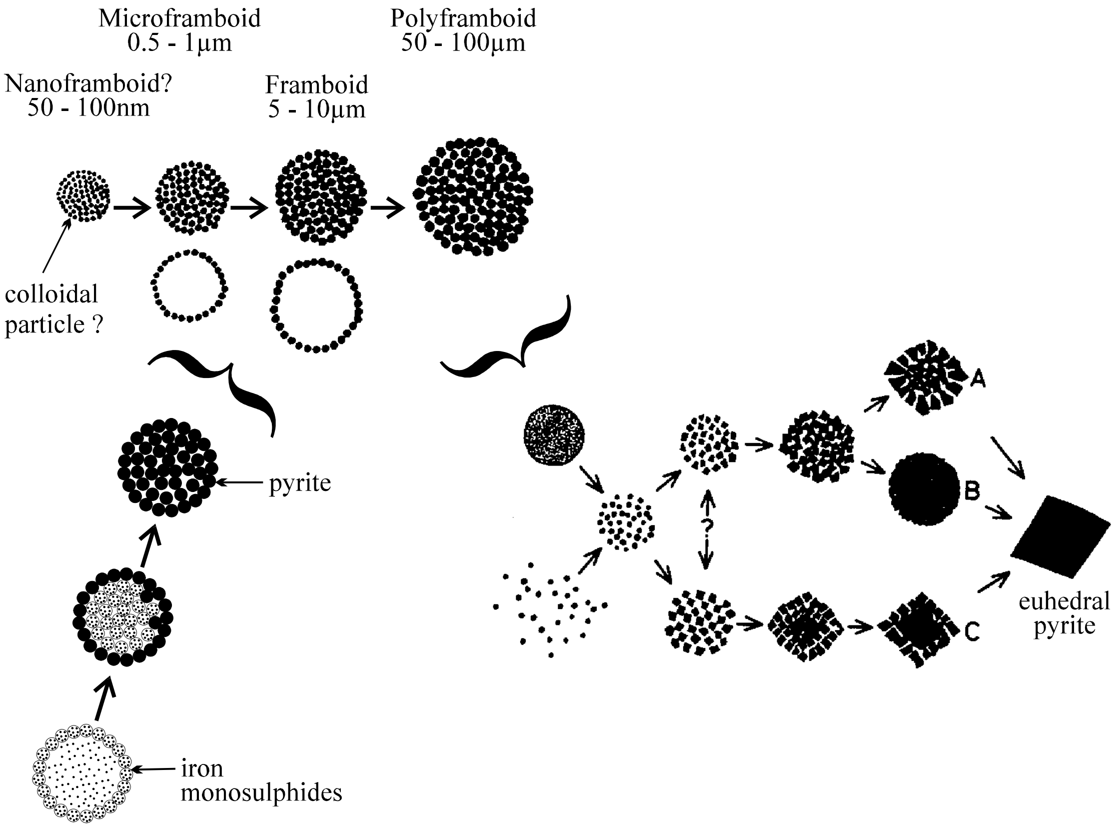


Fig. C 10.1: Possible pathways in the formation process of framboidal and euhedral pyrite (modified after SAWLOWICZ 1993: fig. 2, 4 & 5).

The upper part of the diagram displays various orders of size and complexity of pyrite framboids. It seems that the different scales of size and complexity of framboidal forms show fractal behaviour or self-similarity and are related to a continuous growth and rearrangement of framboids into euhedra (SAWLOWICZ 1993: 153). Polyframboids show "a texture in which the framboidal texture itself is compounded, so that the body is of a higher order of complexity and correspondingly greater size. It is, however, still a spheroid when not deformed." (LOVE 1971:1038f).

The lower left part shows a hypothetical pathway for the formation of framboids via annular framboids. Such 'hollow' framboids consist of a sphere built of minute pyrite grains. Annular framboids form because of the low availability of iron and/or sulphide, early sealing of the empty interior by phosphates or metal sulphides, or replacement of metastable iron sulphide intermediates by some metal sulphides (SAWLOWICZ 1993: 154).

In the right part of the diagram hypothetical pathways for the formation of euhedral pyrite via framboids are displayed. Pathway A: when the microcrysts in the framboid are closely packed, a layer of elongate grains - probably formed during the main stage of crystallisation of pyrite framboids - is sometimes observed. In some instances further growth of the outermost pyrite grains can transform this texture into an idiomorphic crystal. Pathway B: a continuous growth of microcrystals in the framboids is producing amalgamation, which fill in the remaining spaces and induce the formation of massive pyrite spherules (which themselves might evolve to euhedra). Pathway C: stable internal geometric patterns and/or surrounding material which is plastic enough to be displaced, may lead straight to the growth of regular faces of euhedra via a polygonal framboid. (SAWLOWICZ 1993: 152).

Framboids "develop within such comparatively large bodies as the tests of diatoms or foraminifera. In older sediments the [...] framboids are particularly well known developing within the exine material of spores and pollen and hystrichospheres and it is safe to say that smaller individual sacs are the remains of hosts of small few - or single - celled plants or animals." LOVE & AMSTUTZ (1966: 293f, see also, e.g.

CASTANIER et al. (1994) for bacteria-like pyrite aggregates**). It is assumed in this work, that some pyrite framboids developed within phycomata of unidentified acritarch "sacs", which had been mostly observed and are quite abundant in Lower Carboniferous samples** (see fig. C 10.2 and appendix F 2.2, pl. F 2-8).

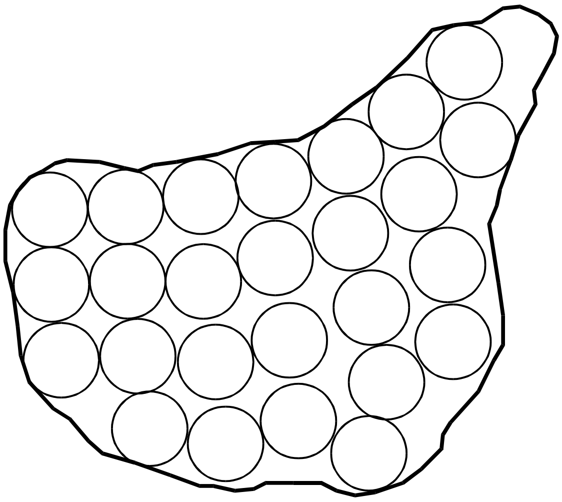


Fig. C 10.2: Unidentified acritarch "sac" before excystment, with phycomata in it (approx. x1000; compare, e.g., palynomorph-slides AV 10-1, 31.4/109.8 (partly transparent); AV 10-2, 52.1/112.8 (partly transparent); AV 227-1, 43.1/110.0 (partly transparent); ? AV 1-4, 39.8/106.3 (plate F 2-8, fig. 7, opaque). The framboid formation could have taken place in single phycomata via iron monosulfide precipitates (greigite). Due to rapid crystal-nucleation at the outer rim initial annular framboids had been built and later pyrite framboids of shape and size of the original phycomata were generated. After disaggregation of the organic material only the framboids had been left. In this way and if the above presented hypothesis is true, great amounts of pyrite framboids may act as indicator for former rapid (prasinophycean?) algae production or algal blooms.

The formation of framboids via aggregation processes does not directly rely on organic substrates, since inorganic laboratory syntheses had also been possible and hydrothermal occurrences of framboidal pyrite had been observed. "However, organic matter may be the site of high rates of sulfide production by sulfate reducing bacteria and the consequent precipitation of iron monosulfides." WILKIN & BARNES (1997: 335). "Combined with geochemical characterization, the study of pyritized microbes in the geologic record may in the future enable us to interpret changes in geochemical signatures more realistically in terms of different sulfate-reducing communities." (SCHIEBER 2002: 531). "In addition, whereas chert-based microbiota are biased toward photosynthetic surface communities (FARMER 1999), the pyrite hosted microbial record enables us to examine the largely unknown fossil record of anaerobic microbial communities." (SCHIEBER 2002: 533).

"In sedimentary rocks, pyrite framboids are generally considered as syngenetic (formed in the water column [...]) or early diagenetic components (e.g. LOVE and AMSTUTZ 1966 [...]). In some instances, however, they can also form during late diagenesis, e.g. by the pyritisation of biotite [...] or magnetite [...]." SAWLOWICZ (1993: 148).

"The regular form and size of microcrystals within individual grains [is most probably due to the development of all microcrystals] during a single nucleation event. Aggregation of microcrystals should result in structures that extend from loose irregular aggregates to dense spherical aggregates and polyframboids." WILKIN & BARNES (1997: 335).
"The arrangement of the microcrysts within framboids varies from random, linear or concentric to polygonal [...]. It seems that the regular arrangement of microcrystals in framboids can be as early as for a primary colloidal iron hydroxide. LOVE and AMSTUTZ (1966) gave detailed descriptions of ordering patterns in the framboids. However, it is not obvious if the ordering of microcrysts in a framboid is a uniform feature partly or completely lost during diagenesis, or if some of the framboids are primarily disordered." SAWLOWICZ (1993: 150).

"The microcrystals within framboids are colloid-sized. [... Calculating van der Waals and electric double-layer interactions] colloidal iron-sulfide suspensions should be stable in fresh waters and unstable in marine waters (pH 5-8). The addition of a magnetic term to account for the interparticle interactions between greigite grains, however, results in unstable suspensions [...], consistent with the occurrence of framboids in both marine and lacustrine sediments. Rates of aggregation are predicted to be fast or on the order of hours to days." WILKIN & BARNES (1997: 335f). The proposed presence of "magnetic aggregation is consistent with the occurrence of framboids composed of other magnetic minerals, e.g., greigite, magnetite, and magnesioferrite." WILKIN & BARNES (1997: 336).

Framboids represent quite probably a metastable form between loose aggregates and euhedral pyrites. "The possibility of pyrite recrystallization from framboidal crystals to single grains has been reported by several works (e. g. LOVE, 1965; [...] LOVE and AMSTUTZ, 1966; [...])." SAWLOWICZ (1993: 150; compare also fig. C 10.1). These reports are consistent with observations of disseminated euhedral pyrite crystals, which are often intimately mixed within a few micrometres of sediments with pyrite framboids of similar size (SAWLOWICZ 1993: 150).

Due to SAWLOWICZ (1993: 150) 3 different "mechanisms may lead to the homogenization of framboids and the formation of euhedral crystals:"

a) Infillings (new pyrite fills the spaces between the granules or microcrystals in the framboids. It seems probable that observations of LOVE (1967: 333) are consistent with this process. LOVE described framboids, whose "internal detail is blurred by continuity of the pyrite between adjacent grains so that the latter do not appear clearly defined or even become indistinguishable.");
b) 'Sammelrekristallisation' (german term for 'collection or fusion-recrystallisation'; LOVE and AMSTUTZ 1966). "In the process of 'Sammelrekristallisation' the existing pyrite crystals weld together without the addition of new material [...]. Although in some instances this process can probably produce framboids, it cannot lead to the development of euhedral crystal from a framboid because [...] this simple reorganisation should bring about a reduction in volume, which is never observed." SAWLOWICZ (1993: 150);

c) Transformation of framboids due to a continuous supply of the constituting material (with framboidal pyrite as an intermediate stage). "The process of transformation of the framboids into euhedra might be the result of a trend towards minimization of the surface energy." SAWLOWICZ (1993: 150).

The majority of sedimentary pyrite crystals (framboidal and euhedral) are made up by three forms: "the octahedron {111}, the cube {100}, and the pyritohedron {210} [..., compare fig. C 10.3]. The majority of the crystals in framboidal, euhedral and finer equant pyrites are built up from the unequal combinations of octahedron and cube or cube and pentagonal dodecahedron [...]".HÁMOR (1994: 174).

Due to HÁMOR (1994: 176) do pure octahedra not occur in metasediments and pyritohedra do not occur in recent or relatively young sediments. This is in agreement with SUNAGAWAS (1957) observations that cubic crystals grow under "unsuitable conditions".

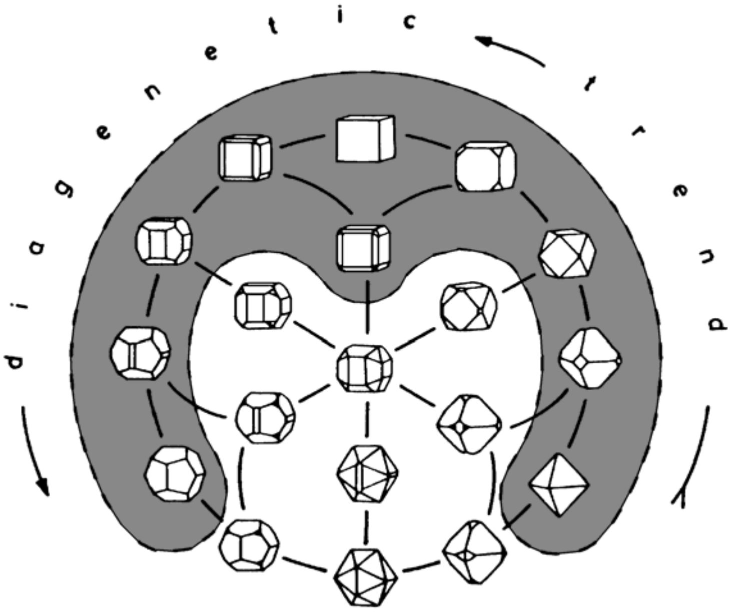


Fig. C 10.3: Crystal habits of pyrite (after SUNAGAWA 1957). HÁMOR (1994: 175) added the interpretation for the grey shaded areas: In the course of his research he found sedimentary pyrite only in these habits and observed the indicated general diagenetic trend to form the displayed crystals. During diagenesis first octahedrons (111) are formed (lower right crystal in the grey shaded area). Via different combinations between cube and octahedron the cubic crystals (100) form (top of the diagram). Next unequal combinations between cube and pyritohedron are observed and lead to the "pyritohedron" or pentagonal dodecahedron (210) itself (lower left part of the grey area). The only exception for a combination between octahedron, cube and pyritohedron is displayed in the lower upper part of the grey shaded area: edges of the cube are modified by small {210}-faces and the corners by {111}-faces.

It has recently been proven by PASSIER et al. (1997: 522) in their research about a young marine sapropel (i.e. organic-rich layers in a hemipelagic sediment sequence) from the eastern Mediterranean, that fluctuations in the production of HS^- relative to the supply of reactive Fe control directly the properties of pyrite. They found, when "HS^- production in the sapropel is relatively low, Fe reaches the source of HS^-

inside the sapropel, a pyrite enrichment forms, and pyrite formation is rapid, resulting in a framboidal texture. When HS^- production is relatively high, HS^- breaks out of the sapropel, and forms the euhedral pyrite [...]."

WILKIN & BARNES (1997: 335) put emphasis on the important role of greigite in framboid formation and described four steps which control the pyrite formation:
1. Initial nucleation and growth of an iron monosulfide,
2. Reaction of the initial monosulfide to greigite (Fe_3S_4),
3. Aggregation of greigite microcrystals, and
4. Replacement of greigite by pyrite.

The formation of greigite requires weakly reducing conditions. "Thus, the formation of greigite and framboids is spatially linked to redox interfaces that separate waters containing dissolved oxygen and sulfide, respectively." WILKIN & BARNES (1997: 336).

Dissolution and precipitation of pyrite-precursors are largely controlled by the unusually large specific surface area exhibited by Fe-bearing solids (Fe(II, III) (hydr)oxides, Fe(II) sulfides and disulfides, and Fe(II) silicates). This allows surface complexation by surface ligand exchange, hence enables them to interact chemically with complex forming ligands, reductants and oxidants and facilitates electron transfer (STUMM & SULZBERGER 1992: 3254).

Another interesting feature has to be revealed. PASSIER et al. (1997: 522) reported that "the $\delta^{34}S$ of the [pyrite] euhedra is not heavier than the $\delta^{34}S$ value of the framboids, because the source of HS^- is the open SO_4^{2-} reduction system close to the sediment-water interface for both textures, and there is no distinction between early diagenetic pyrite formed close to the sediment-water interface and pyrite formed during later diagenesis far below the sediment-water interface." Hence, research on $\delta^{34}S$ isotopes turns out to be useless in characterising the properties of framboidal pyrite in sapropels, since "HS^- has formed in a system with abundant SO_4^{2-} and in the presence of oxidants" (PASSIER et al. 1997: 519).

As reported earlier, framboidal pyrite can not only form in sediments but also from hydrothermal solutions. Since greigite is an essential precursor in pyrite framboid formation we have to ask how greigite-formation and -persistence takes place at elevated temperatures. Experiments of WILKIN & BARNES (1997: 336) "suggest that only below 200°C, can greigite persist in hydrothermal solutions long enough for the aggregation of microcrystals to proceed. The preservation of framboidal texture in hydrothermal environments may be limited by secondary growth of pyrite that results in infilling of framboids with pyrite and continued outward growth of pyrite."

C 11 Fractal analysis: method, results and interpretation

"All too many disciplines harbour the strong wish of becoming quantitative, but do not know even how to begin. One standard way is to ask new questions for known answers, that is to borrow procedures from disciplines that have already reached a quantitative stage, and to hold on to these procedures if they appear to be effective. One finds that procedures one could borrow are not particularly numerous. While the diversity of nature appears to be without bound, the number of techniques one can use to grasp nature is extremely small and increases very rarely. Therefore, the enthusiasm usually generated by the birth of new technique and the desire to test it more widely is healthy, and must not be disparaged."
"... a collegue of ours saw a very old article [...]. Next to a photograph that could have been taken yesterday, a diagram meant to summarise what the original photographer had seen in his work. Unfortunately, what he had seen turned out to lead nowhere, but what he has smoothed away turned out to prove important, and it included the fractal features."

B. B. MANDELBROT (1990: 11)

C 11.1 Introduction

(The following short introduction is mainly extracted from GHOSH & DAEMEN (1993).)

„A fractal is a shape made of parts similar to the whole in some way."

(MANDELBROT 1987, quoted in FEDER 1988)

The fractal (abbreviation for "fractional") dimension quantitatively determines the ruggedness of an object.

Structures in the Euclidian space - e. g. a straight line, a plane surface or a sphere are smooth. However, real objects are clearly distinct from ideal shapes in the Euclidian space. A fractal object can have a non-integer Dimension which exceeds the topological dimension in the Euclidian space. Fractal structures are non-analytic at every point. Hence, these objects are not differentiable and a tangent cannot be drawn at any point on the entire object.

If an object can be divided into N(R) = b subintervals of the dimension R = 1/b, then the dimension D of the object is defined as (MANDELBROT 1982):

$$D = \frac{\log [N(R)]}{\log [1/R]} \qquad \text{(1 - HAUSDORFF-BESICOVITCH dimension)}$$

Equation 1 may be transformed into:

$$\log [N(R)] = D \log [1/R]$$

or:

$$N(R) = R^{-D} \qquad (2)$$

This means that an object may be subdivided into N parts each of which has been scaled down from the original by a factor R<1. Equation 2 is valid only for a self-similar object where the structure of the object is scale invariant.

A natural object is, however, rarely or never exactly self-similar. Its self-similar property can only statistically be determined. A small portion of the body looks alike, but is not exactly the same as the scaled version of the total body. Usually upper and lower limits exist for the scale over which the natural system shows self-similar property.

If the number of squares with a characteristic size $\psi > L$ (some specific value) required to cover the entire network $N (\psi > L)$ varies as:

$$N (\psi > L) \sim L^{-D}$$

then D is the fractal dimension of the discontinuity network.

C 11.2 Methodology used in this study

The fractal dimension D should be specific for specific rock masses on which a certain stress field was applied. Therefore investigations into the fractal properties of apparently similar reacting rock masses from different locations and times should give answers to the following questions:

Q1. Are fractal properties detectable?

Q2. Are different fractal properties for similar reacting rock masses detectable? This would give a valuable hint towards an implacement of nappe-structures.

Q3. Are different fractal dimensions for similar reacting rock masses of different age detectable?

Q4. Do small scale and larger scale tectonic structures show different fractal dimensions?

Q5. Is there any relationship between tectonic structures visible - or not visible - in the outcrop (extension fissures in shear zones, folds) and the fractal dimension?

Q6. What are the upper and lower limits for the scale over which the discontinuity network shows self-similar property?

Q7. Does fractal analysis present new and appropriate means in order to detect and/or describe tectonic properties?

Q8. Is there any important measurable effect if the observed discontinuity network is rotated by a certain amount (i. e. is it necessary that the lines of a square counting box lie parallel or perpendicular to the cleavage and/or bedding planes) ?

In order to answer all these questions appropriate outcrops have been searched for, which should preferably match all the following properties:

a) heavily jointed rock;
b) appropriate size of uncovered jointed rock mass;
c) outcrop surfaces should show preferably a-c-cuts;
d) outcrop surfaces without apparent dominance of bedding surface traces over the discontinuity (fracture/joint/cleavage) network;
e) outcrop surfaces with rock material which apparently reacted in similar ways to the applied stress field.

The only outcrop within the area of interest, which fulfilled nearly all the above mentioned conditions, was that opposite of the Aardecker Mühle, southwest of Limburg. There, mainly dark slates of latest Emsian/earliest Eifelian age occur. Another apparently appropriate location with Late Emsian slates was found north of the Oberhofer Mühle. The Emsian slates are situated directly south of Lower Carboniferous flinty slates in a former small quarry. Along the forest road towards this quarry the Emsian slates were evenly cut through in the course of quarrying, subparallel to their a-c-faces. I cleansed the slates from moss, grass and lichen, and then inspected them again. Unfortunately it then became apparent that the bedding surfaces of these slates with minor silty intercalations as well as very small iron-carbonate nodules dominated the discontinuity network. Hence, this outcrop turned out to be inappropriate. However, the distinctly bedded Tournaisian flinty slates situated directly north of the Emsian slates appeared to be heavily jointed at a cm-scale. In order to verify this, sample AV 1 was taken for laboratory treatment.

In order to meet almost all the above named necessary conditions, the fractal analyses have only been untertaken on two locations:

a) Outcrop with heavily jointed Tournaisian black bedded flinty slates north of the Oberhofer Mühle. There the sample AV 1 was taken and prepared (cut) for small scale analysis. A transparent overlay was fixed onto the a-c surface of the flinty-slate bench cut surface. Within a 6 x 6 cm square all visible joints were traced and drawn on the overlay. Since the joints are quartz-filled and show whitish and light-greyish colours they were easily distinguished from the black "groundmass".

Oberhofer Mühle, sample AV 1 (6 x 6 cm)

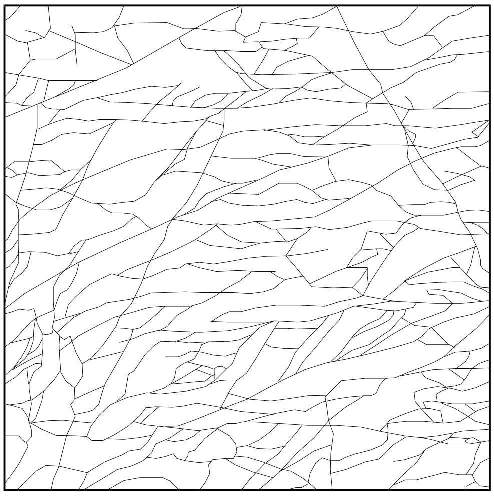


Fig. C 11.1: Visible discontinuity network on a 6 x 6cm area of a Tournaisian flinty slate from a location near the Oberhofer Mühle.

b) Outcrop (more than 40m long) with heavily jointed black slates opposite of the Aardecker Mühle (compare appendix F 1, fig. F 1.1, "section"), mostly of Emsian - Eifelian, partly of Upper Devonian age. The face of the outcrop, which is oriented subparallel to a-c-cuts, shows no plane surface.

The following procedure was applied in order to extract the visible tectonic framework and discontinuity network during a low-vegetation period (April 1995):

1. Construction of a wooden grid-frame, 1.0 x 1.5m, subdivided into 10 cm squares by thin wires. This was to be used as a reference frame for photographic documentation.
2. Cleansing of the surface of the outcrop.
3. Positioning of the reference frame into the range of each photo.
4. Holding of always equal distance to the face of the outcrop (as far as possible) while taking pictures on a black-and-white film.
5. Each photo has to overlap its left and right neighbour by approx. a quarter.
6. Development of the photos - each equally scaled by using the reference frame on the photos.
7. Cut and attach the equally scaled photos together to a long photo-collage.
8. Overlay this collage with a transparency and trace all visible discontinuities - and some other important outcrop features (vegetation, walls, etc.) for a better orientation.
9. Scan (or digitalise) this copy and transfer the resulting picture into a vector graph.

The result of these procedures is presented in **enclosure 1**, where four quadratic areas (Aardeck A - D) have been selected for the fractal analysis. It is important to pay special attention to the fact that the resulting picture is artificial and does not exactly represent the whole visible discontinuity network - but only the proportion detectable from a certain distance, with a certain technique and within a certain observation range. In area D, at the northern margin of the outcrop, the resulting effect after rotation of the discontinuity network was tested. For comparisons also a sedimentary log and a section showing the general structural features have been prepared and presented in fig. C 11.2.

The visible discontinuities may be regarded as space-filling curves. The fractal dimension of the fracture network has been determined using the „box-counting-method" (VOSS 1988). A square grid (64 mm x 64 mm) was laid over the drawing of the fracture network. Then the number of unit squares filled with traces of fractures was counted. A grid of the same size but with more yet smaller squares, was used in the next calculation. Again the counting process was untertaken. This process was repeated with grids with finer and finer squares. The biggest used unit square size was 16mm (16 countable unit squares), then steps of 8mm (64 unit squares), 4mm (256 unit squares) and 2mm (1024 unit squares) have been used.

Three parameters characterise the observed discontinuity network (LA POINTE 1988):

1. *Network complexity*: measures the complexity of the network, formed by the individual traces of the discontinuities by counting the number of unit squares filled with traces of fractures.
2. *Fracture density*: measures the intensity of the discontinuities by counting the number of fractures per unit square area of the rock face.
3. *Block density*: measures the interconnectivity of the discontinuities by counting the number of blocks produced by the fracture traces per unit square area of the rock face.

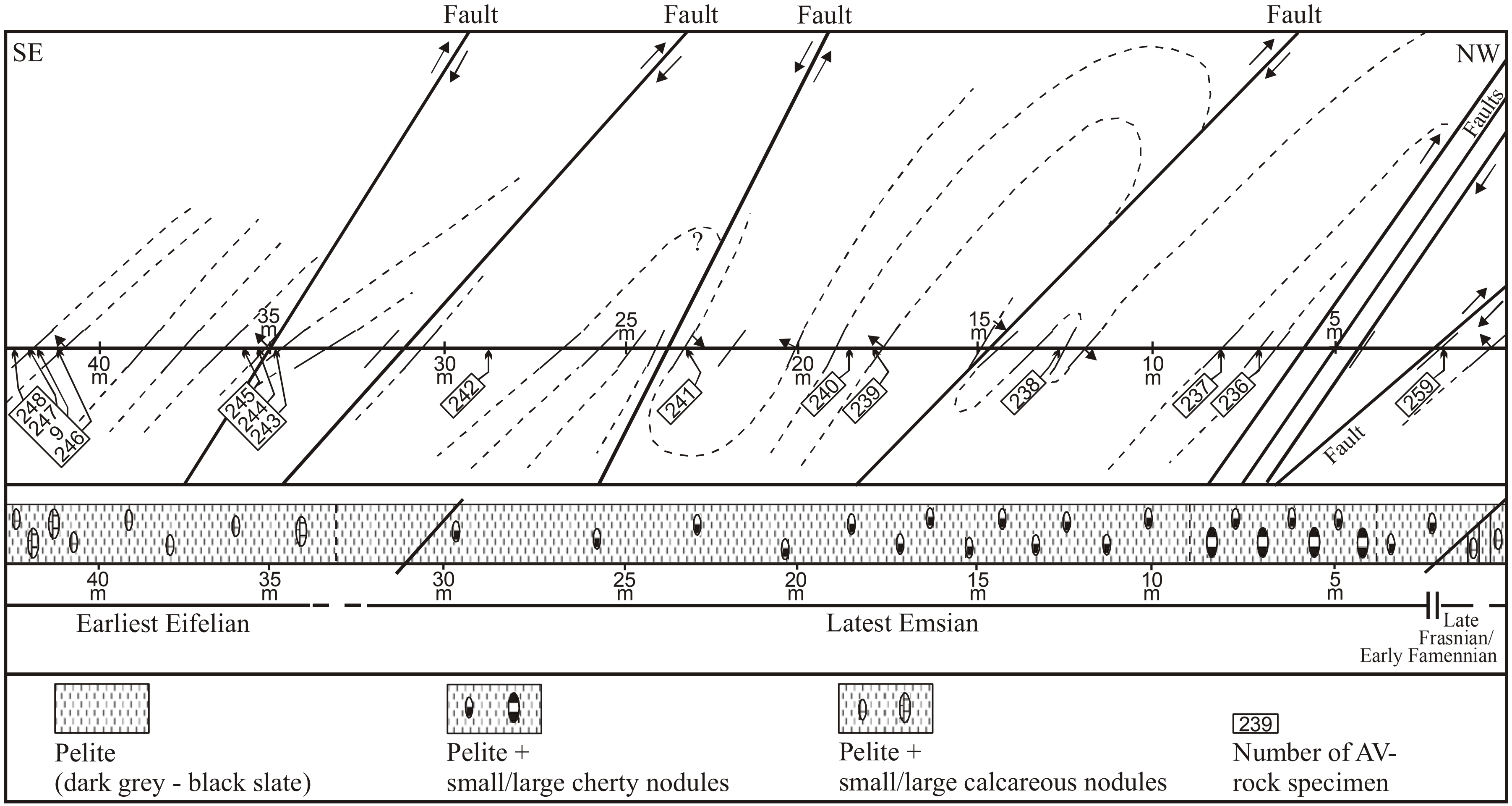
The fractal dimension D_{dn}, which characterises the complexity of the discontinuity network in two dimensions, should lie within the limits $1<D_{dn}<2$. D=1 gives a straight line. D=2 gives the entire plane, i. e. the discontinuity traces cover the whole rock face of interest.

The "three-dimensional parameters" fracture density or block density can be represented as a rugged surface in the X - Y coordinates associated with the rock face. The Z coordinate at any point is proportional to the number of fractures or blocks per unit area. By summing up the height (Z-values) of equal size small squares required to cover the whole rock face of interest, the area of this rugged surface can be estimated.

NEXT PAGE:

Fig. C 11.2: Sedimentary log and a section showing the general structural features of the outcrop opposite of the Aardecker Mühle

Fig. C 11.2: Sedimentary log and the general structural features of the outcrop opposite of the Aardecker Mühle



The same grids used for the determination of the fractal dimension of the discontinuity network (D_{dn}) have been used for intensity and interconnectivity analyses. Instead of counting the unit squares filled with discontinuity traces, for the determination of the fractal dimension of the fracture density (D_{fd}) or the block density (D_{fd}), respectively, the number of fractures or blocks per unit square have been counted.
If the discontinuity network shows self-similar properties in a two-dimensional cut, then the fractal dimension in three dimensions is given by:

(D+1) with the limits: $2<(D+1)<3$

therefore:

$$D_{fd} = \frac{\log [N(R)]}{\log [1/R]} + 1 = \frac{\log [N(R)] + \log [1/R]}{\log [1/R]}$$

The same is true for the determination of D_{bd}.

In the course of the counting procedure the size of the unit squares decreases, hence, more and more peaks and troughs of the surface have to be taken into account. Therefore, the area of the surface increases due to better estimation (CLARKE 1986). As a result, the calculated fracture density and the block density in any region of the analysed rock face increase as the size of the unit square used for counting is increased. To represent the data in a common scale, the calculated densities need to be normalised by the maximum density obtained at any square of the grid (GHOSH & DAEMEN 1993).
The normalised densities have been used in the fractal analyses.

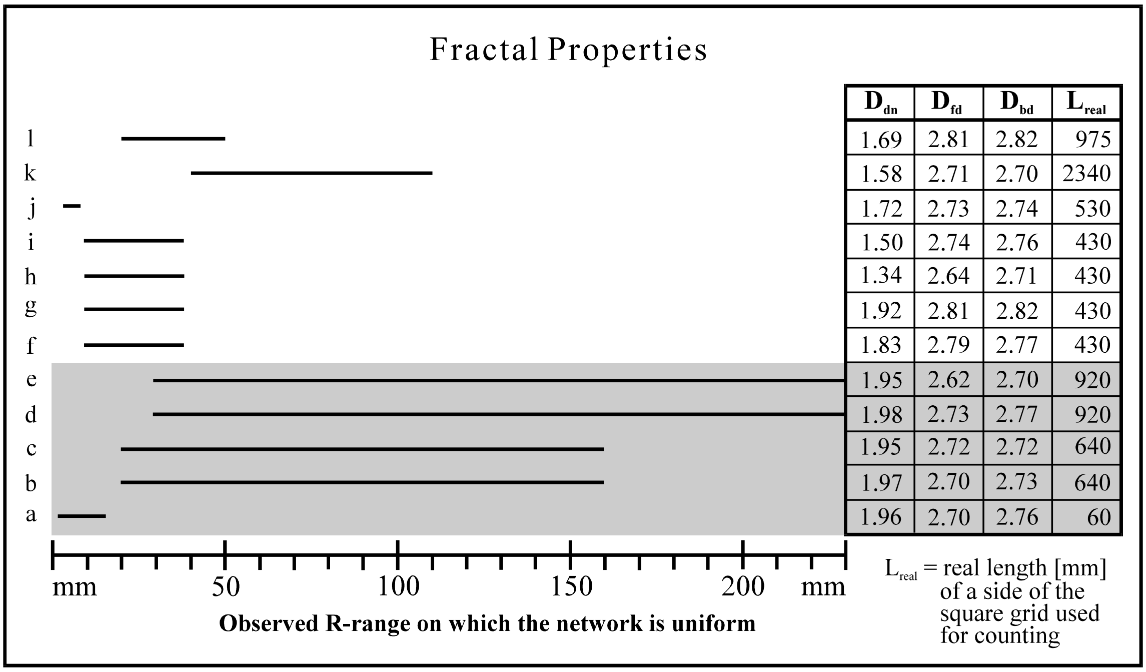
The detailed results for these analyses are presented in tables F 5.1 to F 5.6 in appendix F 5.

C 11.3 Results

1. The fractal dimensions for the discontinuity network, block density and fracture density vary only by 1-3 % for Emsian and Tournaisian slates from 2 locations approx. 12 km apart (but on a line subparallel to the average strike direction of major fold- and thrust-structures (SW-NE)).
   The data for the Tournaisian slate have been obtained from a small (6 x 6cm) polished surface; whereas these for the Emsian slate were derived from several outcrop surfaces.

2. Since we may assume that on both locations the same tectonic regime was employed and both analysed rock types reacted similarly to the applied stress field, it seems obvious that:

a) For future fractal analyses in this region it is sufficient to analyse only small polished samples instead of large outcrop surfaces (scale invariance testified, compare fig. C 11.3). This reduces the necessary expenditures extremely.



	D_{dn}	D_{fd}	D_{bd}	L_{real}
l	1.69	2.81	2.82	975
k	1.58	2.71	2.70	2340
j	1.72	2.73	2.74	530
i	1.50	2.74	2.76	430
h	1.34	2.64	2.71	430
g	1.92	2.81	2.82	430
f	1.83	2.79	2.77	430
e	1.95	2.62	2.70	920
d	1.98	2.73	2.77	920
c	1.95	2.72	2.72	640
b	1.97	2.70	2.73	640
a	1.96	2.70	2.76	60

Fig. C 11.3: Comparison of fractal properties obtained during research on fracture networks by GHOSH & DAEMEN (1993) and in this study. The horizontal bars, which indicate the observed R-ranges on which the network is uniform, reflect the sort of subdivision of the used counting net. Note, esp. when comparing items a - e, whatever the observed ranges are, small or broad, they do not have any effect on the fractal dimensions.
[a: Oberhofer Mühle AV 1 (Tournaisian flinty slate); b - e: Aardeck A - D (Emsian slate); f - l: from GHOSH & DAEMEN 1993: Precambrian pinal schist and dacite, f: photo 16A17 (bench face 1), g: photo 17A18 (bench face 1), h: photo 17A18 (bench face 1, only major joints traced), i: photo 18A19 (bench face 1), j: photo 9 (bench face 2), k: photo 25 (bench face 3), l: photo 1 (bench face 4)]

b) The analysed Emsian slates from the Aardecker Mühle are in a proposed parautochthonous position whereas the Tournaisian slates from near the Oberhofer Mühle are probably part of the Giessen nappe. If this is true it would imply that for both - the parautochthonous as well as for the allochthonous - units in the analysed region the same stress field, hence the same style of tectonic deformation, acted from a certain point in geological history onwards. In other words: if this is true it would be *impossible to distinguish between autochthonous/allochthonous lithologic units only by using small (outcrop-) scale standard tectonic analyses*.

3. What is the meaning of the obtained data for the fractal dimensions?

The fractal dimension D_{dn} = 1.95-1.98 of the discontinuity network would mean the extent of brittle deformation has reached nearly its expected maximum state (2-5% below D_{dn} = 2). The rock mass is systematically shattered into small pieces and the flow of fluids (e. g. groundwater, hydrothermal fluids) through such a rock should reach its maximum. However, when analysed in 3 dimensions, the data for D_{fd} = 2.62-2.73 and D_{bd} = 2.70-2.77 lie well below (38-27% or 30-23%) the maximum value of

D = 3. That means although the discontinuity network has reached a very complex structure, the intensity of the discontinuities (measured through D_{fd}) and the interconnectivity of the discontinuities (measured through D_{bd}) lie a quarter to a third below their theoretical maximum value. This has an obvious practical implication: for measurements across a tectonic deformation front the D_{dn} data would now no longer be indicative since their maximum (within the limits of the observed R-ranges) is nearly reached. The D_{fd} and D_{bd} data, however, could further be used for palaeostress-analysis:
The fractal dimension is proportional to the area of the surface of the whole system, i.e.:

$$\Delta_a = \frac{b^{(D-1)}}{b} - 1$$

where Δ_a is the change of the surface-area, D is the fractal dimension and b is 1/R (HIRATA 1989, TANNER 1996). The surface area is at a minimum, when in two dimensions the value is 1 and in three dimensions the value is 2. It increases when the fractal dimension increases (e.g. the surface of sample Aardeck A is at least approx. 6 times greater at the level of D = 2.7 than at the level D = 2).

4. The displayed discontinuity network in enclosure 1 is much more complex than the general structural features would imply which we get via standard structural analysis (fig. C 11.2). Traces of the latter structures are hard to detect within the observed discontinuity network. In enclosure 1 two small shear zones (small rectangles) are outlined which show characteristic features and would allow for an analysis of shear direction and general compressional and rotational trend.
The explanations for these different results are:
a) For standard tectonic analysis strata-bound features (layers, beds) are analysed with respect to their behaviour if a stress field acts on them, i. e. to what extent are layers tilted, rotated, folded, stretched and/or compressed and what accompanying features like joints, faults etc. develop with respect to each other.
b) In the fractal analysis all the above mentioned structures and even more are analysed together. The complex structure of the visible discontinuity network is generated because of inhomogeneities in the original sediment/rock mass. The presence of such inhomogenities (microflaws, heterogenous material) at the microlevel creates, therefore, a stochastic fractal with no regular pattern like, e. g., a perfect SIERPINSKI gasket would show.

5. Answers (A 1-8)) to the initial questions (Q 1-8):
A1: yes — A2: no — A3: no — A4: no, at least not within the observed range — A5: no directly observable relationship — A6: observed at least: 2mm to 0.23m, no limits detected — A7: yes, but much more research is needed, esp. in order to shorten the analytical process — A8: yes, but only if there is an anisotropy measurable within the discontinuity network; however in our test (Aardeck D) the obtained values showed a difference of less than 4 %.

C 12 Palaeofacies reconstruction from drill core descriptions

Numerous drillings had been put down north of Limburg up to approx. 40m depth during the planning phase for the new railway track Cologne-Frankfurt. The observed lithologies comprised Quaternary, Tertiary, Carboniferous and Devonian strata. Vertical movements along deep-seated fault planes in the Limburg Basin, a NNE-SSW striking graben system (a minor part of the Rhine graben system), lead to the conservation of the Quaternary and Tertiary layers. The process was accompanied by extensive magma outflow, which, in turn, lead to the circulation and injection of hydrothermal fluids into the country rock. Most of these penetrated strata became totally disaggregated in a way that prohibited any further proper geological observation.

Due to the aim of this task only the drill-cores with Palaeozoic lithologies were of special interest. From these, only the relatively well preserved cores had been described in more detail - as correct as possible under the circumstances met. The drill core descriptions had to be regularly undertaken in a relatively short time period, since only small capacities for the storage of the cores had been available in Limburg before removal. At last, it was possible to select 18 of these drill cores from mostly Upper Devonian and Lower Carboniferous lithologies. They were described, sampled, diagrammatically presented and their strata rotated to zero dip for palaeofacies analysis (see fig. C 12.1 for locations and appendix F 3 for detailed descriptions). For comparison, also samples from a Lower Carboniferous sandstone in a nearby quarry (see fig. C 12.1, AV 25) had been collected and analysed.

Due to the relatively short time period available for the description of each drilling (mostly tens of minutes to 1 ½ hours), only rough analyses of the drill cores had been undertaken. They included:

- description of the state of Preservation
- description of the core colour
- description of tectonic features like faults, veins, cleavage, a.s.o.
- description of sedimentary features, like dip and type of bedding, a.s.o.
- short description of the sedimentary inventory (e. g. clay, silt, a.s.o.)
- determination of the rock type (e.g. flinty slate)
- search for macrofossils (none had been detected!)
- determination of the sample locations along the drill core and collection of specimens (for later, more detailed, analyses in the laboratory and search for microfossils).

The results for all these procedures are displayed in appendix F 3, whereas these for the more detailed analyses are documented in appendix F 1.17 and C 4 to C 10.

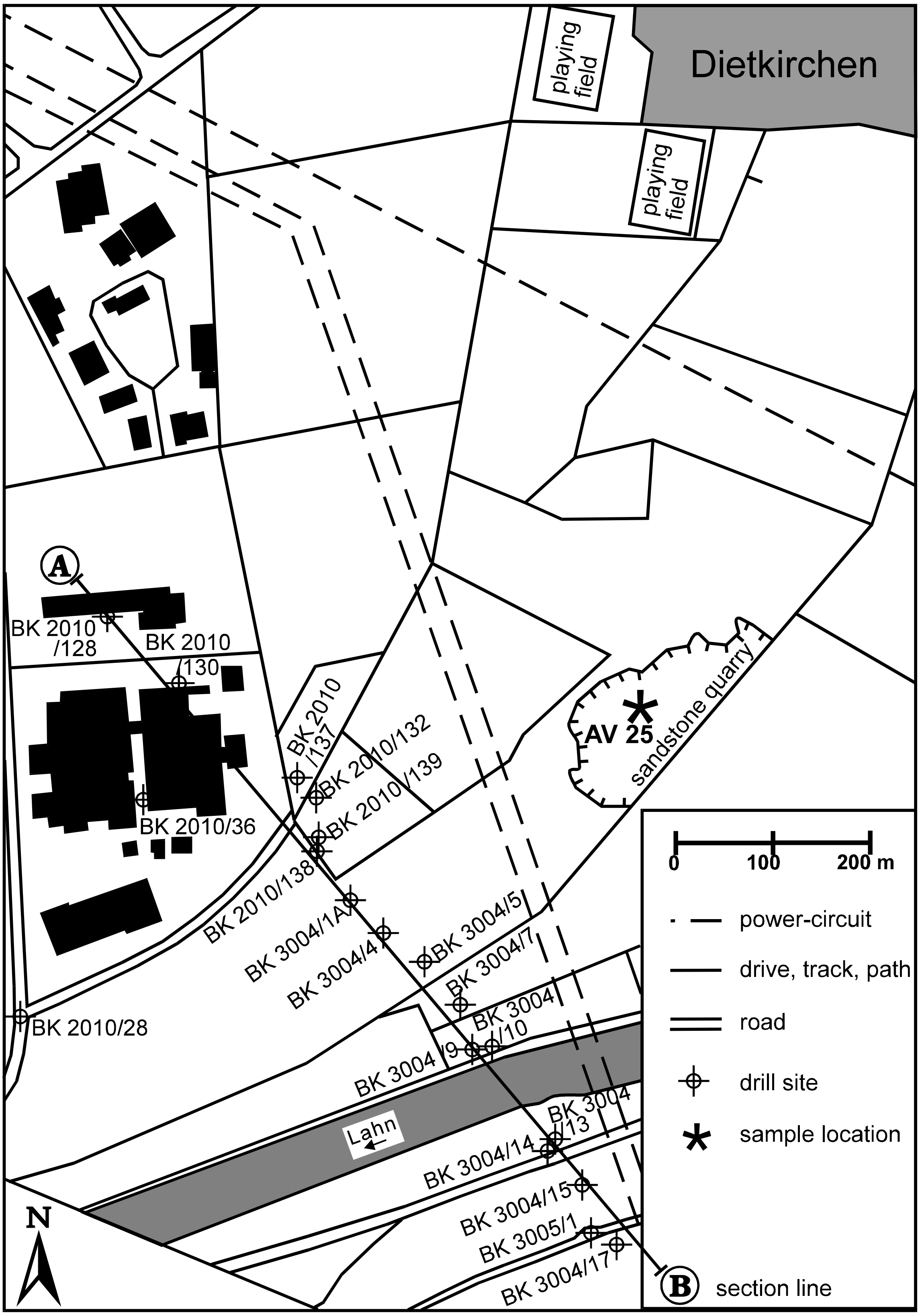


Fig. C 12.1: Map of the area southwest of Dietkirchen (N of Limburg) with drill site locations and position of the geological section line (compare appendix F 3)

A synopsis for all described drillings is presented in enclosure 2. It shows a simplified cross section (compare fig. C 12.1) through the Lahn-valley north of Limburg. It has to be mentioned a lot of uncertainties occurred in the process of deducing a general tectonic trend; e. g.:

- Only two drill cores, BK 3004/13 and /14 had been directly correlatable to each other with some certainty. But the clear and steady upside-down criteria obtained from the drillings with Viséan Bruchberg Sandstone lead to the model of a major syncline (right part of the cross section).
- The dip-direction of the strata was generally assumed to point towards the Southeast (due to the general NE-SW striking trend of the Variscan orogeny). Only a few oriented drillings had been drilled.
- The general overprint of the Cenozoic graben tectonics.
- No drilling reached the base of the proposed Giessen nappe. This part of the cross-section was entirely deduced from other data (see, e.g., chapter C 5 and C 7 and appendix F 2). The real depth and structure of the Giessen nappe is unknown.
- Much more small scale folding and faulting occurred.

Consequently, the tectonic trends were only sketched.

All Palaeozoic rocks in the analysed region had been folded during the Variscan orogeny. Therefore, only inclined strata could be recorded in the course of the drill core descriptions. This implied, that the observed drill core lengths did not represent the real thicknesses normal to bedding, but - in this sense - only apparent thicknesses.

The drill cores were generally quite short (up to approx. 40m length) and it was difficult to induce greater fold structures within the commonly uniform lithology of each core. The base for further calculations were the readings for the dip of the layers and the first cleavage. But only a few parts of the core material for each drilling allowed for the determination of these data. Hence, these data were - in first a approximation - assumed to be representative for whole parts of the total drill core. From these readings model dip-values were derived and used for the calculation of the "real" thickness of the lithologies.

Since only "simple" data were available, only a simple model with a simple trigonometrical procedure for the back-rotation of the strata was applied in order to gain a probable "real" thickness for each drilling.
The model thickness normal to bedding (i. e. the thickness when bedding rotated to zero dip) was gained in the following way:

a) dip < 45°: "true" thickness = cos (dip X°) x (core-length of interest)
b) dip > 45°: "true" thickness = sin (dip Y°) x (core-length of interest)

The results for these calculations are presented in appendix F 3 and in enclosure 3.

By rotating the bedding to zero dip we obtain an additional information about the minimum lateral extension of the sedimentary facies. But in doing so a problem arises: either a) we conclude the facies remained laterally steady for some time, or b) small scale lateral variations are not detectable (i.e. the documented depositional place remained not immobile, but has "moved" laterally through time). Due to these fundamental uncertainties the following calculations may give only a hint towards the possible minimum lateral extension of the facies for each core and all cores together.

The model lateral extension of the sedimentary facies was gained in the following way:

a) dip < 45°: lateral extension = sin (dip X°) x (core-length of interest)

b) dip > 45°: lateral extension = cos (dip Y°) x (core-length of interest)

All foregoing procedures were aimed to acquire an idea of the total overall sediment thickness which is preserved in the drill cores. We remember, that only two drill cores within the Bruchberg sandstone formation have been directly correlatable to each other (BK 3004/13 and /14) since their strata overlap for approx. 16m (compare enclosure 2). More important, however, was to try to find out what total thickness the formation may reach in the analysed region. The best location for such a try was decided to be the northern slope of the Greifenberg near Limburg. There, 5 appropriate drillings had been selected and their strata seemed to be relatively unaffected by small scale folding. After exclusion of the overlap of two drillings and rotation to zero dip an added net thickness of approx. 52m had been derived. But also the gaps without record between the drill sites had to be recognised, which amounted to approx. 68m. Therefore a total minimum thickness of approx. 120m can be derived for the Bruchberg sandstone formation at this location, if we assume the lithologic succession to be without major faults (compare enclosure 3).

In enclosure 3 a synoptic reconstruction of possible relative palaeopositions for sedimentary piles of the Bruchberg-sandstone formation is presented. From this reconstruction we may even obtain a possible thickness of approx. 300m and a lateral extension of approx. 325m.

The relative palaeopositions and sedimentary facies of the sedimentary piles in the "Viséan sandstone basin" reveal a several tens of metres ongoing succession of clay/silt, interrupted by short-termed incursions of sandstones (compare chapters C 7.3 and C 8.2). No general trend towards the relative position of this part within the greater, not preserved, basin can be derived. But due to the major clay/silt-component within the sedimentary piles a relatively distal position relative to the source area for the sandstones seems most probable.

From the drillings within the early Famennian debris flows near Limburg a minimum net thickness of approx. 20m had been derived after rotation of strata to zero dip.

C 13 Geological sketch map 1:25000, area between Weilburg and Holzheim (enclosure 4)

C 13.1 Main processes governing the general geological development of the area

A general trend to a basinal facies from Emsian to Lower Carboniferous times is recognised within the mapped area. Therefore; a finegrained, clayey - silty, background sedimentation is the most striking sedimentary inventory through time. But it did not build up the largest rock masses. Mainly during Givetian times, but with less power also during the Upper Devonian, great amounts of basic volcanic material as well as their pyroclastic deposits was produced. It created submarine highs up to several 100 m height above sea bottom. On top of some of these highs, when they reached up to or passed through the sea-level, carbonate production lead to the build-up of reefs. This was especially significant in the western part of the mapped area, where a massive - more or less continuous - reef complex was established. All reefs were drowned by early Frasnian times; but the persisting submarine relief acted as topographical barrier well up into the Lower Carboniferous. Due to varying sea-levels, these drown highs also acted during the whole Upper Devonian as sites for carbonate production and sources for carbonate debris shed onto the flanks or near the base of the submarine highs. A major transgressive phase towards the end of the Upper Devonian terminated the carbonate production at the now completely drown submarine highs for more than 10 million years. The next younger limestones found were derived from submarine highs built up by a second major volcanic phase during the late Tournaisian / early Viséan.

The emplacement of the newly explored Giessen nappe must have taken place early in the Variscan orogeny since no major differences in the tectonic style between autochthonous and allochthonous units are detectable at outcrop scale. An early Variscan emplacement also explains the lack of relatively plain bottom surfaces of the nappe: autochthonous and allochthonous strata were folded together during the Variscan orogeny.

C 13.2 Why presenting a "sketch" map?

In the map areas with relatively high information about the spatial distribution and structural development of Palaeozoic strata are displayed *together* with areas with very low or no reliable information. The aim of this map is to show the main features of the Palaeozoic geology between Weilburg and Holzheim. It displays the difference between allochthonous (nappe-) and autochthonous rock units and reveals their spatial distribution. Too many details on the map would have obscured the main tectonic structures. Apart from that: a) it would have been too time-consuming to map in detail all the displayed 127.5 km² and b) a detailed mapping was not the task of this study.

70.7 % of the mapped area is covered by more than 2m thick Tertiary and Quaternary rocks. They are mainly situated within the range of the "Limburger Becken" (L. basin), a major Tertiary - Quaternary graben system with sediments and volcanic rocks. Especially in the area between Niederneisen, Holzheim, Eschhofen and Lindenholzhausen only a few small outcrops with Palaeozoic rocks are present. The reconstruction of the spatial distribution of these rocks remains therefore entirely enigmatic. As a consequence, this part of the geological map is highly speculative.

The reef complex west of Wirbelau represents some sort of tectono-stratigraphic terrain of "exotic" nature. Due to the bad outcrops around these limestones (or the total lack of them), it is impossible to reconstruct their tectonic and/or stratigraphic relation to the surrounding rock masses at this time. Hence, it is displayed on the map as a rock-mass which cuts through the general tectonic trend in order to pay attention to - and not to conceal - the still remaining problems.

No topography is displayed on the map, but the reader may get an impression about the maximum differences in relief (mostly less than 100m) by studying the geological cross sections in fig. C 13.1. Instead of the topography - which can easily be acquired from the standard topographical maps 1:25,000 for this region (TK 5614 Limburg, 5514 Hadamar, 5515 Weilburg) - the *mappable Palaeozoic areas* are displayed, which sum up to only 29.3% of the total area. The nowadays accessible areas are - in general - almost identical to the areas displayed on the "historical" geological maps (available at the Hessisches Landesamt für Umwelt und Geologie (formerly: Hessisches Landesamt für Bodenforschung), Wiesbaden).

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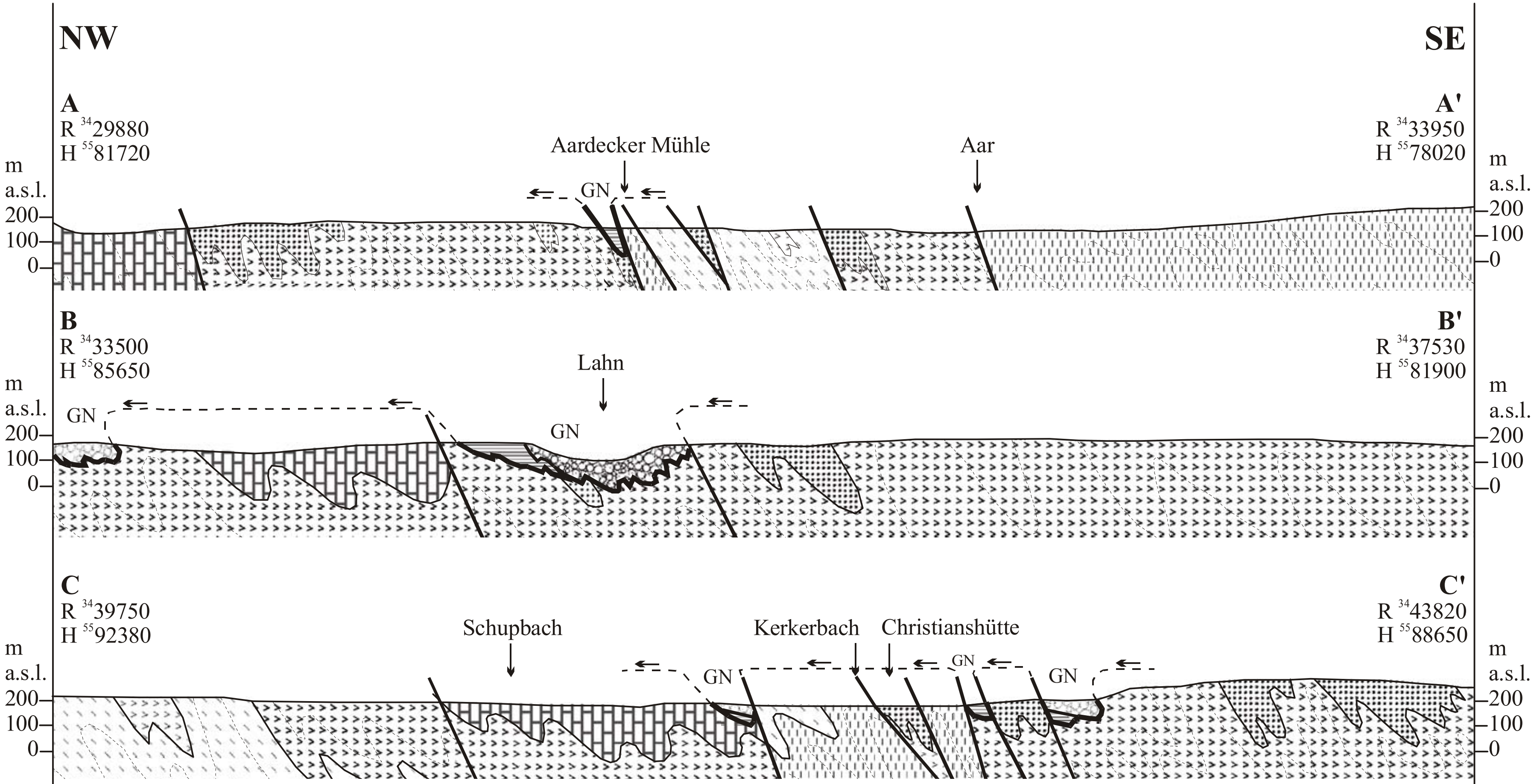
Fig. C 13.1: Idealised cross sections to the geological sketch map 1:25000. Explanation for the symbols on the geological map (enclosure 4).



Idealised cross sections to the geological sketch map 1:25000

(explanation for the symbols on the map, enclosure 4)

(GN = Giessen Nappe)

Part D

Compilation and discussion of results

D 1 Results of the historical investigations

The thorough historical review had been the foundation of this study (see chapters B 2.1, C 3 and appendix F 1). It revealed such a wealth of information that completely new concepts for the geological development of the region had to be considered.

The first published findings of fossils from the region had been presented by SEDGWICK & MURCHISON (1842) from the Villmar reef complex. The brothers Guido and Fridolin SANDBERGER (SANDBERGER 1847, SANDBERGER & SANDBERGER 1850-56, SANDBERGER 1889), KOCH (1881) and KAYSER (1886) contributed much to the first understanding of the geological history.

But it had been Johannes AHLBURG (1910, 1917, 1918, 1921) who first tried to explain the complex geological setting in the area between Weilburg and Limburg on a general level. It resulted in a geological map of the whole Lahn-syncline which unfortunately AHLBURG could not publish. Due to a sudden and unexpected disease he died before completing the explanatory text. This task was fulfilled by KEGEL in 1922.

As also mentioned in chapter B 1, AHLBURG developed a new concept for the interpretation of the geological situation in the Lahn region between Marburg and Limburg: the syncline-theory. Within this "Lahn-syncline" an idealised symmetrical succession of structural and facies features was proposed. He recognised a general trend to a basinal facies from Emsian to Upper Devonian times within the "syncline", which was divided from the Middle Devonian onwards by the build-up of volcanoes and reefs in the middle. The syncline was divided 3-fold into: a) the "Southern Marginal Facies", b) a zone of volcanic ridges and reefs in the *middle* and c) the "Northern Marginal Facies" (which nowadays is called Hörre-facies).

While mapping the area which is covered by the Geological Map Weilburg (GK 5515), he came across a small zone of somewhat "exotic" rocks within the known Lower to Upper Devonian lithologies. They seemed to be similar to the lithologies of the Northern Marginal Facies. Unfortunately, no reliable time-correlations were available for these rocks. But he assumed them to lie directly above the Upper Devonian "Clymenienkalke" (*Clymenia*-limestones), which he considered to be situated at the boundary between "Cypridinenschiefer" (*Cypridina* (*Entomis*) -slates) and "Gaudernbacher Schichten". At one location, in the outermost southwest of map sheet Weilburg, at the eastern slope of the Kerkerbach-valley, approx. 500m westsouthwest of "Forsthaus Runkel", he found fossils within these Clymenienkalke (sample A 5), which were correlatable to the *Prolobites delphinus*-zone. Since AHLBURG (1918) considered these "Clymenienkalke" to be the top of the "normal" Upper Devonian succession, the base of AHLBURG´s "Gaudernbacher Schichten" must be slightly younger and can, therefore, now be fixed approximately to DK1996: ds 15.2 (approx. Early *postera*-zone; late Hembergian).

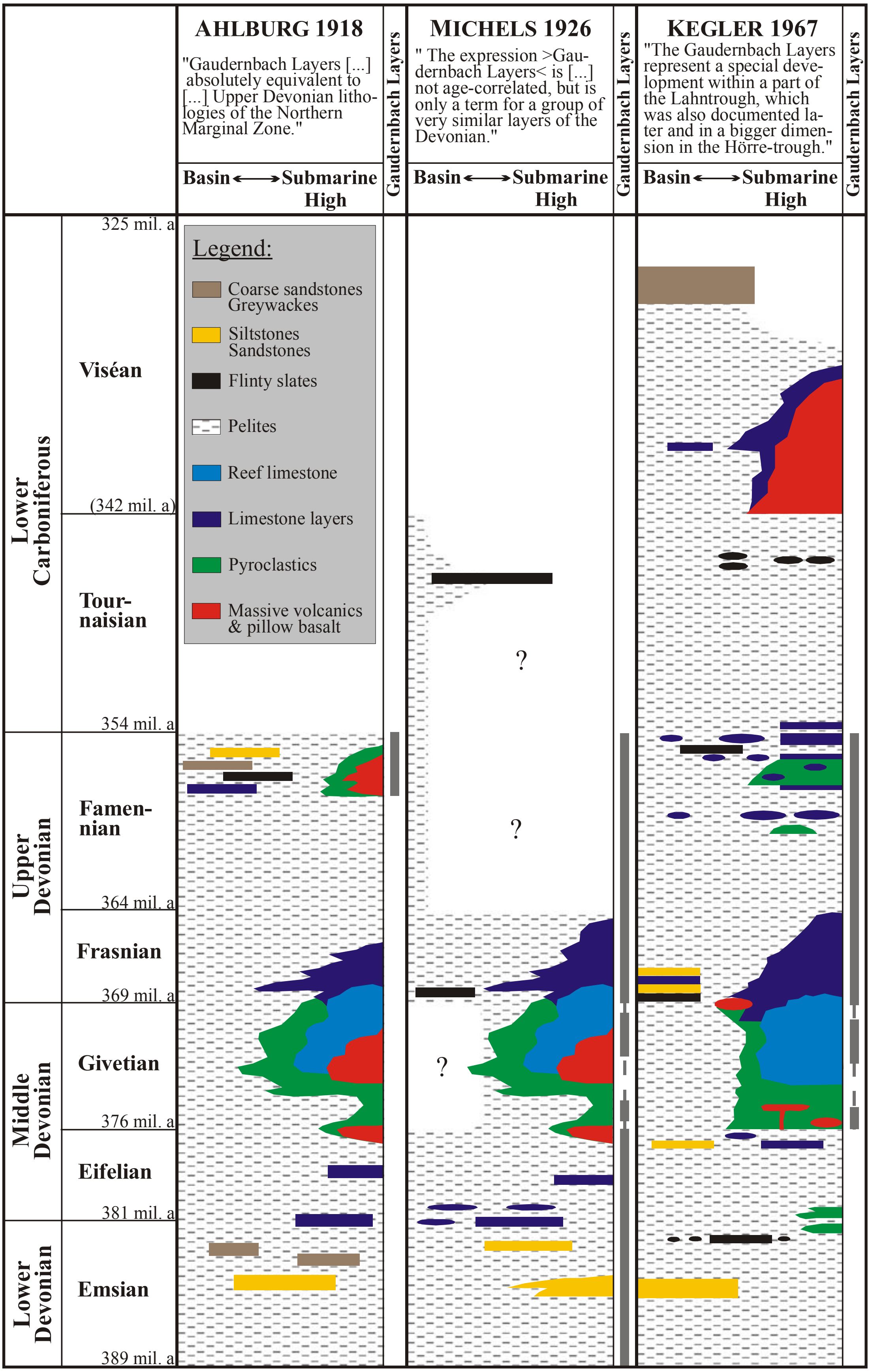


Fig. D 1.1: Stratigraphic correlation chart for historical interpretations of the geological situation between Weilburg and Aardecker Mühle

The only direct evidence for a presumed Upper Devonian age of the Gaudernbacher Schichten was presented with sample A 6 and mentioned both in AHLBURG (1918) and KEGEL (1922). But neither had the sample-location been properly described nor had the age-correlation been reliable at all (see discussion for A 6 in appendix F 1.1). But it remains to be AHLBURG's greatest reward to detect the "foreign" nature of the rocks within the proposed Gaudernbach Layers. In his opinion, the "succession of dark, sometimes roofing-slate like slates with intercalations of Kieselschiefer [= flinty slates, lydites; ...], competent finegrained greywackes and [...] grey quartzites [...], which will be shortly called *Gaudernbach layers*", presented an Upper Devonian facies transitional (?hemipelagic) to the Upper Devonian facies within the Northern Marginal (= Hörre) Zone. In the legend of the geological map Weilburg the former mentioned lithologies had been attributed to the Northern Marginal Facies and not been named Gaudernbacher Schichten. "The whole formation is forming a continuous, from [...] Odersbach to the southwestern map-margin [geol. map Weilburg] and beyond that point on maps Hadamar and Limburg observable succession, which inhabits the innermost part of the great [...] Upper Devonian syncline.“ (AHLBURG 1918). A summary of AHLBURGs model is displayed in fig. D 1.1.

The first proper definition of the Gaudernbach Formation turned out to be the least fitting example, since it failed to define a formation at all. MICHELS published in 1926 new findings within the region. For the first time a Lower Carboniferous age correlation had been possible for some of AHLBURGs proposed Upper Devonian lithologies. These findings, together with newly described samples of Lower Devonian age from the Kerkerbach valley, forced MICHELS to establish a new model in order to explain the geological development. He denied direct links of the Gaudernbacher Schichten to AHLBURGs Northern Marginal Facies and explained the whole lithologic succession to consist of "normal" late Lower Devonian to Upper Devonian (to Lower Carboniferous) marine lithologies, nowadays forming the centre of an anticline. In consequence, this succession would have covered many different formations from as many different times. Hence, it constituted more the definition of a "supergroup" than of a single Gaudernbach Formation. DILLMANN (1952, 1953) extended this model with new fossil findings and a first concise map of the Gaudernbacher Schichten on map Weilburg (GK 5515). A summary of MICHELS and DILLMANNs model is displayed in fig. D 1.1.

KEGLER (1967) could rely on new data and interpretations from WALLISER (1960), TRAUTWEIN & WITTEKIND (1960), RIETSCHEL (1961, 1966), HENNINGSEN (1965) and probably GOLDMANN (1967). He reinstated the direct link of the Gaudernbach Layers to AHLBURGs Northern Marginal Facies and confined their special development within the "normal" Devonian marine facies from the Givetian to the Famennian. In his opinion the Gaudernbach Layers had been the predecessor of a similar, but later, development which produced the Hörre facies. They were created within a narrow graben structure within the "Lahntrough". His most striking evidences for the "special" development had been a thick succession of proposed Upper Devonian sandstone in a quarry between Limburg and Dietkirchen and the occurrence of proposed sandstone and cherty nodule layers (e. g. K1, K6) within the Upper Devonian lithologies. When compared to AHLBURGs concept (see fig. D 1.1), it appears most similar - apart from some more detailed observations in the Frasnian and important new descriptions in the Lower Carboniferous. But again, since within this concept the Gaudernbach Layers (which cover an elongated, c. 23 km long and max. c. 1.8 km wide, area between Weilburg and Limburg) occupy many different formations from the Givetian to the late Famennian, they rather constitute the definition of a "group" or even a "supergroup" - than of a single Gaudernbach Formation.

KEGLERs model to explain the nature of the Gaudernbach Layers remained untouched up to now. Although THEWS (1979) published a new Geological Map Limburg (GK 5614), he introduced no new concepts, since he only presented a map, which had been nearly completed by MICHELS several years before KEGLERs publications. Between 1981 and 1994 Heinrich ZANKL (with some assistance by Peter BENDER) initiated and supervised several diploma-theses in the region (MUNK 1981, BAUMGARTEN (1983/1984, manuscript), KAPP 1987, PETER 1994). The diploma-thesis of FEY (1983, 1985) had been supervised by Gerhard HAHN. Due to the very restricted scope of these theses none of them developed new concepts to explain the occurence of the proposed Gaudernbach Layers. PETER (1994) accepted KEGLERs model but restricted/widened in a short historical review the occurrence of the Gaudernbach Layers to lithologies of Emsian, Eifelian, Hembergian and Lower Carboniferous age.

The characteristic but indistinguishable "dark slates" within the Gaudernbach Layers, interpreted by AHLBURG (1918) as Upper Devonian "deep-water" basinal facies, had always been the main problem. In the course of the development of new biostratigraphic approaches more and more criteria had been found to divide these "dark slates" into several members of different ages and depositional environments. This development is truly reflected in a synopsis of historical maps of the area between Hofen and Christianshütte (fig. D 1.2). The 4 geological maps had been generated by different authors during the past 90 years - and each one considered his/her map as the ultima ratio in explaining the complex geological record.

By summarizing all above mentioned models and investigations we can conclude:

A) AHLBURG (1918) could only find a few stratigraphically useful fossils, so his conclusions about the age of the members of the Gaudernbach Layers, which he himself named a *formation*, were almost entirely derived from logical inferences. Since MICHELS (1926) and DILLMANN (1952, 1953) widened the age range from the Upper Devonian to a special development which lasted from the Emsian to the Upper Devonian (Lower Carboniferous), the original "Gaudernbach Formation" became invalid.

B) MICHELS (1926) and DILLMANN (1952, 1953) considered the expression "Gaudernbach Layers" to be not age-correlated, but to represent a term for a group of very similar layers of the Devonian. In this way they defined a *group* or *supergroup* but failed to explain what made the members of the group so special in order to give it a separate name.

C) KEGLER (1967) revived the group concept for the Gaudernbach Layers. And he did explain a separate development from the Givetian onwards to the Famennian, which was distinct from the normal

Lahntrough-facies. He proposed that the lithologies of the Gaudernbach Layers had filled up a small graben structure within the Lahntrough. Especially the sandy intercalations - which amounted in his opinion up to several metres - had been the key evidence for a special development. But from where did these sandstones come from? And why was it necessary to assume a narrow graben structure to explain their occurrence? And where is the evidence for the proposal that "the Gaudernbach Layers represent a special development within a part of the Lahntrough, which became also documented later and in a bigger dimension in the Hörre-trough"? KEGLERs most striking evidence, the several metres thick succession of proposed Upper Devonian sandstone in a quarry between Limburg and Dietkirchen lacked any datable fossils. So again in the history of the Gaudernbach Layers concept development, an author proposed something which was in key parts derived from logical inferences.

One has to think a that weak definition for a group or formation would - without further evidence put forward in favour of its existence - soon have been focus of controversial dispute. But it is obviously much easier to establish and even hold on an inadequately defined formation or group than to account for severe contradictions or insufficiencies within the concept.

But even if all above mentioned concepts are insufficient in some way or another the major question remains: what other phenomena created the puzzling tectonostratigraphic situation observable?

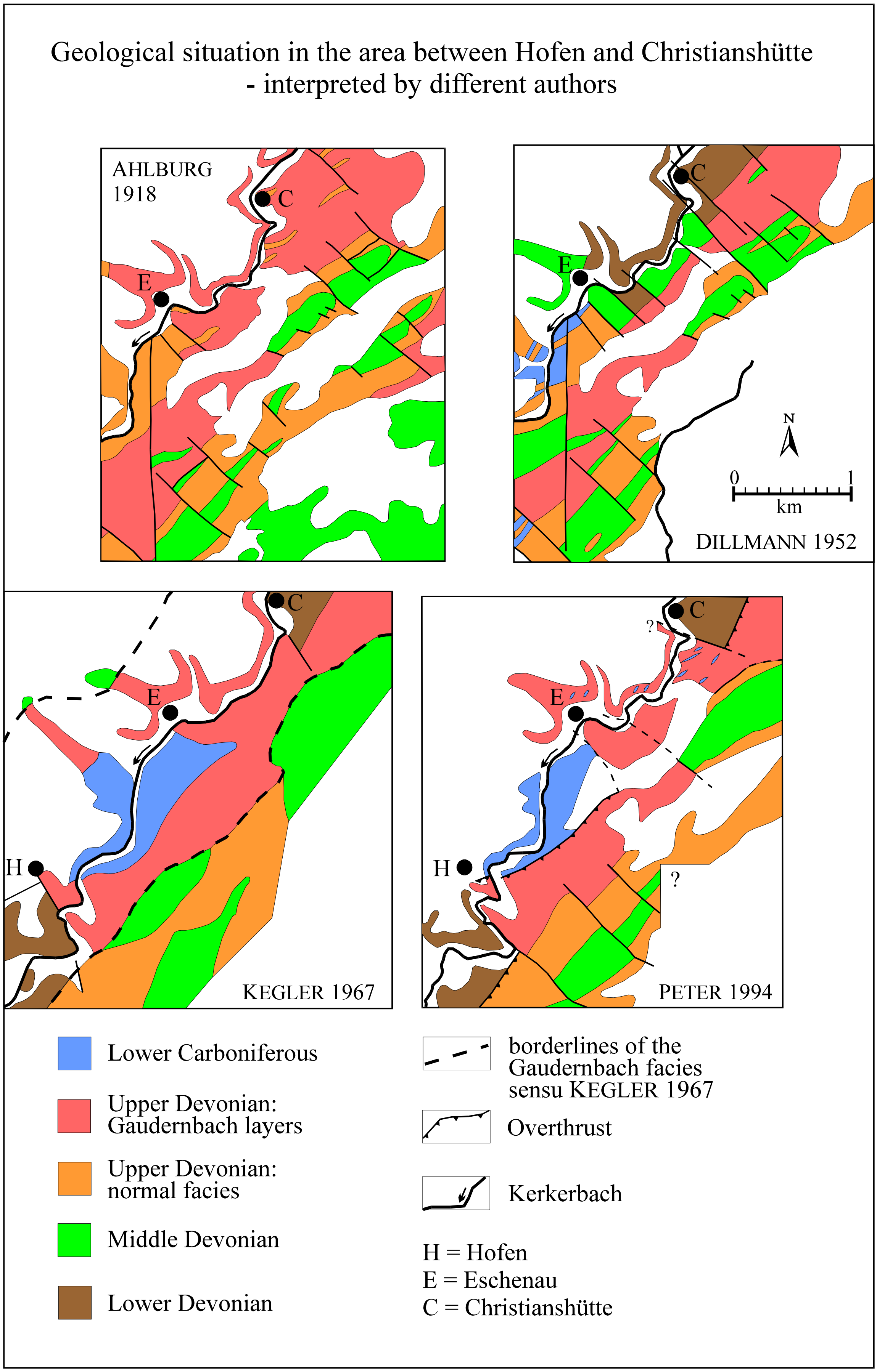


Fig. D 1.2: Historical geological maps featuring the area between Hofen and Christianshütte

D 2 Development of palaeofacies and palaeoenvironment in Devonian and Lower Carboniferous times

The following chapters summarise the main results of the historical investigations and revisions (C 3, app. F 1) as well as the new biostratigraphic results (C 5, app. F 2). In order to avoid logical inferences as much as possible and cross-references from other areas nearby, the description of the lithologies and their interpretation is mostly restricted to the observed data.

This is especially true for the schematic reconstructions of the palaeoenvironments in figures D 2.1 -
D 2.7. Due to

a) the relatively small and narrow study area (the former "Gaudernbach Layers occupy a approx. 23km long and max. 1.8km wide area) which
b) inhabits lithologies from Emsian to Viséan times and
c) is intensively faulted and folded and bears remnants of the Giessen nappe

no spatial palaeogeographical reconstructions had been possible. Therefore, the displayed pictures show a summarising arrangement of different depositional environments, which had been deduced from sample-data and sedimentological descriptions.

Additional information from other data from nearby regions had only been added and discussed where appropriate and/or necessary for a thorough understanding of the regional geological development. The applied methodology allows for a clear distinction between approved facts and mere suggestions due to a lack of local evidence.

D 2.1 Silurian

There are no outcrops with Silurian lithologies in the study area. All data for this time span were derived from small reworked pelitic components in the following samples:

a) in dark Lower (— Middle) Devonian slates from the following locations: Oberhofer Mühle (AV 2, 3+8), Aardecker Mühle (AV 9, 242, 246), s' former railway station Schupbach (AV 18, 271), nne' Wirbelau (AV 51). The preserved palynomorphs consist of
aa) compact, sparsely branched acritarchs of a relatively near-shore palaeoenvironment,
ab) simple spores from early land plants, which were blown to the sea by wind and transported via currents into deeper marine environments,
ac) mostly disaggregated chitinozoans;
The palynomorph spectrum indicates a relatively near-shore, but open marine palaoenvironment during Upper Silurian (Ludlowian — Pridolian) times.

b) in Lower Devonian components in Upper Devonian debris flows from the following locations: sw' Dietkirchen (AV 69, 83, 86), w' Eschenau (AV 258), se' Christianshütte (AV 282, 283), Greifenberg near Limburg (AV 297).

The preserved palynomorphs consist of

ba) compact to branched acritarchs,

bb) mostly disaggregated chitinozoans;

The palynomorph spectrum indicates an open marine palaeoenvironment, probably farther off-shore than aa), during Middle — Upper Silurian (Wenlockian — Ludlowian) times.

D 2.2 Lower Devonian

The southern Rhenohercynian region was part of an intracontinental basin with pelitic background sedimentation during the Lower Devonian. From the late Lochkovian onwards the first coarser-grained clastic influx, consisting of eroded and reworked rock fragments from the Caledonian mountains of the Old Red continent in the north, were shed into the basin. Due to successively increasing amounts of psammitic clastic detritus influx in the early Pragian - and when the sedimentation rate was higher than the rate of subsidence - even terrestrial sedimentation could occur within the basinal area at certain locations. During the late Pragian and Emsian an increasing deepening of the depositional realm occurred due to enhanced subsidence, which was caused by the successively increasing sedimentary load of the Caledonian molasse sediments. The resulting transgression was also triggered by a beginning rift generation in the south (WIERICH 1999). The thinning of the continental crust led to the development of successively more synsedimentary fault systems within graben and horst structures of the evolving rift. Especially during the Emsian a transition from the doming to the volcanism stage of a passive rift generation occurred. The rift axis with the main volcanic magma production was situated southward in respect to the present Lahn-syncline. Due to the finding of MOR-type metabasalts (compare chapter C 2), together with a) the proposed deposition of "hemipelagic" and/or condensed sediments and b) bimodal volcanism, several geoscientists proposed the onset of the opening of a small, max. 400 km wide, ocean ("Giessen or Rhenohercynian ocean", e. g. FRANKE & ONCKEN 1995:64, FRANKE 1995:38, FLOYD 1995:77-78; DALLMEYER et al. 1995) during the Early Emsian.

D 2.2.1 Emsian

The oldest preserved sediments in the study area are Emsian in age. They consist mainly of dark pelites, partly with minor sandstone and/or calcareous and/or episodic basic to intermediate volcanic intercalations. In general, the Emsian is represented by a widespread relatively shallow marine facies with small islands. Partly keratophyr (rhyolite) together with basic volcanism occurred at weakened positions within the evolving rift.

The accessible strata in the study area start with sediments from the Lower Emsian (A1, M2, M3; see chapter C 3, C 5, app. F 1, F 2, fig. D 2.1). The sedimentation took place somewhere on a relatively distal position of the inner/outer shelf of the Old Red continent. The samples indicate the deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (tempestitic) incursions of rapidly deposited silt to finesand. The dominating bedding features are flaser bedding, graded bedding and laminated sand/silt. The wave energy and mud supply control the mud abundance. During heavy storms brachiopod shells together with trochites, other fossils and calcareous sediments were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds. Sometimes occurring small nodules which show a cherty character (Kieselgallen) are probably thin finesilt intercalations which became separated during diagenesis and compaction. The occurrence of *Phacops* in sample M2 indicates a max. water depth of 75-150m.

Probably contemporaneous, but farther offshore on an outer shelf position, the sedimentation which is represented in samples D1, D2, D6, D7, AV 18 and AV 21 took place. The dominating bedding features are lenticular bedding and laminated sand/silt. In sample AV 21, from a fault zone, typical far-shore acritarchs (*Baltisphaeridium anfractum*) are present. In contrast, sample AV 18, from a location close to AV 21 (see fig. F 2.2), bears no determinable Devonian acritarchs. Either this is due to the limited preservation of the palynomorphs or some relatively short-termed local elevations (horsts) in the region caused an environment that was relatively shallow marine or near to small islands.

Towards the upper part of the Lower Emsian a regressional tendency and/or the slight elevation of the area caused more erosion and sedimentation of coarser-grained material. In samples D3 and AV 231 this increased sandstone content is reflected. Their sedimentary inventory points to a transition zone between coastal environment and inner shelf. Deposition of fine sand and mud from suspension along protected low-energy coast or on open coasts took place. The wave energy and supply controlled the mud abundance. The dominating bedding features were flaser and lenticular bedding and laminated sand. During heavy storms brachiopod shells together with trochites and *Pleurodictyum problematicum* were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds. The palynomorphs of sample AV 231 indicate a palaeoposition not too far away from terrestrial areas, since the spore spectrum dominates over the acritarch flora. North of Christianshütte the sandstone beds are several cm to dm thick and in their appearance get close to the classical "**Emsquarzit**" or "Emssandstein". The whole succession may reach a total thickness of approx. 25m (RIEMANN 2000). Maybe the sandstones from the Mensfelder Kopf west of Mensfelden (AV 303 a+b) are also part of the "Emssandstone"-succession. At least they are certainly sandstones of Lower Devonian age, which was proven by comparative petrographical analyses performed by Frank WIERICH (Philipps-University Marburg, personal communication).

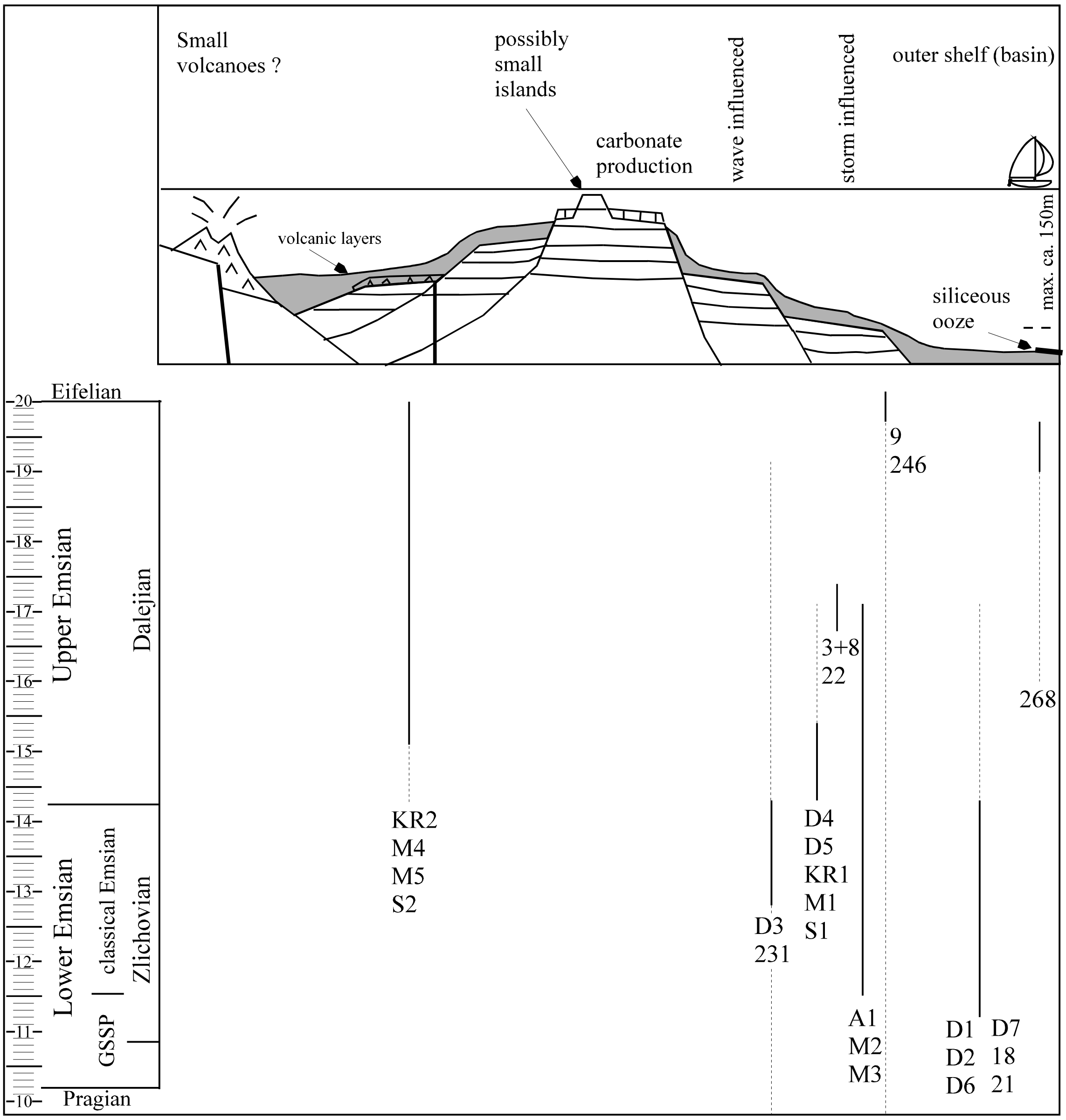


Fig. D 2.1: Schematic reconstruction of the palaeoenvironment during the Emsian, when the area formed part of the Old Red continental shelf. Extension tectonics lead to the development of listric fans and counterfans in undeformed Silurian to Pragian lithologies. Grey shaded: Emsian syn-rift-sediments and volcanics. The age correlations for the samples show the least determinable time increment of probable time range of deposition (not the time range of the succession!). The black vertical lines indicate the most probable time range common to all mentioned samples, the stippled lines display the uncertainties.

During the lower Upper Emsian the water column rises successively. The drowning (subsidence and/or transgression) is reflected in the samples D4, D5, KR1, M1, S1, AV 3+8 and AV 22, where less coarser-grained sedimentary input is observable. Characteristic features were the deposition of mud from suspension below the wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. The dominating bedding features were graded bedding, lenticular bedding and laminated sand/silt. The wave energy and mud supply controlled the mud abundance. During heavy storms brachiopod shells together with trochites, *Zaphrentis* and *Pleurodictyum problematicum* were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds. The palynomorphs of sample 3+8 indicate a palaeoposition not too far away from terrestrial areas, since the spore spectrum dominates over the acritarch flora. The presence of upper Silurian acritarchs, spores and chitinozoans testifies that tectonic activity (probably due to rifting) lead to redeposition of upper Silurian (upper Wenlockian — Ludlowian) sediments. The succession is very similar to that of the Lower Emsian which is represented by samples A1, M2 and M3 and probably also reflects a relatively distal position of the inner/outer shelf of the Old Red continent.

The palaeofacies reflected in samples KR2, M4, M5 and S2 is probably still similar to the foregoing, especially to the ones of samples AV 3+8 and AV 22. But in sample M4 extensional tectonics and crustal thinning is mirrored by a first direct evidence for episodic volcanic activity which lead to submarine **basaltic magma** outflow. Samples KR2, M5, S2 had probably been taken from identical locations and sample M4 from a location nearby, but still within the same lithological succession. All samples indicate a deposition at the slope of a submarine ridge. The main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge. MICHELS (1926) describes small scaled intercalations of eruptiva in sample M4, which developed from a keratophyric magma. However, HENTSCHEL recognises the magma as spilitic (1979:67-69) and gives a more detailed description (1979: 69): "At last it has to be mentioned as a mineralogically-petrographically rarity, that a small spilitic succession contains breccia-like broken parts, in which with irregular shape black-gleaming anthracite, formerly described as schungite, occurs. The quartzose cement and the next-neighbour spilitic rock are also penetrated by sufficient amounts of epidote. This spilite lies parallel to bedding [...]." HENTSCHEL (1979:67) defines the spilites in this area of the Lahn-syncline as "effusive rocks, of which the main mineral components are: albitic plagioclase + chlorite". The metamorphic mineral chlorite is treated as mappable index mineral in order to distinguish the spilites from diabases with the main mineral constituents: pyroxene + plagioclase."

The deepening of the submarine shelf environment and the reduction in sedimentation of coarser-grained detritus continues during the Upper Emsian and towards the early Eifelian. Sample AV 268, from the upper part of the Upper Emsian, indicates a sedimentation within the marine outer shelf or basin. Only deposition of mud from suspension is observable. High equatorial productivity in connection with reduced clastic influx from the Old Red continent (with reduced topography) allowed for a temporary sedimentation of siliceous oozes. The observed palynofacies is dominated by (poorly preserved) spores, which indcate a still near-terrestrial position; however, since acritarchs are present an open marine, but still shelf-influenced off-shore palaeoposition seems most probable. Due to the mostly nodular and lenticular-shaped layers of siliceous (flinty) slates, they are termed "**Kieselgallenschiefer**" (translation approx.: "flinty gall-stone slates") in the Lahn-syncline. During the uppermost Emsian a transition from these "Kieselgallenschiefern" towards slates with some carbonaceous intercalations took place (sample AV 9 and 246). They also represent a palaeoposition on the marine outer shelf. The main sedimentary process was as well the deposition of mud from suspension below or within the wave base, but in addition was sometimes punctuated by sudden (tempestitic) incursions of rapidly deposited calcareous debris.

Dominating bedding feature was laminated silt or mud. The wave energy and the mud supply controlled the mud abundance. Tectonic activity (rifting ?) lead to redeposition of middle to upper Silurian sediments, which is evidenced by the finding of reworked palynomorphs. The sedimentation which is represented by sample 9 may have taken place at the base of the slope of a submarine high, but not too close to terrestrial areas, since the Devonian spore and acritarch flora are nearly in equilibrium.

D 2.3 Middle Devonian

The palaeofacies development in the Early Middle Devonian is characterised by a successive transition from passive to active rifting under marine conditions. Moderate movements along preexisting horst- and graben-structures initiated local topographical elevations within the water column, that reached into levels where carbonate production became possible.

During the Givetian the signs for an active rifting, with deep-mantle upwelling, became most obvious. The doming phase occured during the late Eifelian to early Givetian. Successively increasing amounts of intrusions and submarine outflows of massive volcanics and pillow basalts marked the time span during transition to the volcanism phase, which has its peak in about mid-Givetian. Massive reefs built up on top of the volcano-chains and also on elevated flanks of horst structures, e. g. north and south of the Lahn-syncline volcano-complexes. Even the existence of subaerially exposed landmasses cannot be ruled out, since large and diverse mid-Devonian spores have been found as components in early Famennian debris flow deposits (see chapter D 2.4.2.2 and appendix F 2.3; DALLMEYER et al. 1995, WIERICH 1999).

D 2.3.1 Eifelian

The characterising rocks of the Eifelian in the study area are black slates ("**Wissenbacher Schiefer**"), which mostly lack determinable fossil remnants and, therefore, cannot be sufficiently age determined. According to SCHUBERT (1996) this is caused by prevailing dysoxic bottom waters that allowed only for a restricted benthic life.

SCHUBERT (1996: 112) detected 3 main factors that influenced the transformation of the Emsian aerobic shelf-facies towards a dysaerobic marine facies ("Wissenbacher Schiefer") with reduced influx of coarser-grained detritus: a) relocation of the Rhenohercynian shelf to the north, b) a worldwide transgression during the Late Emsian, c) the rise of dysaerobic water masses from the lower part of the water column. "Water depths in the Wissenbach ocean presumably ranged between approximately 50 and 200 m [...]. There are no indications of subaerial exposure [...]." (SCHUBERT 1996: III).

Only a few samples of proven Eifelian age have been collected during the past 35 years: K 15, TW1, (AV 9, 246), AV 271 (see chapter C 3, C 5, appendix F 1, F 2 and fig. D.2.2). But they allow for the description of three different palaeopositions within the outer shelf.

As indicated in chapter D 2.2.1, no clear lithological distinction between uppermost Emsian and earliest Eifelian strata is possible. The time span is merely characterised by a transition from the "Kieselgallenschiefer" towards slates with some carbonaceous intercalations. The palynomorphs of sample AV 9 allow only for a correlation into the range from late Upper Emsian to the earliest Eifelian. The designation of the sample to the earliest Eifelian (compare also fig. C 11.2) rests solely on its carbonate-content, following a mapping recommendation of SOLLE (1942).

A clear correlation with the Eifelian is possible for sample AV 271. In continuation to the palaeoenvironment represented by sample AV 9, we can deduce an open marine position, but not too far away from terrestrial areas, since spores are still observable in the palynofacies. Mainly the deposition of mud from suspension below or within wave base took place, but was sometimes punctuated by sudden (tempestitic) incursions of rapidly deposited finesilt and calcareous debris from submarine highs. Since reworked upper Silurian palynomorphs are present, we can infer that tectonic activity (rifting ?) lead to redeposition of Silurian (Wenlockian) sediments. The dominating bedding features were lenticular bedding and laminated finesilt or mud. The wave energy and the mud supply controlled the mud abundance.

The deposition of sediments at the slope of a submarine ridge is deducable from sample K 15. The main constituent of the sedimentary facies was clay-silt with intercalations of calcareous debris and finesand from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (and salinity ?) prevailed. Repeated (discyclic ?) influx of fine-grained sediment, perhaps in the form of distal turbidites, is reflected by the concentration of the fossils on the bedding planes, which are separated by mm to cm thick layers of shale or limestone. Conodonts and pyritised ostracods, styliolines, tentaculites, gastropods and bivalves had been found by KEGLER. Due to SCHUBERT (1996) the pyritization of fossils is a good indicator for some factors that have influenced the ancient environment: "The relationship between oxygen content in the lower water column and pyritization of fossils plays an important role in interpreting the ecology of the fauna. There is a causal relationship between oxygen/rate of sedimentation and the pyrite crystal mineralogy [...]. Pyritized steinkerns can only form if sulfidic microenvironments exist within the shell. Naturally, these microenvironments do not form under euxinic, i.e. anoxic-sulfidic conditions, but rather in bottom water low in oxygen, i.e. under dysoxic conditions. Sequences within the Wissenbach facies that contain pyritized steinkerns are ecologically interpreted as gyttja." (SCHUBERT 1996: I).

Remnants of an environment at the slope or close to the base, but proximal to the top of a rising submarine ridge, are preserved near Kirchhofen (sample TW 1). The debritic carbonate input into the pelitic background sedimentation increases towards the top of the succession, indicating the generation of succeedingly favourable conditions for the carbonate-production at the top of the ridge - due to sea-level fall and/or tectonically induced rise of the ridge.

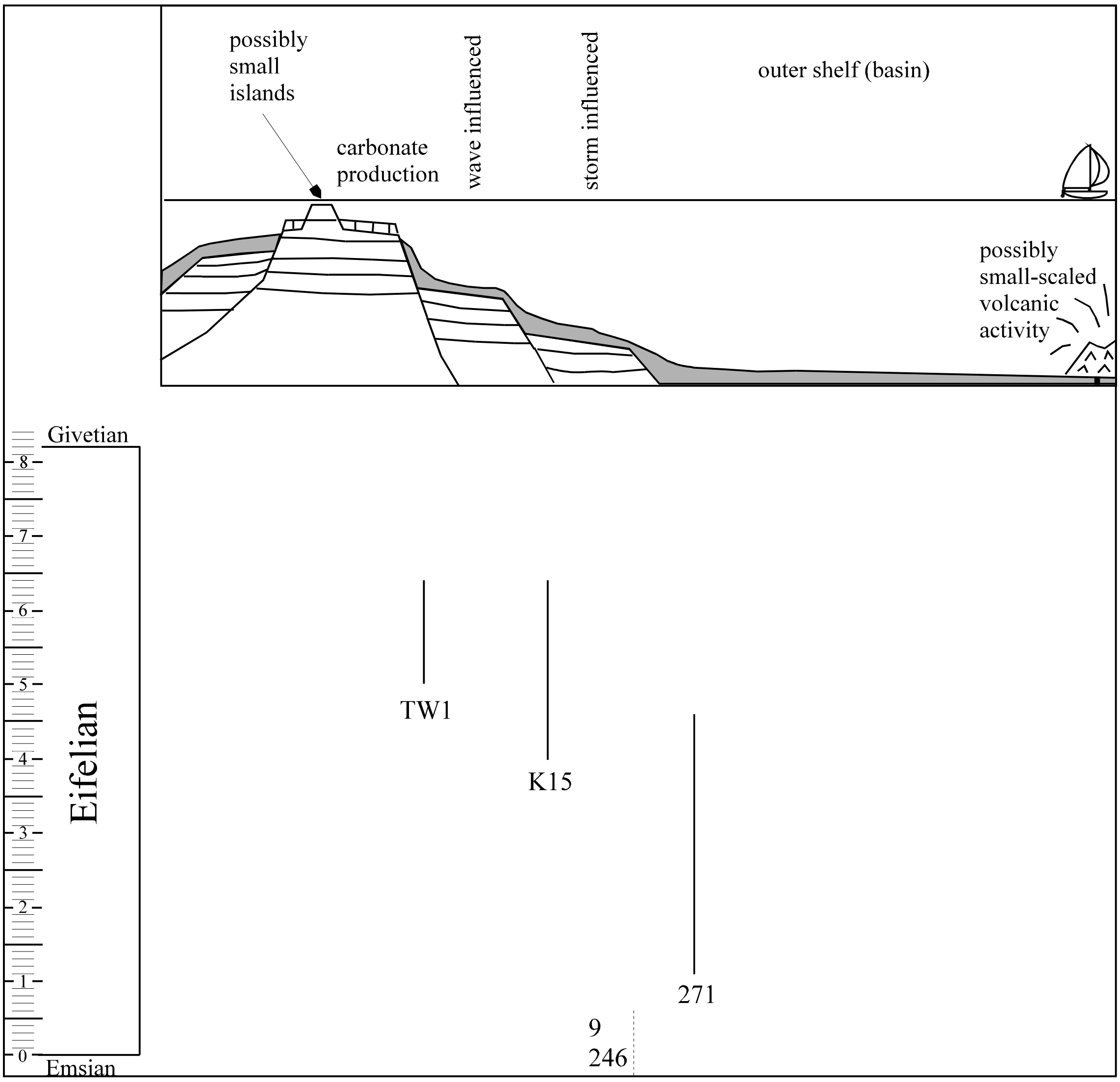


Fig. D 2.2: Schematic reconstruction of the palaeoenvironment during the Eifelian, when the area formed part of the distal Old Red continental shelf. Transition from passive to active rifting. Moderate motions along preexisting horst and graben structures. Grey shaded: Emsian and Eifelian syn-rift-sediments and volcanics. The age correlations for the samples show the least determinable time increment of probable time range of deposition (not the time range of the succession!). The black vertical lines indicate the most probable time range common to all mentioned samples, the stippled lines display the uncertainties.

D 2.3.2 Givetian

In the early Givetian the region is part of an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. From samples K16 and K18 we may infer a depositional environment at the slope of a submarine ridge. The main constituent of the sedimentary facies was clay-silt with intercalations of calcareous debris and finesand from higher parts of a submarine ridge. Probably due to episodic submarine volcanic activity, repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, occurred. Sample K 24 even displays intercalations of reworked pyroclastic deposits. The reddish colouration of the slates from sample K 17 points towards an iron-enriched water column (compare chapter C 9), which probably originated through enhanced release of iron-rich hydrothermal solutions.

During the early Givetian we can recognize a successively increasing volcanic activity in the region, with accountable production of magma and pyroclastic deposits as well as the release of iron-enriched hydrothermal solutions. Since directly datable rocks from the **diabas** and **pyroclastic deposits** are rare or absent in the region, in the following paragraphs a short summary of data - obtained by different authors often with other than biostratigraphical means - are given.

The doming phase of an active rift generation lead to successively increasing amounts of intrusions and submarine outflows of volcanics and pillow basalts from late Eifelian to early Givetian times in the Lahn- and Dill-syncline. This transition towards the volcanism phase of the rift generation had its peak in the mid-Givetian. We can observe a decline in this activity during the late Givetian and Frasnian. But in the Famennian - up to the Wocklumian stage - a slightly enhanced activity with some lava outflows and mainly pyroclastic deposits emerged (RIETSCHEL 1961, 1966, GOLDMANN & KEGLER 1968, BUGGISCH & FLÜGEL 1992). The Upper Devonian volcanic rocks are similar in respect to their composition to the ones of the Givetian/Frasnian-phase and, hence, can be treated as rearguard and direct successors to the main phase (HENTSCHEL 1970, BEHNISCH 1993, NESBOR et al. 1993, THEWS 1996). So far there don't exist sufficient evidences for a continuous volcanic activity from the Givetian up to the Lower Carboniferous "Deckdiabas" phases (HENTSCHEL & THEWS 1979).

Predominantly basaltic melt (regionally called diabas, a meta-basalt) emerged during the main phase of the volcanism phase of the rift generation (Givetian to early Frasnian) - either as submarine lava flows or as explosively generated original and subsequently reworked pyroclastics (**Schalstein**). But at certain locations - and no longer from the late Frasnian to the Famennian stages - also some trachytic and alkali rhyolotic melt reached the surface.

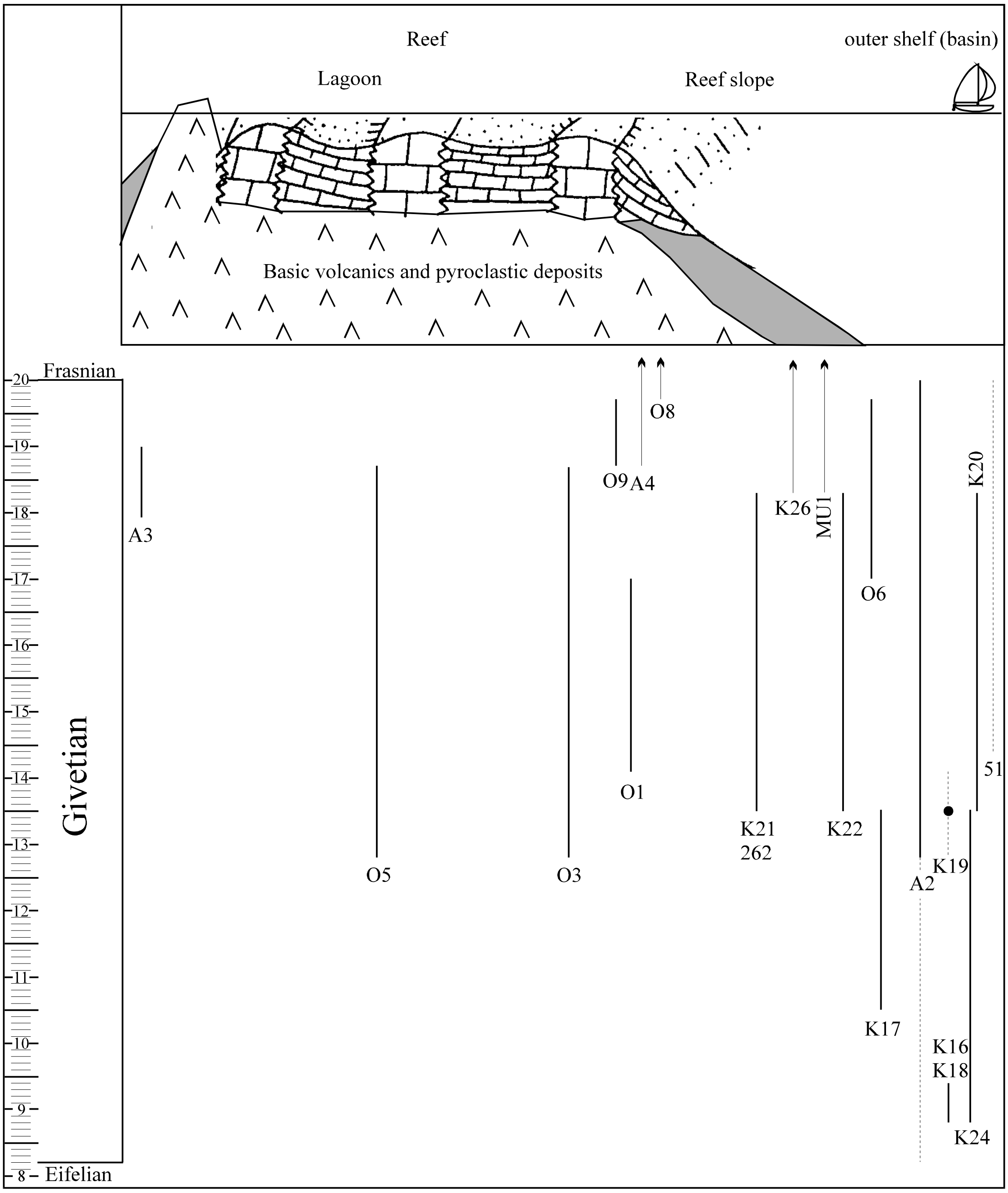


Fig. D 2.3: Schematic reconstruction of the palaeoenvironment during the Givetian, when - esp. from the mid-Givetian onwards - large volcano-complexes evolved. Doming phase of active rifting. Moderate motions along preexisting horst and graben structures. Grey shaded: syn-rift-sediments and volcanics. The age correlations for the samples show the least determinable time increment of probable time range of deposition (not the time range of the succession!). The black vertical lines indicate the most probable time range common to all mentioned samples, the stippled lines display the uncertainties.

Due to HENTSCHEL (1970), VOSSOUGHI-ABEDINI (1979) and FLICK & NESBOR (1988) the **diabas** (or meta-basalts) can, with respect to their phenocryst phases, be subdivided into the following types:

- feldspar-pyroxenephyric diabas
- feldsparphyric diabas
- aphyric diabas
- pyroxenephyric diabas (with up to 25 vol.-% clinopyroxene).

The pyroclastic deposits are composed of materials fragmented by explosive volcanic activity. Later on they often had been reworked under marine conditions. Finally they had been metamorphically overprinted and deformed during the Variscan orogeny. The resulting "**Schalstein**" typically has a greenish colouration due to the high content of chlorite (compare petrographical description for Schalstein-sample AV 277, chapter C 7.2). Schalstein is an ancient german miners term and means "peel-stone", because cleaved and weathered rocks of that type often segregate ("peel") into lense-shaped fragments.

In the study area we can observe 3 different types of fragments in the Schalstein (compare NESBOR et al. 1993, THEWS 1996):

1) juvenile vesiculated fragments of newly generated lava.
2) crystals, which may had been derived by fragmentation of partially-crystallised porphyritic magmas and often may have behaved as a distinct polulation during transport and deposition within the pyroclastic deposits.
   The majority of the crystals are albitised euhedral, partly sericitised, plagioclases. Clinopyroxenes, amphiboles and/or olivines are mostly chloritised. The matrix which bears these phenocrysts often consists of a sparitic galeite or chlorite. It is a common feature that that the former matrix minerals were replaced by calcite.
3) lithic fragments, which are either a) genetically related to the volcanic host (lava fragments) or b) are country rock fragments accidentally incorporated during eruption or transport (reef-limestones and less abundant also sand-, siltstones and pelites). In the course of the submarine lava outflow polymictic pillow-fragment-breccias were generated. They consist either of brecciated fragments of the outer rim of the pillows or rounded, irregularly spaced, up to several decimetres large, lava masses and their brecciated fragments. Typically they are incorporated into a matrix of altered glassy hyaloclastites.
   Especially former glassy basaltic material underwent an alteration to finegrained or flaserstructured chlorite mineral phases. Former vesicles are generally filled with finegrained chlorite, but became in parts successively replaced by calcite or quartz. We can also observe these alterations in the vesicle-rich outer rims of pillow basalts.

For the area covered by the Lahn- and Dill-syncline NESBOR et al. (1993) were able to employ a classical scheme for the detection of a central, proximal and distal volcanic facies - depending on the distance from each volcanic centre:

A) Central facies:

characterised ba lava flows (blanket-like and pillow basalts ("Mandelsteine")), intrusions and minor pyroclastic deposits;

B) Proximal facies:

consists of successions of basaltic magma and pyroclastics which mostly lack internal stratification. They contain:

- fragmented submarine lava flows
- breccias of pillow basalt fragments
- hyaloclastites
- pyroclastic flow deposits
- lithic fragments which are either a) genetically related to the volcanic host (cognate lithics) or b) are accidentally incorporated country rock fragments (accessory/accidental lithics);

C) Distal facies:

consists predominantly of layered pyroclastic deposits which normally contain fragments with many vesicles (due to rapid exsolution of dissolved volcanic gases during explosive eruptions).

During the Givetian and early Frasnian huge, elongated complexes of submarine volcanic chains and composite volcanoes generated in the Lahn-syncline subparallel to the rift axis. Some of the volcanoes even rose above the sea water surface. The resulting small islands existed long enough in order to permit a diverse land plant production, which is evidenced by the preserved spore spectrum from samples from the base of these submarine highs (appendix F 2, AV 51; AV 73-88 (indirectly)). Also some subaerically produced pyroclastic surge deposits with high contents of accidentally incorporated country rock fragments had been described by BEHNISCH (1993).

A thorough stratigraphic subdivision of the volcanic rocks and pyroclastic deposits is impossible, so far, since only a few small outcrops exist especially within the Schalstein deposits. Even when one finds useful fossils one often doesn't know for sure if they represent the age of the deposition or are reworked specimens.

A far better subdivision of the reef limestone complexes on top of the volcanic chains had been possible. Just recently - and for the time beeing - OETKEN (1997) was the last in a long range of biostratigraphers and palaeoecologists who inspected the formerly famous "Lahnmarmor"-quarries (whose products were shipped e.g. to St. Petersburg, New York, India) and described the sometimes rich fauna of these reef- and reef-derived limestones: SEDGWICK & MURCHISON 1842, SANDBERGER & SANDBERGER (1850-56), KAYSER (1886), AHLBURG (1910a+b, 1917a+b,1918, 1921), SCHWARZ (1928), BISCHOFF & ZIEGLER (1958), KEGLER (1967 a-c), KREBS (1971), MIRSAL (1978), MIRSAL & ZANKL (1979), MUNK (1981), KAPP (1987), BUGGISCH & FLÜGEL (1992), OETKEN & ZANKL (1993), BENDER & KÖNIGSHOF (1994), BRAUN & OETKEN & KÖNIGSHOF & KORNDER & WEHRMANN (1994), PETER (1994).

OETKEN (1997) described initial stages of a reef development in the Kerkerbach-valley, in the Lahn-valley south of the village Fürfurt and within the Villmar **Massenkalk** (limestone). At these locations we can observe the interfingering of limestones with pyroclastic material, with increasing amounts of limestone - up to pure reef limestones - towards the top of each succession. These initial deposits continually grew to reef-limestones of a central-, back- and forereef environment with typical reef faunas of that time. Amongst the preserved fossils are: massive and branched stromatopores, branched tabulate corals, rugose corals, brachiopods, bivalves, gastropods, crinoids, ostracods, calcispheres, algae, sponges, cephalopods, tentaculites, fish-remnants and conodonts.

During the "mid-Givetian", from the middle *varcus*-subzone onwards, the first reefs developed in the region, which was at that time situated at about 20° south of the equator (compare fig. D 4.1). Location O3 gives evidence for a partly protected, near- to central-reef environment with short-distance lateral changes of different facies types. Its sediments had been partly synsedimentary reworked and brecciated. Sediments with characteristics of the shallow, open "shelf" (deposition within a lagoon between two neighbouring submarine ridges?), where sedimentation took place in a quiet milieu below the wave base, are also present (O5). A typical feature within the limestone quarries are massive clastic limestones, which were deposited within a fore-reef region proximal to the reef. The layers of location O1 represent probably an ecological succession from the first settlement of reef organisms towards a fully developed reef. It is not an easy task to recover the - for biostratigraphic and bioecological reasons - most useful conodonts from the reef-limestones, since the conodont-animal obviously preferred deeper marine environments (maybe the turbulence of the reef kept them away; oral comm. ZIEGLER 2002) and is therefore rare, "juvenile" or absent in most reef-samples (OETKEN (oral communication 1997) had some very hard times in trying to get some conodonts out of these limestones at all.).

The deeper slope environment downhill the volcano- and reef-complexes yielded more conodonts and, hence, better conditions for biostratigraphic correlations and determinations of the conodont-biofacies (OETKEN 1997). The main constituent of the sedimentary facies was clay-silt with intercalations of (turbiditic?) calcareous debris from higher parts of the submarine ridge (K22).

Downslope the ridges and hence deeper in the water column, the deposition of clay from suspension was punctuated by (repeated, discyclic?) sudden incursions of calcareous debris from higher parts of the submarine ridge (K 21, AV 262, see fig. D 2.4 for details; K 19). The sedimentary inventory points to a low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites occurred.

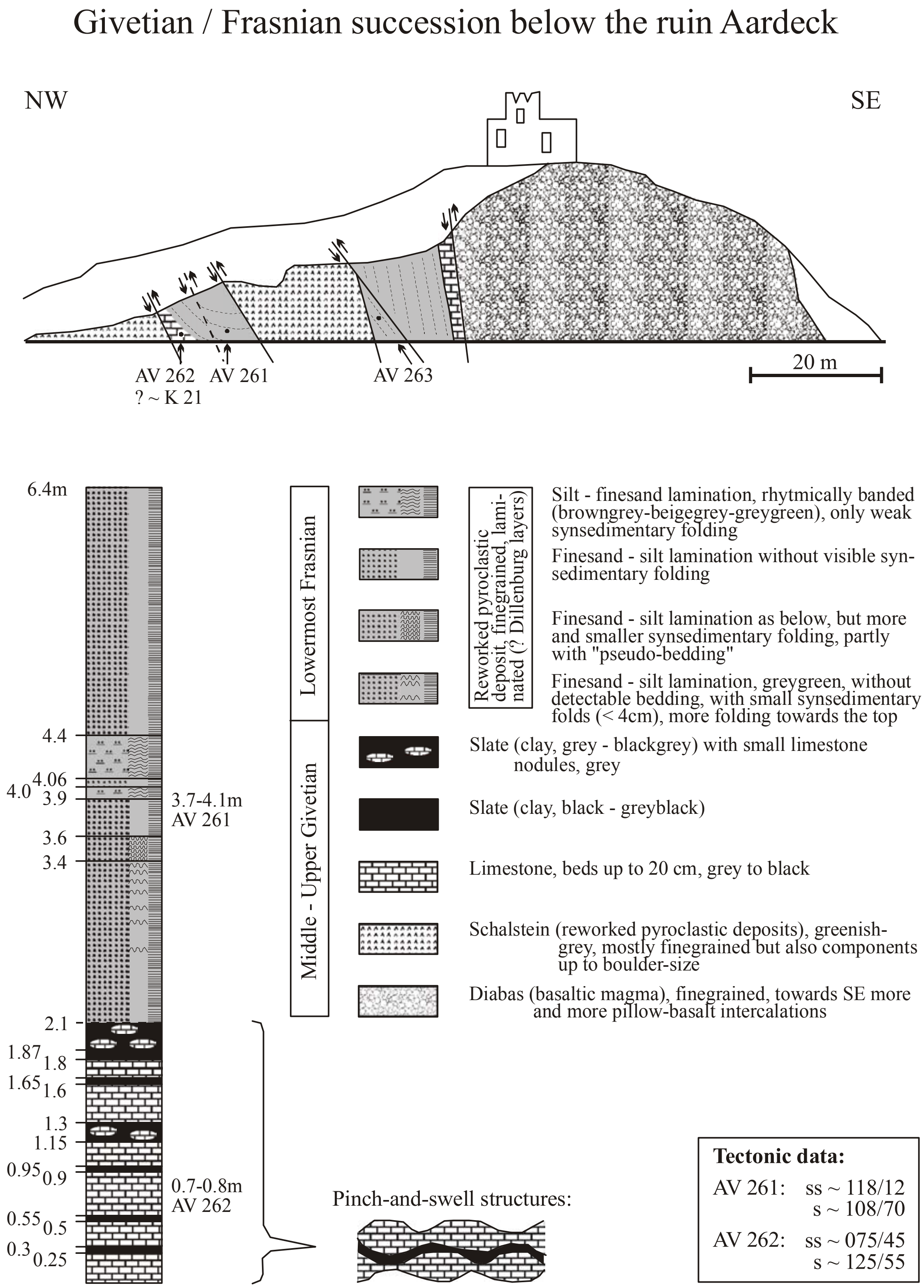


Fig. D 2.4: Givetian / Frasnian succession below the ruin Aardeck with sample locations AV 261-263 and presumed sample-location K 21 of KEGLER 1967a. Drawing of the outcrop below the ruin strongly modified after KEGLER 1967a.

But also deposits from volcanic ridges without significant carbonate production are preserved. Sample A2 represents a deposition at the slope of a submarine ridge which was built up by a (composite?) volcano, however still proximal to the volcanic eruption centre. The main constituent of the sedimentary facies is clay- to silt-sized tuff with intercalations of (reworked?) sand- to boulder-sized pyroclastic deposits (formerly erroneously described as "Keratophyr-conglomerates") from higher parts of the submarine ridge. Glassy components of the tuffs almost entirely altered by oxidation and adsorption of water into yellowish-brown palagonite. During heavy storms brachiopod shells together with other benthic fossils were brought in from shallower (max. 75-150m water depth due to the occurrence of *Phacops*) or epitopographical marine regions and became partly deposited as shell beds.

The ridge-influenced, but more basinal environment can be found at locations K20 and AV 51. Dominating feature is the deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) influx of rapidly deposited tuff-bearing silt due to episodic submarine volcanic activity. Moreover, the palynological analysis for sample AV 51 indicates an open marine environment, considerably away from terrestrial areas, since the acritarch spectrum dominates over the spore flora, but near the centres of submarine volvanic activity. Periodical tectono-seismic activity (rifting?) lead to redeposition of Silurian (Wenlockian — Ludlowian) sediments. The dominating bedding features had been lenticular bedding and laminated silt or mud. The wave energy and mud supply controlled mud abundance.

Subsidence and reef growth must have been slightly in equilibrium during the late Givetian, since the mid-Givetian palaeoenvironment persisted. The typical slope lithologies, with debritic reef-limestone, that had sometimes been reworked in several cycles on its way downslope (sample O6) occurred, as well as mixed and partly reworked mud/carbonate/pyroclastics successions (sample MU1).

An interesting succession of such slope deposits is observable at location K26, at the abandoned limestone-quarry north of Flacht. Due to the results obtained by KEGLER during detailed inspection of the quarry (KEGLER 1967a: 25, fig. 7: sedimentary log; also 1968: 351, fig. 5: sedimentary log), the whole approx.18m thick succession contains a) 11 beds/layers of biosparitic/biosparruditic limestones, b) 46 beds/layers of micritic/microsparitic limestones, c) 52 beds/layers of dark slates, partly with calcareous nodules. Hence, this fossil-bearing (conodonts, "planktonic" organisms) sedimentary succession could act as an excellent and easily accessible locality for further detailed studies on the **Givetian-Frasnian boundary** (a similar lithologic succession is described in OETKEN 1997:84 (= sample O 10) from the drilling "Georg 3"). The main constituent of the sedimentary facies was clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge (?polygnathid-ancyrodellid biofacies-zone). The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, is reflected by frequent concentration of fossils on the bedding planes, which are separated by mm to cm thick layers of limestone.

From the end of the 18th to the beginning of the 20th century the search for **iron ores** had been a major motivation for geological research in the region. AHLBURG (1918; sample A3) describes the lithological constraints for the detection of the iron-enriched "**Grenzlager** (border layer)" horizon, which for some time also was regarded as lithological boundary between the middle and Upper Devonian. The sedimentary inventory at location A3 points to permanent marine conditions with a low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. The deposition of pyroclastic deposits on top or at a position proximal to the top of a submarine ridge was succeeded by a period of strongly reduced production of pyroclastic deposits with the build-up of "Grenzlager"-lithology: thin bedded succession of iron oxide, calcareous layers, red slates and tuffs with varying contents. Either a) the water column above the ridge top was too large in order to allow larvae-settlement of shallower water species or b) long-term episodic outflow of toxic waters/gases (which may have fixed all free oxygen in the water column) from the volcano which build up the ridge, prohibited the settlement of benthic species (maybe the ammonites found in these layers died while they tried to cross this toxic water column). The processes which lead to the deposition of the iron-ore deposits in the Lahn-syncline are still matter of controversial discussions.

Typical reef-derived lithologies of the latest Givetian are represented at sample locations O9, A4, O8 near Wirbelau. At location O9 "[the] depositional environment of the sediments was characterised by a steadyly acting high water energy. Therefore the sedimentation of micritic material was impossible. The enrichment of the sediment in washed-out crinoid- and coral-detritus point to a depositional environment in shallow to medium-deep water. The frequent occurrence of branching tabulate corals may indicate the neighbourhood to a "*Thamnopora*-lawn". The depositional environment was situated at the edge of the reef /reef-slope or in a shallow, plain, fore-reef shelf region." (OETKEN 1997: 68). AHLBURG (1918) described debritic limestones, deposited within a fore-reef region, at location A4. Due to OETKEN (1997:72-73) the layers represent probably short-term events, caused by (volcano-tectonically induced ?) instability of accumulated reef-organisms at the 30-35° inclined palaeoslope. In general, the limestones of Wirbelau are mainly coarse debritic limestones of the distal fore-reef (compare O8). Only the outcrops in the north of the quarries show evidence for facies types which would allow for a correlation with a more protected back-reef or within-reef environment. The sediments in the Wirbelau limestone quarries give evidence for a depositional environment at a shelf-slope area with free exposition to the open sea.

D 2.4 Upper Devonian

In the Frasnian we observe the rift phase of the active rift system. Enhanced partitioning and subsidence due to successive cessation of the mantle upwelling occurred. Fast, but short living, motions along preexisting horst and graben structures lead to deposition of a) debris flow deposits, partly with huge (>1m) components (e. g. HUCKRIEDE 1992), b) syn-rift greywacke turbidites south of the recent Phyllite zone along and subparallel to the Rhenohercynian/Saxothuringian borderline from SW-England to Bohemia, c) erosion of former volcano and reef-covered areas within the Lahn-syncline (DALLMEYER et al. 1995, WIERICH 1999).

In the middle Lahn-syncline a typical basinal marine palaeoenvironment with pelitic background sedimentation persists during the Famennian. Only on submarine highs carbonate production had been periodically possible. The sedimentary material of neptunian dykes within massive limestones from outcrops near Gaudernbach (location O3) show fossil evidence for a generation from Famennian to Lower Carboniferous time (KREBS 1971: 58), indicating that for a long time and especially during phases of enhanced tectonic activity the former reefs had still been in contact with the sea water column (as persisting submarine highs?) and continuated to act as sediment traps. Up to the Wocklumian stage an enhanced volcanic activity with lava outflows and pyroclastic deposits emerged. The Upper Devonian volcanic rocks are similar in respect to their composition to the ones of the Givetian/Frasnian-phase and, hence, can be treated as rearguard and direct successors to the main phase (HENTSCHEL 1970, BEHNISCH 1993, NESBOR et al. 1993, THEWS 1996).

D 2.4.1 Frasnian

The build-up of (**Massenkalk**-) reefs in this region persisted at least until the Late *falsiovalis*-zone in the early Frasnian. In northeastern parts of the Lahn-syncline (e.g. near Braunfels and Bieber) it lasted up to the late Frasnian (HENNINGSEN & QUADE 1962, RIETSCHEL 1966). KREBS (1971) described the carbonate complex near Gaudernbach, which was also erected on submarine volcanic rises on top of diabases and diabas tuffs as well as keratophyrs (KRE1). The resulting reefs form atolls or table-reef like bodies in the earliest Frasnian. Near Schupbach, OETKEN (1997) reported the deposition of biostromal reef-limestones on top of a submarine ridge, succeeded by deposition of clay with intercalations of detrital limestones due to increasing rise of the sea-water level. Episodic deposition of tuff layers was due to short-termed explosive volcanic activity (sample-location O2). At location O4 we observe limestones of an open marine shallow water environment. OETKEN (1997: 43) noted: "Therefore a development of the depositional environment from [a:] a perhaps open-lagoonal milieu with connection to the offshore-sea or [b:] a fore-reef position with steady influence of currents or waves - via a milieu of more reduced energetic influence - towards a region of enhanced biotic production within a shallower, higher energetic milieu is derivable. Frequent intraclasts point to enhanced water energy and reworking of sediments. [...]

This development is explainable by varying sea-water levels." The deposition of sediments at a backward position of the reef-region under influence of medium - sometimes enhanced - water energy, in a restricted milieu, is observable at location O7.

At borehole-location O10 (drill-site "Georg 3") a more basinal facies with sediment supply to the slope of a submarine ridge (former reef) can be observed. The main constituent of the sedimentary facies was clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. The repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, is reflected by frequent concentration of fossils on the bedding planes, which are separated by mm to cm thick layers of limestone. OETKEN (1997:82) characterises these lithologies as "deep-water limestones". Enhanced tectonic activity with moderate motion of horst and graben structures is indicated by the occurrence of reworked faunas from the Givetian and later on from the drowning reefs of the earliest Frasnian.

The still ongoing production of **basic volcanic lava** is documented at sample-locations K25 and K23, where we can observe the deposition of silt-finesand with intercalations of calcareous debris from higher parts of a submarine ridge. The sedimentary inventory at location K25 points towards a sedimentary facies where "pure" pyroclastic deposits were deposited and subsequently reworked and transported downslope. Repeated (discyclic?) influx of fine-grained, partly reworked Givetian, sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity occured as well as submarine basaltic magma outflow into the slope-deposits.

The stratigraphic correlation for sample A6 is uncertain (Frasnian and/or late Viséan). The sedimentary inventory points towards a deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited, partly fossil-bearing, silt-finesand. The occurrence of flaser bedding indicates punctuate low-energy to medium-energy bottom currents, which probably often lead to erosion of just before accumulated sediments. Episodic submarine volcanic activity lead to deposition and subsequent reworking of tuff layers. Personally, I think the sample belongs to the late Viséan, but without significant evidence no reliable statements are possible.

As mentioned earlier, within the *falsiovalis*-zone all reef-growth stopped, the volcano- and reef-complexes drowned successively and the reef-limestones fell open to marine erosion. Enhanced tectonic activity with moderate motion of horst and graben structures is indicated by the occurrence of reworked faunas from the Givetian. The "**Adorf-Plattenkalke** (-platy limestones)", observable at locations MU2, MU3 and less typical at K0, developed as products of the deposition of former reef-detritus at the slope of a submarine ridge. The main constituent of the sedimentary facies was clay-finesilt with episodic intercalations of calcareous debris from higher parts of the submarine ridge. For locations MU2 and MU3 the depocentre near the top of the ridge is indicated by the relative thick succession of calcareous debris. The preserved conodonts may even allow for the hypothesis, that relative near-shore polygnathid-ancyrodellid biofacies conodonts had been reworked (during heavy storms?) and transported downslope into an environment of polygnathid-palmatolepid biofacies.

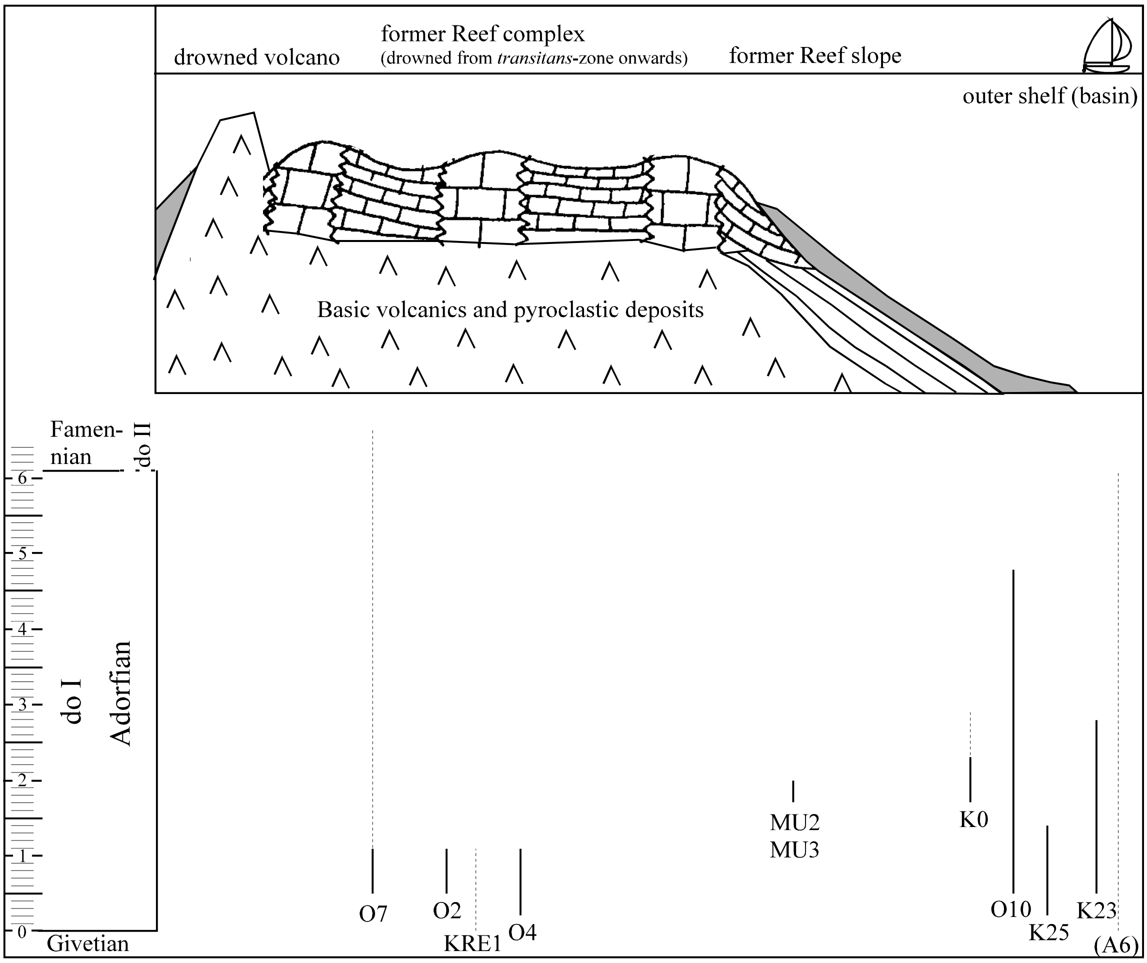


Fig. D 2.5: Schematic reconstruction of the palaeoenvironment during the Frasnian in the study area. Rift phase of the active rift system produces enhanced partitioning and subsidence due to successive cessation of the mantle upwelling. Grey shaded: syn-rift-sediments and volcanics. The age correlations for the samples show the least determinable time increment of probable time range of deposition (not the time range of the succession!). The black vertical lines indicate the most probable time range common to all mentioned samples, the stippled lines display the uncertainties.

D 2.4.2 Famennian

In the Famennian for the first time 2 distinct facies realms are discernible within the study area. Therefore, autochthonous units had been separated from allochthonous units of the Giessen nappe.

D 2.4.2.1 Autochthonuous units

There is a lack of evidence for sedimentation from the late Frasnian to the earliest Famennian, i.e. so far no datable samples had been encountered for this time span. But from the Late *triangularis*-zone onwards we can inform about the geological development in the area in more detail - due to the relative abundance and the well developed zonation of conodonts. But, since a pelitic basinal marine environment prevailed, no major facies changes occurred. The predominant facies realm was only intermittently disturbed by release of basic volcanic magma and pyroclastics.

In the Late *triangularis* to Late *crepida* zones during the **Nehdenian** stage we observe the deposition of mud from suspension, sometimes under reducing conditions, within a basin, maybe at the basal parts of the slope of a submarine ridge at sample-locations B2, B3, B6, B7, and AV 293, punctuated by sudden (turbiditic) incursions of rapidly deposited silt to finesand. At location K4 also frequent intercalations of calcareous debris from higher parts of the submarine high occurred. In the Late *crepida* zone the typical reddish slates of the Famennian with intercalations of nodular limestones appear at location K32. The reddish colouration is most probably due to the enhanced iron-content in the water column, which originated through increased release of hydrothermal solutions during volcanic activity (compare chapter C 9).

An increase of tectonic activity is indicated in the late Nehdenian Early *rhomboidea* zone, although the pelitic sedimentation with more or less frequent intercalations of calcareous debris and finesand from higher parts of the submarine ridges persisted (K1, K2). In sample K1 the erosion of lower Nehdenian and upper Adorfian deposits from near the ridge-tops is documented. C. 30m uphill of location K2 along a Kreuzweg (pilgrims path) Lower Carboniferous (cu I) slates (compare sample AV 297) appear near the Kreuz-Chapel. Since KEGLER (1967) assumes the lithology at this locality to be equal to that of K0 and K1 it has to be noted that this is not true.

In the "latest" Nehdenian Early *marginifera* zone the reddish slates predominated and are observable at locations K30 and K31. We notice the deposition of clay-silt (**reddish slates**) with intercalations of calcareous debris from higher parts (**nodular limestones**) at the slope of a submarine ridge. Greenish colours generated during prevailing reducing conditions at the time of deposition (compare chapt. C 9). The repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, was most probably due to episodic submarine volcanic activity (compare loc. K 27). Samples MU5, MU6, MU7 indicate the deposition of mud from suspension near the base of the slope of a submarine ridge. An increasing carbonate-content towards the top of the succession was maybe due to a slight sea-level fall with increased carbonate production or erosion.

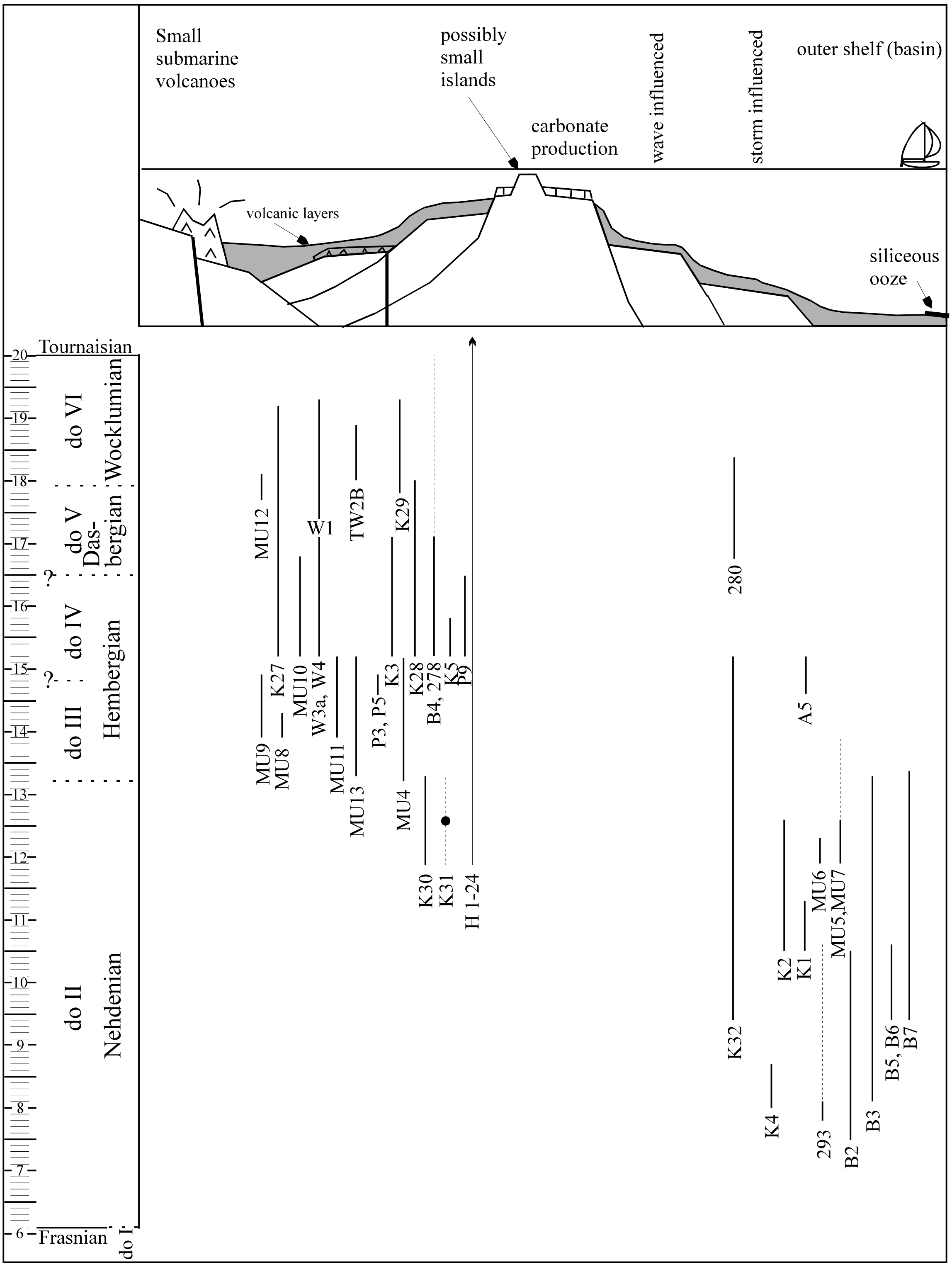


Fig. D 2.6: Schematic reconstruction of the palaeoenvironment during the Famennian in the study area. Transition from active to passive rifting. Moderate motions along preexisting horst and graben structures. Grey shaded: Famennian sediments and volcanics. The age correlations for the samples show the least determinable time increment of probable time range of deposition (not the time range of the succession!). The black vertical lines indicate the most probable time range common to all mentioned samples, the stippled lines display the uncertainties.

During the early **Hembergian** biostratigraphic evidence is available from the Latest *marginifera* (MU4) up to the Late *trachytera* (A5, P3, P5) zone. At position MU4 the deposition of mud from suspension within an iron-enriched water column at the slope of a submarine ridge, punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous debris (and maybe of silt) from higher parts of the submarine ridge occurred. At least reworked late Adorfian sediments had been incorporated. Colour changes from red to green to black indicate varying redox conditions and iron-content - probably due to submarine release of hydrothermal solutions during enhanced volcanic activity nearby. Also observable are small nodules which show a cherty character, but bear internal sedimentary structures (lamination) as well as single detrital clasts. They are probably thin finesilt intercalations which became separated during diagenesis and compaction. The above indicated submarine basic volcanic activity at the slope of a submarine ridge is evident at locations MU11, MU13, P3, P5 with a) submarine basaltic magma outflow on and in unlithified siliceous and calcareous sediments; b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris from higher parts of the submarine ridge and c) development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments. The fossil evidence from the calcareous nodules incorporated into pillow basalt maybe does not reflect the true time of submarine magma outflow. Samples MU8 and MU9 bear information about the deposition of mud from suspension within an iron-enriched water column near the base of the slope of a submarine ridge. The sedimentary facies consists of clay-silt with intercalations of calcareous debris as well as reworked pyroclastic deposits. The latter probably originated during explosive submarine magma release with subsequent deposition and turbiditic redeposition of sand-sized volcanic particles from higher parts of the submarine ridge. Seemingly not influenced by volcanic activity is sample A5. We also observe the deposition of mud from suspension at the slope of a submarine ridge. But the main constituent of the sedimentary facies is only clay-silt with intercalations of calcareous debris from higher parts of a submarine ridge. The described fauna with prevailing nektonic species indicate a deposition at the base of a submarine slope.

The early Hembergian palaeoenvironment persisted from the late Hembergian Early *postera*-zone onwards. We observe the deposition of mud from suspension at the slope of submarinene ridges, punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous debris (and maybe of silt) from higher parts (B4, P9, K5, AV 278, K28, K3, W3a, W4, MU10, K27). Short-term carbonate production on top of the submarine highs was probably generated after enhanced volcanic activity formed ridges of pyroclastic deposits. Due to progressive compaction, the layers with limestone-debris typically formed horizons of limestone nodules during diagenesis. Probably the same happened to sometimes observable thin finesilt intercalations, which became separated during diagenesis and compaction and formed small flinty nodules (B4). The increased volcanic activity is also documented through the colouration of the sediments: colour changes from red (K28, K3, W4, MU10, K27) to green (P9) to black (B4) or grey (AV 278) indicate varying redox conditions and iron-content - probably due to submarine release of hydrothermal solutions. Evidence for significant volcanic activities are preserved at sample-locations W3a (magma outflow + pyroclastic deposits) and K5, W4, MU10, K27, AV 278 (original and/or reworked pyroclastic deposits). A thorough petrogaphical description for these Hembergian pyroclastics (Schalstein) is given in chapter C 7.2 (sample AV 277). The reworking processes during the downslope transports of the sediments lead to the incorporation of at least Nehdenian and lowermost Hembergian sediments (W3a, K5, K27, K28).

The magma production continued in the **Dasbergian**, at least during the Early and Middle *expansa*-zones (sample-location W1). And the palaeoenvironment with deposition of mud from suspension, which was periodically interrupted by the influx of calcareous debris from higher parts of submarine ridges (AV280, W1), persisted as well.

The same is true at least up to the **Wocklumian** Late *expansa*-zone (K29 (reddish slates), MU12). At sample-location TW2B presumably a succession with strata deposited at the slope of a submarine ridge from the uppermost Devonian to the Lower Carboniferous is preserved. The main constituent of the sedimentary facies within the late Famennian was clay-silt (greenish and reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (marls, limestones, calcareous nodules). Episodic submarine volcanic activity lead to submarine magma outflow (pillow-basalt) or subsurface intrusions. A short-termed rapid sea-level fall during the Early *praesulcata*-zone, was followed by a (?sudden) influx of anoxic bottom waters (Hangenberg event). The sea-level rose continuously during the lower Lower Carboniferous within a starved basin. Periodical submarine volcanic activity lead to the reactivation of old submarine ridges which is also evidenced through the occurrence of reworked Hembergian to Wocklumian faunas. Rising ridges became environments of carbonate production in the lower Tournaisian.

D 2.4.2.2 Allochthonous units:

Debris flow

The most interesting lithological unit of the Devonian is a newly encountered early Famennian (approx. Latest *crepida*-zone, DK1996: ds 10.3 — 10.6) open marine debris flow sediment with a relatively well preserved flora (samples 57, 67-69, 72-88, 258, 259, 282-283, ?295, 297). 59 different spore and 58 different acritarch species (within 34 spore and 31 acritarch genera) from Silurian up to Famennian age have been detected within this sediment. From a statistical viewpoint, both for the spores and acritarchs, the preserved floral spectrum is relatively poor in individuals (individuenarm) but rich in different species (artenreich).

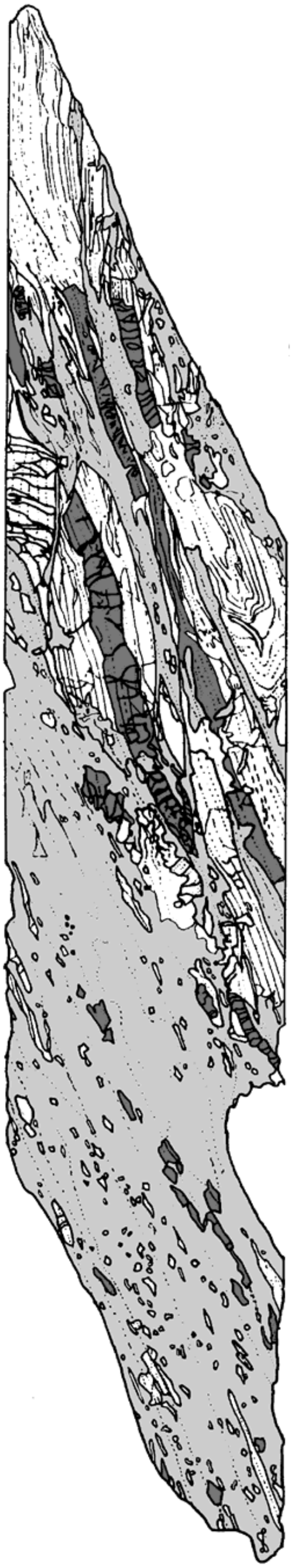


Fig. D 2.7: Drawing showing the main features of core sample AV 74 (= DK 2010/132, 16.3 - 16.7m; original core diameter: 100mm). Early Famennian debris flow (compare chapter C 7, fig. C 7.1).

- - - --- - Clay with traces of lamination and/or layering

Clay with fine-silt

Coarse-silt to fine-sand

⇐ Clay - component with relictic preserved synsedimentary folding (= plastic deformation of not yet completely lithified clay layers during debris flow formation).

⇐ On the left side: laminated clay layers with coarse-silt layer inbetween. Note that the clay-silt intercalation must have been partly lithified before redeposition; this is evidenced by a) the compact but patchy and irregular appearance and b) the cracks normal to bedding, induced by reworking forces.

Part of the sample, from where HF-sample AV 74 was taken. Note that clay, clay/silt and coarse-silt to fine-sand components are small and show small scale intermixing. That's the reason why in most HF-processed debris flow samples several different age correlations have been possible.

Furthermore we should draw special attention to the fact, that these different age correlations had been possible at all. Considering the reworking process and even the conservation of reworked Silurian species the preservation of palynomorphs in the Giessen nappe samples is quite good and seems to be limited only by the pyrite content. This is in remarkable contrast to the generally bad preservation of Devonian palynomorphs in outcrop samples from proposed autochthonous units.

⇓ A plausible explanation for this is: The allochthonous units have been overthrusted somewhere around the borderline Lower/Upper Carboniferous, thus placed on top (at least up to approx. 300m) of the parautochthonous units. Therefore, later (in the course of the Variscan orogeny) they became less deeply buried and hence less thermally altered. That seems to be the most conclusive reason why younger greywacke units (Famennian) are datable at all - with a sometimes good preservation of palynomorphs (limited not by thermal alteration but in majority by bacterial attack, weathering and pyritization prior to final deposition).

A compilation of all identified fossils from the analysed Famennian debris flow sediments is listed in tables F 2.1 - F 2.4 in appendix F 2.3). A short analysis of these listings is presented in tables D 2.1 and D 2.2.

Tab. D 2.1: Number and type of data sets with possible temporal correlation from identified spores and acritarchs in samples from Famennian debris flow sediments.

Type of species determination	**Spores**	**Acritarchs & prasinophycean algae (cysts)**
Genus species	36	40
Genus cf. *species*	17	17
cf. *Genus species*	19	14
Genus sp.	16	15
Total	88	86
Number of species of Famennian age (% of all species)	5 (8.8 %)	15 (33.3 %)
Number of species of assumed Frasnian age (% of all species)	17 (29.8 %)	17 (37.8 %)
Number of species of assumed Middle Devonian age (% of all species)	19 (33.3 %)	4 (8.9 %) (only Givetian)
Number of species of assumed Emsian age (% of all species)	16 (28.1 %)	3 (6.7 %)
Number of species of assumed Silurian age (% of all species)	0	6 (13.3%)
Number of different spezies	**59**	**58**
Number of different genera	**34**	**31**

If we consider the whole spore- & acritarch-spectrum it is obvious, that 80.4 % of all identified species do not reflect the true age of the analysed debris flow sediments. The percentages of species (spores + acritarchs) with sufficient stratigraphic correlation are as follows: Famennian (19.6%), Frasnian (33.4%), Middle Devonian (22.5%), Emsian (18.6%), Silurian (5.9%). Therewith, for the first time reliable statistical data about to what extent reworked fossils could be comprised in greywacke-bearing Upper Devonian debris flow sediments are available.

In the Famennian the acritarch spectrum dominates over the spore spectrum, therefore indicates an open-marine, far-shore palaeoenvironment. During the Frasnian the ratio spores/acritarchs is nearly equal - indicating a far-shore, open-marine palaeoposition, but closer to terrestrial areas than in the Famennian. In the Middle Devonian (Givetian) and the Emsian the flora was dominated by spores, which is evident in a relatively near-shore, but fully marine palaeoenvironment. The sparse Silurian flora consists almost entirely of acritarchs; chitinozoans are also present. This indicates an open-marine, far-shore palaeoenvironment. Since reworked Silurian species are also present in Emsian sediments in the study area, the Silurian species within the debris flow are interpreted as reworked species from reworked Emsian components.

The detected relative age correlation for the different small lithoclasts incorporated into the debris flow is presented in table D 2.2.

Tab. D 2.2: Results of the achieved stratigraphic correlation with spores and acritarchs for the Famennian debris flow sediments

	Spores	**Acritarchs & prasinophycean algae (cysts)**
Famennian	DK1996: ds 10.3 — 10.6 (approx. Latest *crepida*-zone)	DK1996: ds 6.0 — 13.3 (approx. *triangularis*— *marginifera*-zone)
Reworked components in the debris flow:		
Frasnian	DK1996: ds 0.0 — 6.0	DK1996: ds 0.0 — 6.0 (with data-accumulation in DK1996: ds 4.2 — 5.1)
Middle Devonian	DK1996: dm 0.0 — 20.0 (with data-accumulation in DK1996: dm 11.7 — 17.7)	DK1996: dm 8.2 — 20.0 (only Givetian)
Emsian	DK1996: di 11.2 — 20.0 (with data-accumulations in DK1996: di 19.0 — 19.7 DK1996: di 11.2 — 17.4)	DK1996: di 10.2 — 20.0
Silurian	none	(Wenlockian — Ludlowian)

The sedimentary inventory of the debris flow points toward a deposition of clay from suspension punctuated by sudden incursions of silt, calcareous debris and, partly, greywacke by currents (probably turbidity currents) of waning strength (compare fig. D 2.7 and fig C 7.1). The subsequent elevation of the depositional environment, followed by low-medium velocity gliding of the clay/silt/greywacke sediment pile with Emsian to Frasnian strata occurred along a slope. Then large volumes of these sediments were carried onto the deeper sea-floor and became finally deposited when a reduction in slope caused deceleration (compare SALAMON 2002 for Givetian Debris Flows in the Lahn- and Dill-Syncline).

The grainsize of the analysed Famennian greywackes lies mostly in the range from coarse silt to coarse sand (see chapter C 7.1). The shape of grains varies between 'very angular' to 'subrounded', seldom 'rounded'. The grains are moderately to poorly sorted with many different components in a mostly silty-pelitic matrix which accounts for approx. 5 - 15% of the total mass. The component-spectrum consists of 30-40% detrital single mineral grains, 20-30% clasts of reworked sedimentary rocks, approx. 5 - 10% clasts of magmatic rocks or their derivatives and approx. < 5% clasts of reworked metamorphic rocks. The "sum-results" for reworked sedimentary, magmatic and metamorphic rocks proved to be in similar orders of magnitude as the published data for Upper Devonian greywackes from the Giessen nappe (DÖRR 1990: 46, Typ A; HENNINGSEN 1962, 1963, 1966, 1970). But a greater percentage of single mineral grains have been attributed in this study to the former three groups. DÖRR (1990: 48) states, that most of the magmatic rock remnants are attributable to acid/silicic plutonites in the Giessen area. Although such plutonite-fragments are present in the greywackes from the Weilburg — Holzheim region, they are not a major part of the clast-spectrum of the magmatites, which also, in approximately equal proportions, consist of basic to intermediate/silicic volcanites. The source region is proposed to have lain somewhere in the south in a - not yet localised - major rift region which successively came under influence of the prograding Variscan orogeny. In more general terms WIERICH (1999: 2) states: "Due to the beginning of the continent-continent collision of Gondwana in the south with the Old-Red-Continent in the north, supply and sedimentation of flysch sediments starts with the basal upper Devonian. Proven by their grainfabrics the source of the widespread upper Devonian and lower Carboniferous greywackes was the southern part of the formerly mentioned innercontinental rift and not an active continental margin."

The depositional environment of the debris flows was significantly different from the one described in the foregoing chapter D 2.4.2 for the Nehdenian lithologies.

The newly explored early Famennian greywackes are petrographically almost identical to Upper Devonian greywackes from the Giessen nappe. They do not contain limestone fragments, nor major amounts of magmatic rocks, as would be expected for sediments derived from the only known important submarine highs at that time: the (then tectonically reactivated?) remnants of middle Devonian reefs on top of magmatic ridges. The considerable content of metamorphic rocks (together with other evidence) indicates a source region somewhere in the south in a "mid-German" palaeoposition. The clasts which were shed from there could impossibly be transported directly to their present day position by passing over the remnants of the magmatic ridges of the Lahn-syncline.

The early Famennian debris flow sediment does neither contain considerable amounts of calcareous fragments nor any basalts or pyroclastics - as would be expected if their present position had been identical with their relative palaeoposition. Since the palynological analysis revealed that all - clayey to sandy and only seldom calcareous - sediments from Emsian to early Famennian times are confined in the debris flow (within a less than 20m (condensed?) sediment pile) a palaeoposition relatively far away from the magmatic ridges of the Lahn-syncline is evident.

We should draw special attention to the fact that so much different palynological age correlations for these reworked sediments had been possible at all. Considering the reworking process and even the conservation of reworked Silurian species, the preservation of palynomorphs in the Giessen nappe samples is quite good and seems to be limited only by the pyrite content. This is in remarkable contrast to the generally bad preservation of Devonian palynomorphs in outcrop samples from proposed autochthonous units. A plausible explanation for this is: The allochthonous units have been overthrust sometimes around the borderline Lower/Upper Carboniferous, thus were placed on top (at least up to approx. 300m) of the parautochthonous units. Therefore, later (in the course of the Variscan orogeny) they became less deeply buried and hence less thermally altered. That seems to be the most conclusive reason why younger greywacke units (Famennian) are datable at all - with a sometimes good preservation of palynomorphs (limited not by thermal alteration but in majority by bacterial attack, weathering and pyritization prior to final deposition).

A small outcrop with proposed Upper Devonian greywackes north of Hadamar near Elbgrund had been described by HENNINGSEN (1970). The outcrop lies approx. 11km northwest of an outcrop with Famennian greywacke west of Eschenau. Due to HENNINGSEN (1970: 198) these greywackes are similar to the Upper Devonian (Nehdenian - Hembergian) Hörre-greywackes southeast of Nenderoth.

The Upper Devonian to Lower Carboniferous section H 1-24 near Steeden

Due to a new interpretation of data from HENNINGSEN (1965), Gerhard & Renate HAHN (1982), and FEY (1983, 1985), the Upper Devonian to Lower Carboniferous section H 1-24 is also characterised as being part of the Giessen nappe in this study.
The section (see fig. D 2.8) is assumed to reflect a concordant lithologic succession from the late Famennian to the early Viséan and bears in parts reworked late Famennian and Lower Carboniferous faunas.
The deposition took place at a proximal position of the slope of a submarine ridge. The main constituent of the sedimentary facies within the late Famennian is clay-silt (greenish and reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (marls, limestones, calcareous nodules). Repeated (discyclic?) influx of fine-grained reworked tuffs and reworked pyroclastic deposits, due to episodic submarine volcanic activity occurred. A moderate late Famennian regressive trend is evidenced by continuous carbonate production at the ridge top in spite of apparently constant subsidence rates with no reworking of older conodont-bearing deposits. We can infer a short-termed rapid sea-level fall during Early *praesulcata* zone, followed by (?sudden) influx of anoxic bottom waters (Hangenberg event). A continual sea-level rise during the lower Lower Carboniferous within a starved basin is indicated. Due to submarine volcanic activity, the buildup of new (or reactivation of old) submarine ridges in the *anchoralis-latus*-zone and in the early Viséan occurred together with carbonate production at the tops. Subsequent deposition of crinoid-limestone debris followed in the form of turbidites at the slope or within the basin.

The Viséan Erdbach limestone III from section H 1-24 near Steeden yielded a trilobite fauna which is significantly different to other Erdbach limestone faunas of the eastern Rheinisches Schiefergebirge and reveal closer relations to contemporaneous Harz-faunas from the Winterberg (HAHN, HAHN & MÜLLER 1998: 199).

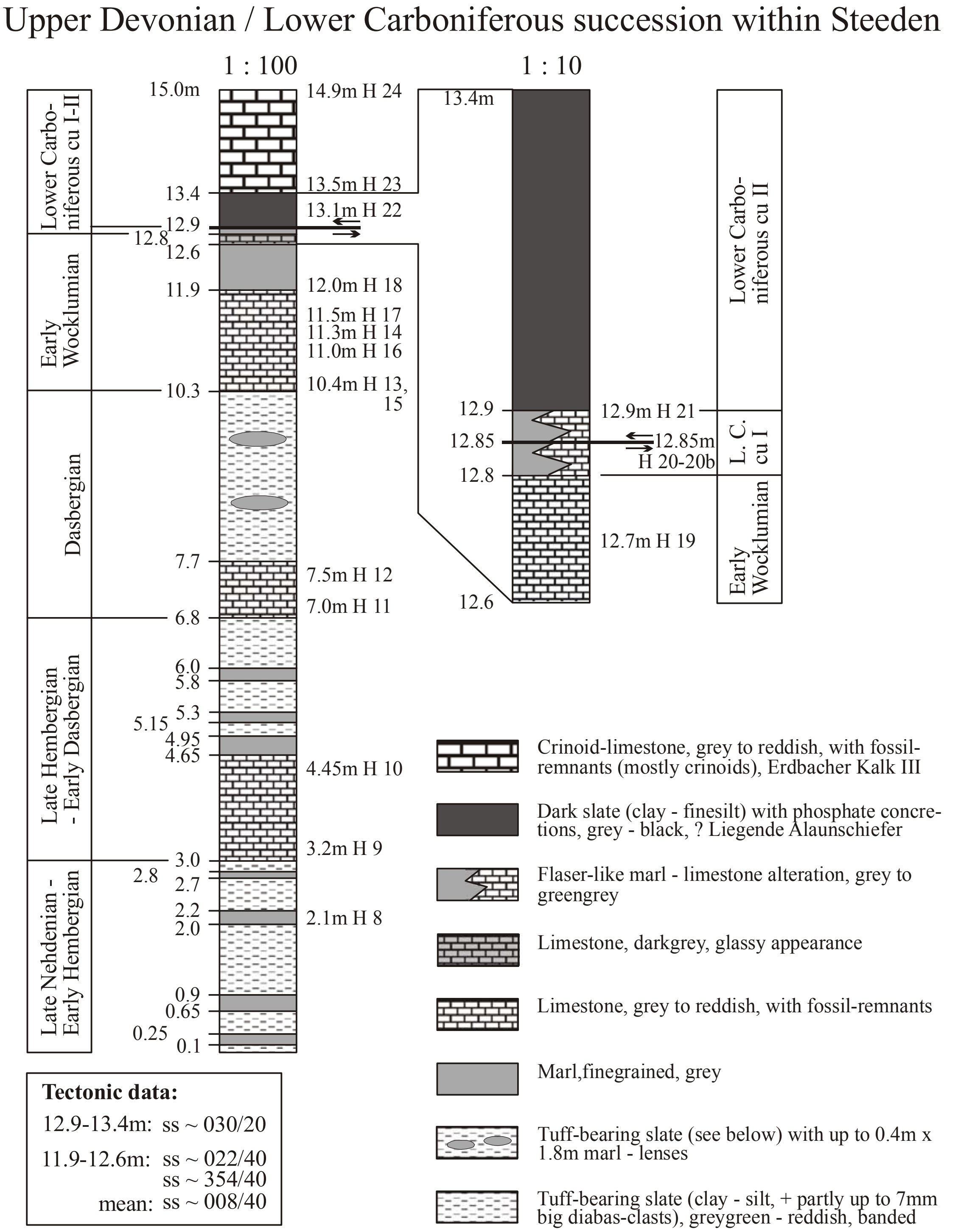


Fig. D 2.8: Composite sedimentary log of the Upper Devonian / Lower Carboniferous succession within the village Steeden (comp. by VOGT). Outcrop first described by HENNINGSEN 1965. HENNINGSEN, 1965: 619 bottom, described a concordant succession: "While the upper limestone-beds at the [morphological] cliff as well as the uppermost layers at the quarry wall dip with approx. 20° towards the east, the lower beds of the cliff show a dip towards the north. In this way the impression is generated that there exists an angular unconformity between the lithologies of the lower and upper parts of the cliff. However, this discordance only apparently exists; it is generated by bending of the beds of the lower lithologies and slowly terminates towards the top of the succession." HENNINGSEN's observation concerning the different dip direction is confirmed by VOGT, but the interpretation as (?synsedimentary) bending of the lower lithologies without tectonic influence lacks proper evidence.

D 2.5 Lower Carboniferous

During the Tournaisian a southward directed burial of the Phyllite zone within c. 2-2.5 mio. a (for an assumed velocity of convergence of 14 mm/a and a downthrust angle of 30°) to a final depth of 14-20 km at 4.2-5.8 kb occured. The process lead to internal attachment/ stacking of slices of the downthrusted phyllite zone on to the upper unit (i.e. to parts of the sediments of the later developed Giessen nappe; KLÜGEL (1997)).

In Viséan times an asumed anti-clockwise rotation of Gondwana (+ Armorica) induced strike-slip movements along former rift-related lineaments. The subsequent development of small pull-apart basins and local extension provided space for local magma outflow (Deckdiabas) and turbiditic sedimentation of the Bruchberg sandstone (compare fig. D 4.2 and D 4.3).

During the Upper Carboniferous the subsequent northward directed overthrust of the phyllite zone on the Taunuskamm-unit took place. The elevation of the whole sequence lead to the exposition of the sediments of the upper unit and to subsequent basal detachment with gravity gliding and nappe formation (Giessen nappe). KLÜGEL (1997: 113+154), who convincingly proposed the scenario mentioned above, explained the burial of the Phyllite unit within a reactivated (?) subduction zone at the position of the former Giessen ocean between the Rhenohercynian (Avalonia) and the Saxothuringian (Armorica). However, the existence of a subduction zone is not an inescapable condition for the scenario shown and can therefore not act as evidence for the existence of the Giessen ocean. The late Variscan cycle provided a longer lasting convergence with late folding and thrusting of autochthonous and nappe units together. In this way the originally flat discordant contacts became often irregular shaped and cut by later thrusts - therefore: hard to detect in small outcrops, which are predominant in the Rhenohercynian (DALLMEYER et al. 1995).

D 2.5.1 Tournaisian

The controlling factors during the Tournaisian had been a continuous sea-level rise during the lower Lower Carboniferous within a starved basin with reduced clastic influx (AV1, AV23, AV47, AV49, AV52, AV 53, AV292, TW4; appendix F1 and F 2), submarine volcanic activity (K14, TW2A, TW3, TW4), the buildup of new (or reactivation of old) submarine ridges and the carbonate production at the ridge-tops. The subsequent deposition of crinoid-limestone debris followed in the form of turbidites at the slope or within the basin (K14, (KRE1), P1, P8, TW2A, TW3).

Neither is direct evidence available for the occurrence of sediments from the **Obere Hangenberg Schichten** (Upper Hangenberg formation) nor from these of the **Liegender Alaunschiefer** (Lower alumn-slate formation). But within the *sandbergi* conodont-zone the **Deckdiabas I** and **Erdbach limestone I** occured at sample-location TW2A and TW3. Episodic submarine volcanic activity lead to submarine magma outflow (pillow-basalt) or subsurface intrusions. Carbonate production became possible at certain locations on top of such newly built or reactivated submarine highs. The subsequent erosion of these limestones lead to the downslope transport of fossiliferous calcareous debris and final deposition together with reworked sediments/faunas of late Famennian to early Tournaisian age.

The pelitic background sedimentation of at least "middle" Tournaisian strata is preserved at locations AV23 and AV47. The lithogies from both sample-locations generated on a marine outer shelf, not too near to terrestrial areas, since acritarchs are present in sample AV47 and presumably also in AV23. Also some (not very significant) floral evidence in favour of the influx of reworked Famennian sediments is present in sample AV23. The sedimentary inventory for both samples indicates a deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt and calcareous debris. Dominating bedding features were lenticular bedding and laminated silt or mud. The wave energy and mud supply controlled mud abundance. Sometimes small nodules which show a cherty character occur and are probably thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable.

During the late Tournaisian the influx of silt-sized detritus decreased steadily and the deposition of mud from suspension within a basin was clearly dominant. High equatorial radiolarian-productivity in connection with reduced clastic influx from an increasingly arid southern Laurussian continent (with reduced topography) allowed for a sedimentation of radiolarian-rich siliceous oozes (**Dunkle Lydite**, Dark flinty slate fm., AV1, AV292, AV52). The silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood. The dark colouration is induced by a high content of finely dispersed organic matter (CORRENS 1924, HAAGE 1966, LITJES 2001). During the uppermost Tournaisian, episodic submarine volcanic activity lead to submarine magma outflow (pillow-basalt, tuff-layers, **Deckdiabas II**) into the siliceous oozes. Accompanying tectono-seismic activity probably induced the reworking of "middle" Tournaisian sediments (TW4). The process may have also lead to the formation of "**Kieselschieferbrekzien**" (flinty slate brecias) via reworking of lithified upper Tournaisian-Viséan flinty slates and pelites (the flinty-slate parts of the breccia, which bear radiolarians, had been completely lithified before brecciation). The components of the evolved breccia consist of very angular flinty slate and pelite gravel. The reworking could have happened a) during sea-level fall with exposition of flinty slates sedimented on top of a submarine high or b) during volcanic (Deckdiabas-) activity with sudden destruction of a flinty slate succession at a flank of a submarine high and subsequent gliding of the shattered components towards the foot of the slope. In this study alternative "b" is preferred because of the very angular components of the breccia which show no evidence of intensive (near-shore-) reworking and the spatial vicinity to an ancient submarine high built up by diabas. The Deckdiabas II-phase maybe even lead to the built-up of small islands.

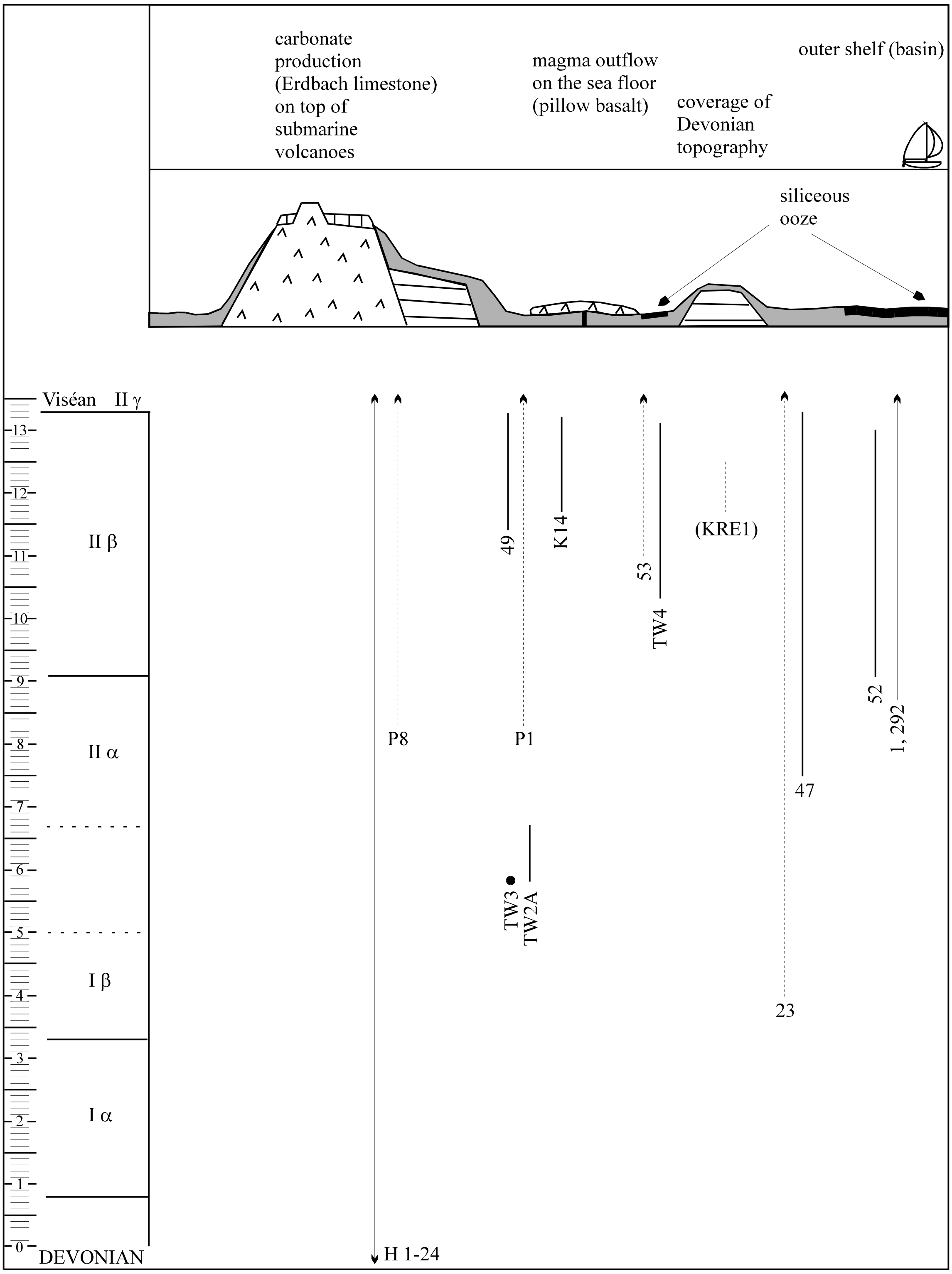


Fig. D 2.9: Schematic reconstruction of the palaeoenvironment during the Tournaisian in the study area. Continuous sea-level rise during the lower Lower Carboniferous within a starved basin. Due to submarine volcanic activity buildup of new (or reactivation of old) submarine ridges with carbonate production at the tops. Grey shaded: Tournaisian sediments and volcanics. The age correlations for the samples show the least determinable time increment of probable time range of deposition (not the time range of the succession!). The black vertical lines indicate the most probable time range common to all mentioned samples, the stippled lines display the uncertainties.

Although we observe at sample-location AV 49 an open marine environment, it must have been somewhat close to terrestrial areas (islands?), since the spore spectrum dominates well over the acritarch flora. Maybe the deposition took place near the base of the slope of such an island below and was punctuated by sudden (tempestitic) incursions of rapidly deposited finesilt. Probably tectono-seismic activity lead to the redeposition of late Famennian sediments. The dominating bedding features were lenticular bedding and laminated finesilt or mud. The platy to brittle appearance is probably induced by thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable.

The uppermost Tournaisian topography in the region was not even, but characterised by remnants of former Devonian reefs and volcanic build-ups. Sedimentary dykes within early Frasnian reef-complexes with faunas of Tournaisian age had been described by KREBS (1971, KRE1). Also the **Deckdiabas-II**-phase (K14) allowed for the carbonate production on top of some newly generated or activated submarine highs (**Erdbacher Kalk II**, E. limestone II, P1, P8). Sample P1 is indicative for a deposition near the base of a basinal slope. The main constituent of the sedimentary facies was dark, oxygen-depleted, clay-silt with episodic (seismically induced?) intercalations of (turbiditic) calcareous debris from higher parts of the submarine ridge. Sample-location P8 had its depocentre near the top of the ridge, as indicated by the occurrence of a relative thick succession of calcareous debris.

D 2.5.2 Viséan

Around the Tournaisian/Viséan border a successive change from blackish to greyish colouration within the flinty slates took place. Maybe this was due to reduced influx of organic material. At sample-location AV290 probably parts of the "**Helle Lydite**" (Light flinty slate formation) occur, although a surficial reddish colouration prevails. AV290 bears remnants of conodonts, echinoderms (spines), sponges (masses of spicules) and radiolarians, but nearly all are indeterminable. All conodonts are broken along tectonically induced microfissures. All radiolarians display enhanced crystal growth of quartz during diagenesis and metamorphism. Due to the classification of GURSKY (1997: 52), AV290 represents a "spiculitic flinty-slate", since the sample contains > 1% spicules of sponges. "Such rocks have almost entirely been observed at the level of the Light Flinty-Slates and Flinty Limestones ..." GURSKY (1997: 52, in german). The sedimentary inventory points towards the deposition of mud from suspension within a basin. High equatorial radiolarian-productivity in connection with reduced clastic influx from an increasingly arid southern Laurussian continent allowed for a sedimentation of radiolarian-rich siliceous oozes. At sample location AV290: 1248cm compacted sediment, divided by 184 layers, are preserved at the abandoned quarry south of Eschenau (E 3440890 - N 5588770); with an average layer-thickness of 6.8cm. By using readings from this outcrop (tab. F 2.2, appendix F 2) and identifying cyclic sequences within the data set, it was possible to calculate the sedimentation rate. GURSKY (1997: 75) mentions an estimated sedimentation rate of 1.8 mm/ka for the Rhenohercynian flinty slates of Lower Carboniferous age. The range of the herein calculated sedimentation rates, which lies between 2.6 - 4.1 mm/ka, is slightly higher but still in good agreement with GURSKY's guess.

The **third distinct Deckdiabas-phase** is documented at sample-locations K7, K8, K11, P6 and probably also at D10. Submarine basic volcanic activity lead to the development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments of Upper Devonian to Lower Carboniferous age. At location P6 we can observe a succession of a) submarine basaltic magma outflow; b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris from higher parts of a submarine ridge. The temporary sample location D10 gives a more detailed insight into the succesive processes. The Schurf showed a succession of:

a) submarine basaltic magma outflow;

b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris (and maybe of finesand) from higher parts of a submarine ridge. Redeposited fossils indicate a former depositional region at a higher position of the slope near or on top of the ridge; the sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed; repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, is reflected by the concentration of the fossils on the bedding planes, which are separated by mm to cm thick layers of clay to silt or calcareous debris; this interpretation is in accordance with results obtained by BLESS (1992:204) for a contemporary succession at the Velbert anticline, near Aprath (Germany);

c) deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited, partly fossil-bearing, silt-finesand. The appearance of flaser bedding indicates punctuate low-energy to medium-energy bottom currents, which probably often lead to erosion of sediment accumulated just before. The occurrence of wood remnants indicates a position near a subaerial environment (?island). Episodic submarine volcanic activity lead to deposition of tuff layers.

Together with the **Deckdiabas III**-phase at certain elevated locations the **Erdbach limestone III** formed. Its fauna had been subject of several studies within the last decades and is, therefore, well known (G. & R. HAHN (1982), FEY (1983, 1985), HAHN, HAHN & MÜLLER (1998). At sample-location HH1, F1, H1-24 near Steeden the deposition of sediments near the base of a basinal slope took place. The main constituent of the sedimentary facies was clay-silt with intercalations of (turbiditic) calcareous debris from higher (max. water depth 75-150m, FEY 1983: 101) parts of the submarine ridge. HAHN, HAHN & MÜLLER (1998) described several new trilobite taxa from this location and presented the following conclusion in their english abstract (p. 199): "Palaeogeographically, the fauna of Steeden is in a relatively isolated position: 10 taxa [all new species, ...] are endemic, and this situation is even more accentuated if the *Cystispinae* are taken into consideration. Among the remaining taxa, 6 of them [...] show palaeogeographic connections to the Winterberg. But only two taxa [...] are known from the region of

Erdbach. The reasons for this peculiar geographical distribution are unknown." And on page 164 of the german text it is mentioned "in spite of the geographical position at the SE margin of the range of distribution of the Erdbach limestones the relations of Steeden to the more distant Harz are closer than to the nearer located sample points in the Erdbach region."

More distal to the tops with Erdbach limestone production the sediments of sample-locations K6, K9, P7 K10, K12 and W2 had been deposited near the base of a basinal slope. The main constituent of the sedimentary facies was clay-silt with intercalations of (turbiditic) calcareous debris from higher parts of the submarine ridge. Since reworked conodonts with a lifetime well before the first described occurrence of "Erdbacher Kalk, type I" appear within the calcareous debris of sample K6, it seems probable that unlithified sediments of that age were incorporated into the calcareous debris flow on its way downslope. At locations K10 and W2 submarine basic volcanic activity with development of pillow-basalts with inclusions of (?) syngenetic soft sediments occurred.

Sample-location AV70 probably represents an open marine palaeoenvironment at the slope of a submarine high without carbonate production on top. The palaeoposition must have been not too far away from terrestrial areas (islands?), since only spores, no acritarchs are observable in the palynospectrum. Predominant sedimentary feature had been the deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited finesilt. Furthermore, tectono-seismic activity lead to redeposition of Famennian sediments. A sometimes observable platy to brittle appearance was probably induced by thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable, but no, e. g., radiolarians or sponge-spicules.

At a palaeoposition more distal than AV 70, within a low-energy environment, but still in reach of distal turbidites from submarine highs with carbonate production, we assume sample locations K13, P2, P10 and W3b. We observe a succession of light flinty slates and layers of limestone debris which originated by deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous and fossiliferous debris. The cherty/flinty slates are probably products of deposition of primary siliceous oozes which became partly separated during diagenesis and compaction. At location W3b episodic submarine volcanic activity occured and lead to the deposition of "pure" pyroclastic deposits. Also pyroclastic deposits which were firstly deposited at/near the top of the ridge are observable in the form of subsequently reworked and downslope transported sediments.

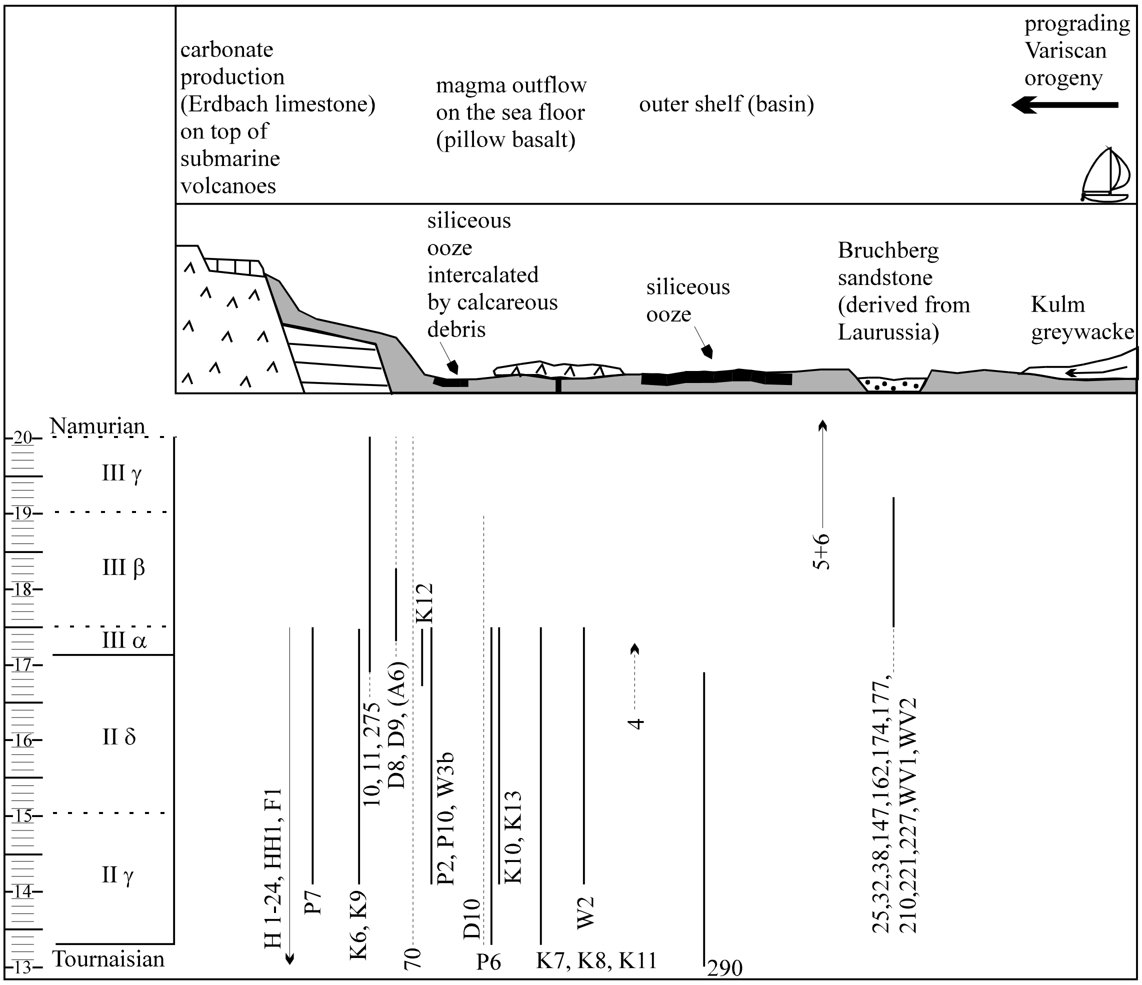


Fig. D 2.10: Schematic reconstruction of the palaeoenvironment during the Viséan in the study area. Continuous sea-level rise during the lower Lower Carboniferous within a starved basin. Due to submarine volcanic activity buildup of new (or reactivation of old) submarine ridges with carbonate production at the tops. Grey shaded: Viséan sediments and volcanics. The age correlations for the samples show the least determinable time increment of probable time range of deposition (not the time range of the succession!). The black vertical lines indicate the most probable time range common to all mentioned samples, the stippled lines display the uncertainties.

As in the late Tournaisian (AV53), we find evidence for the formation of **Kieselschieferbrekzien** (flinty slate breccias) in the Viséan (AV 4). They document the reworking of lithified upper Tournaisian-Viséan flinty slates and of Famennian-Tournaisian pelites, whereby the flinty-slate parts of the breccia had been completely lithified before brecciation. The components of the evolved breccia consist of very angular flinty slate and pelite gravel. The reworking could have happened during sea-level fall with exposition of flinty slates sedimented on top of a submarine high. But because of the very angular components of the breccia which show no evidence for intensive (near-shore-) reworking and the spatial vicinity to an ancient submarine high built up by diabas, this explanation seems to be unsatisfying. More probable is the sudden destruction of a flinty slate succession at a flank of a submarine high during volcanic (Deckdiabas-) activity with subsequent gliding of the shattered components towards the foot of the slope.

The typical deposits of the younger part of the Viséan are the **Kulm-Tonschiefer** (K. slate formation). At sample-locations AV275, AV10, AV11, D8, D9 (Kahlhau mountain, see also composite sedimentary log in fig. D 2.11) we can observe a succession of slates, silty slates, silty-sandy slates and siltstones, which partly inhabit tuff-layers. The sedimentary inventory points towards a deposition of mud from suspension within a basin or at the basal parts of the slope of a submarine ridge, punctuated by sudden (turbiditic) incursions of rapidly deposited, partly fossil-bearing, silt-finesand. Tectono-seismic activity maybe lead to redeposition of Famennian-Tournaisian sediments. The appearance of flaser bedding indicates punctuate low-energy to medium-energy bottom currents, which probably often caused erosion of the sediment accumulated just before. The occurrence of plant remnants indicates a position near a subaerial environment (?island). Episodic explosive submarine volcanic activity lead to deposition of tuff layers. The palynofacies is dominated by acritarchs which indicates an open marine palaeoenvironment, but the occurrence of (often badly preserved) spores testify that terrestrial areas (?islands) were not too far away. Presumably, sample-location A6 represents also the Kulm-Tonschiefer, but due to the uncertainties concerning its age-correlation, no reliable evidence is available so far. Probably the youngest sediments in the area had been encountered from a temporary outcrop within Steeden. Sample-location AV 5+6 represents an open marine palaeoenvironment not too far away from terrestrial areas, since the spore spectrum dominates the acritarch flora in this Kulm-Tonschiefer.

Bruchberg Sandstone (AV 25, 32, 38, 147, 162, 174, 177, 210, 221, 227; WV1, WV2)

Probably the most interesting lithological unit within the study area is the Bruchberg sandstone near Limburg/Dietkirchen. The sandstones had formerly been described by KEGLER 1967 and correlated to Upper Devonian sandstones from the Hörre zone. They had been a key argument in his proposal for a special palaeofacies development in the area during the Upper Devonian. But a first thin section analysis by WIERICH (compare WIERICH 1999) revealed, that they had little in common with the former mentioned Upper Devonian sandstones but seemed to be similar to the "Hörre-Gommern-Quartzite". This somewhat puzzling result caused a thorough investigation into the petrography of the "Hörre-Gommern-Quartzite" from different locations (WIERICH & VOGT 1997).

The sediments comprise sandstones, small quantities of pebbly sandstones and mostly thin layered shales. Qualitative and quantitative analyses for composition of the light- and heavy-mineral fractions of these sandstones show uniform composition along a distance of more than 300 km (fig. D 2.12). Proven by composition and fabrics of clastic grains, the source area of the Lower Carboniferous sandstones was the Old Red Continent.

Viséan pelite succession from the Kahlhau - mountain

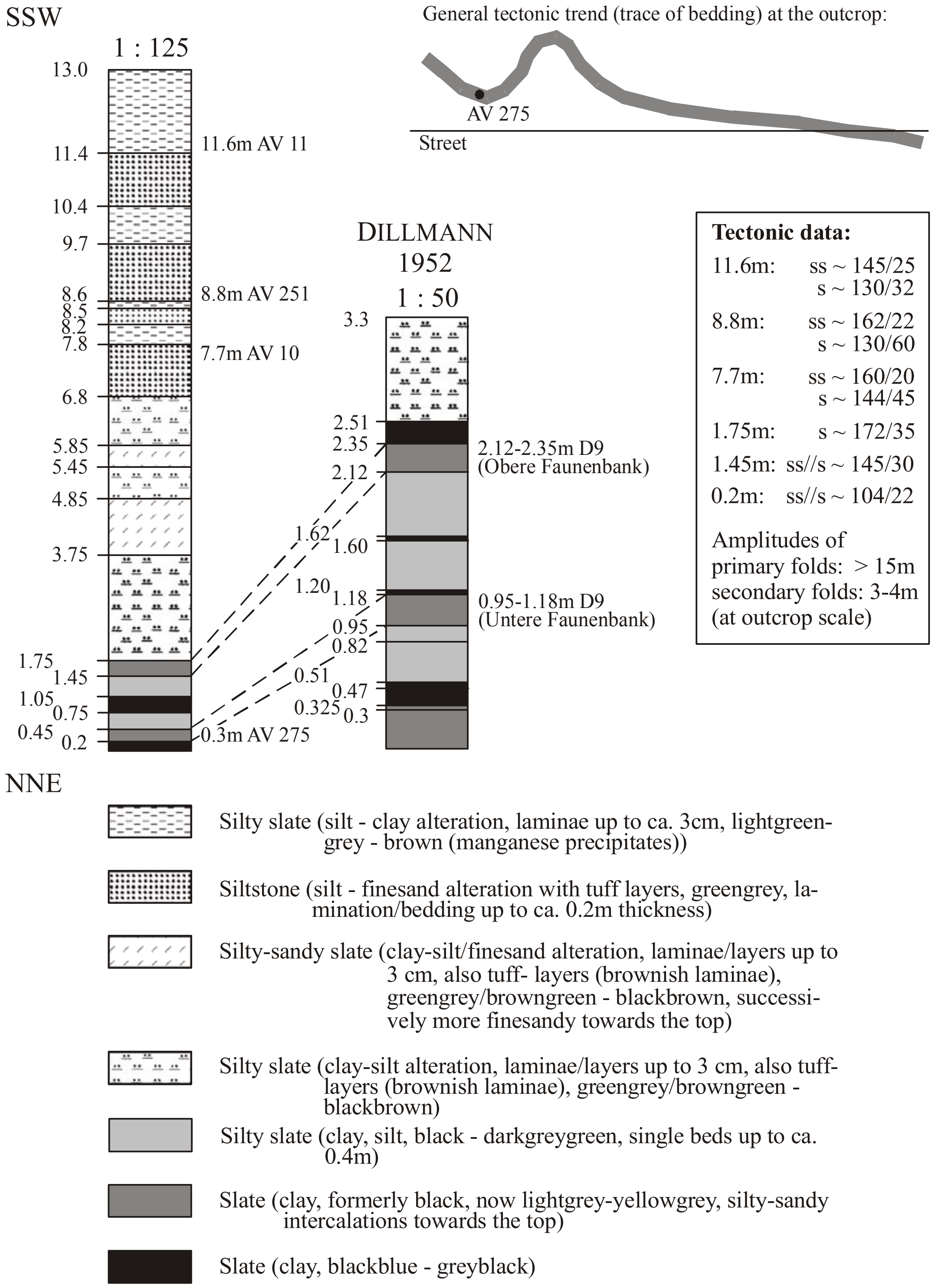


Fig. D 2.11: Composite sedimentary log (left column) with sample locations AV 10, 11, 251, 275. For comparison the data submitted by DILLMANN 1952 from a similar location nearby are presented as sedimentary log in the right column (with sample locations for D9, compare appendix F 1.3).

The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin. Figure D 4.3 (chapter D 4) displays palaeogeographic and palaeotopographic maps showing the situation between eastern Laurussia and Gondwana during the Lower Carboniferous (Viséan). A possible position of the depositional environment for the Bruchberg sandstone is also shown. It is assumed that an anti-clockwise rotation of Gondwana (+ Armorica) induced strike-slip movements along former rift-related lineaments. The subsequent development of small pull-apart basins and local extension provided space for local magma outflow (Deckdiabas) and turbiditic sedimentation of the Bruchberg sandstone.

A petrographic analysis for the Bruchberg sandstone from Dietkirchen is presented in chapter C 7.3 (AV 44, AV 50). The grainsize of the analysed samples from the region north of Limburg lies mostly in the range of very fine- to coarse sand. The shape of grains varies between very angular (0) to well-rounded (5) with an arithmetic mean value of 2.5 (WIERICH & VOGT 1997: 117). The grains are moderately sorted, dominated by quartz, however with many different components. The matrix in this grain-supported sediment is mostly silty-pelitic. The typical lightgrey to whitish colour of the sandstones, which is predominantly observable in outcrops, is a result of weathering. The sandstones from drill cores show mostly a grey colouration.

In the course of their study WIERICH & VOGT (1997) encountered many regional names for these sandstones. The actualised list is displayed hereafter:

- Bruchbergsandstein (von TREBRA 1785, WIERICH & VOGT 1997, this publ.)
- Quarzfels des Bruchberges (LASIUS 1789, ROEMER 1850)
- Sandsteine des Bruchberges und Ackers (ROEMER 1852)
- Culmquarzit (KOCH 1858)
- Wollenberg-Quarzit (KOCH 1858, KAYSER 1915, CORRENS 1926, 1934a, KLÜPFEL 1952, BISCHOFF & ZIEGLER 1956, BISCHOFF & STOPPEL 1957)
- Culmsandstein des Jeust (WÜRTTENBERGER 1865)
- Acker-Bruchberg-Quarzit (KOCH 1888, DAHLGRÜN & GOTHAN 1940, SCHWAN 1952)
- Ecker-Ilsequarzit (KOCH 1888)
- Kellerwald-Quarzit (DENCKMANN 1892, DAHLGRÜN 1931, SCHMIDT 1926, 1933, SCHWAN 1952, EDER et al. 1969)
- Wüstegarten-Quarzit (DENCKMANN 1896, 1897, KAYSER 1915, AHLBURG 1921)
- Quarzit des Sandberges (DENCKMANN in POTONIÉ 1901)
- Pflasterstein-Quarzit (DENCKMANN in POTONIÉ 1901)
- Klippenquarzit (KAYSER 1907, 1915, AHLBURG 1921)
- Schiffelborner Quarzit (KAYSER 1907)
- Bruchbergquarzit (AHLBURG 1921, KOCH 1888)
- Gommern-Quarzit (AHLBURG 1921, PAECH 1973b, BURCHARDT 1977a)

- Kammquarzit (AHLBURG 1921, MEMPEL 1934, 1950, SCHRIEL 1933, 1954, KOCKEL 1958, SCHRIEL & STOPPEL 1958, SCHWAN 1958, 1991, STOPPEL 1961, BENDER & BRINCKMANN 1969, PUTTRICH & SCHWAN 1974, BURCHARDT 1977b, HOMRIGHAUSEN 1979, BIRKELBACH et al. 1988, BUCHHOLZ et al. 1990, JÄGER (1999 a+b), JÄGER & GURSKY (2000))
  [JÄGER (1999a, only "electronically" published at http:\\elib.tu-darmstadt.de/diss/000015) redefined the "Bruchberg-Sandstein Formation" (WIERICH & VOGT 1997) and called it again "Kammquarzit Formation". However, none of the arguments put forward in favour of the term "Bruchberg Sandstone Formation" had been properly discussed. Therefore, the latter term is reinstated herewith and the term "Kammquarzit" treated as beeing a synonym.]
- Schiffelborner Quarzit (KAYSER 1915, AHLBURG 1921)
- Gießener Quarzit (BISCHOFF & STOPPEL 1957; proven by WIERICH & VOGT 1997 to be a primarily calcareous Lower Devonian psammite)
- Acker-Quarzit (SCHWAN 1950, 1958)
- Ilsenburg-Quarzit (BURCHARDT 1977a)
- Quarzsandsedimente von Gommern (BURCHARDT 1994)
- Limburger Quarzit (VOGT 1996)

The first description of Hörre-Gommern-type sandstones was published by von TREBRA (1785) from the Bruchberg (Harz). By honoring this fact and considering the confusion caused by the vast amount of local names used for the Lower Carboniferous sandstones of the Hörre-Gommern-Zone, WIERICH & VOGT (1997) presented a new lithostratigraphically based definition: "Bruchberg-Sandstein Formation". All above listed names therefore have to be treated as synonyms.

WIERICH & VOGT (1997) also asked why a sandstone should not be termed "sandstone" but "quartzite" just because its grains are bound together by a silica-enriched matrix. In their opinion the term "quartzite" should be restricted to metamorphically overprinted (greenschist to granulite facies), recrystallised silica-enriched rocks (see WIERICH & VOGT 1997, chapter 6.3.1., for a detailed discussion). "The herewith analysed sandstones of Lower Carboniferous age gained their exceptional hardness mainly because of strong compaction of a poorly sorted, silica-enriched sediment under typical conditions of diagenesis. The additional, but limited, cementation due to oriented growth of clastic quartz-grains triggered the resulting hardness to some extent." By using the classification of PETTIJOHN et al. (1973) the sandstones could also be termed quartz-arenites to sublith-arenites.

A thorough analysis of the Bruchberg sandstones in the area north of Limburg - both for drill cores and outcrops - had been undertaken. The results are presented in appendices F 1-3, and chapters C 3, C 5, C 6, C 7, C 8, C 12. All collected data allowed for a synoptic reconstruction of possible relative palaeopositions for different sedimentary piles of the Bruchberg sandstone formation (enclosure 2 and 3). By using the reconstruction a total minimum thickness of approx. 120m can be derived for the Bruchberg sandstone formation at this location. When we further assume that no major faults and/or overthrusts had occured, we may even obtain a possible thickness of approx. 300m and a lateral extension of approx. 325m. The latter data are directly obtainable from the drawing on enclosure 3, which represents a graphically unfolded/backrotated version of the graph on enclosure 2. In chapter C 8.2 a maximum sedimentation rate of 10 mm/ka for the pelitic background sediments had been derived by analysing light/dark- (MILANKOVITCH-) cycles in the pelites. In doing so, the 17.1ka and 20.3ka precession cycle of the Earth during the Lower Carboniferous had been detected within the Bruchberg sandstone. By presuming a constant sedimentation rate for a 120m long and predominantly pelitic sediment pile, it would cover approx. 12 million years. This value represents the maximum time span, since we know the sedimentation rate had not been constant due to more ore less frequent short-termed sandstone intercalations.

In clear contrast to JÄGER's (JÄGER 1999 a, JÄGER & GURSKY 2000:426) statement of a predominant "quartzite facies" (= sandstone dominated) in the area around Dietkirchen, we can observe an ongoing succession of several tens of metres of clay/silt, interrupted by short-termed incursions of sandstones (compare chapters C 7.3, C 8.2 and enclosure 3). No general trend towards the relative position of this part within the greater, not preserved, basin can be derived. But due to the major clay/silt-component within the sedimentary piles a relatively distal position relative to the source area for the sandstones seems most probable.

The age of the Bruchberg sandstone formation had long been the topic of discussions. WIERICH & VOGT (1997) reviewed the former findings and applied for the first time palynostratigraphy to the Bruchberg sandstone. Their results - gained from samples from the Harz (drill site Ackerstollen 3), Kellerwald (quarry south of ruin Löwenstein) and Lahn-syncline (Dietkirchen) - allowed for a correlation to the PU-sporezone (Ackerstollen 3: 53.5m; Dietkirchen: AV 25 & 147), the TC-zone (Ackerstollen 3: 375.8m) and the DP (VP)-zone (Kellerwald: Fs5). The sample "Ackerstollen 3: 53.5m" and the ones from Dietkirchen were assumed to be of younger age, but due to the lack of characteristic younger species or the restricted state of preservation of the palynoflora no further adjustments had been possible. JÄGER (JÄGER 1999 a, JÄGER & GURSKY 2000) states a stratigraphic range for the Bruchberg sandstone in the Harz and Gommern area that begins at the base of the PU-spore zone and lasts well into the ME-spore zone. Several new analyses in the area of Dietkirchen (see chapter C 5, appendix F 2) revealed a preserved onset of the Bruchberg sandstone sedimentation in the TC-spore zone, but some samples indicate an even younger age (DP- or even VF-spore zone). Many uncertainties remain due to the often poor preservation of the palynoflora. Framboidal pyrite is a common constituent of the palynospectrum (compare chapter C 4 and C 10). The occurrence of pyrite in any form is not a limiting factor for a good stratigraphic correlation itself (since pyrite is also present in some *good* samples) but surely on a statistical level. It is assumed in this work, that some pyrite framboids developed within phycomata of unidentified acritarch "sacs", which had been mostly observed in Lower Carboniferous samples (see fig. C 10.2 and chapter F 2.3, pl. F 2-8). The framboid formation could have taken place in single phycomata via iron monosulfide precipitates (greigite). Due to rapid crystal-nucleation at the outer rim initial annular framboids had been built and later pyrite framboids of shape and size of the original phycomata were generated. After disaggregation of the organic material only the framboids had been left. In this way and if the above presented hypothesis is true, great amounts of pyrite framboids may act as an indicator for former rapid (prasinophycean?) algae production or algal blooms.

Since the base of the formation in this area had not been detected, a younger onset remains a possible option. WIERICH & VOGT (1997) described a new finding of Bruchberg sandstone in the forest approx. 1.1km southwest of Weipoltshausen (sample F 23 = AV 38, see fig. D 2.12). A more thorough investigation into the palynoflora revealed additional data (chapter C 5 and appendix F 2.1) that allow for a correlation of this sample into the NM-spore zone.

Another interesting result has to be mentioned. The palynospectrum of the samples from the Bruchberg sandstone of the Dietkirchen area (chapter C 5, appendix F 2) contained several reworked spores which cover a biostratigraphic range from the uppermost Devonian (?*pusillites-lepidophyta* spore zone) to the uppermost Tournaisian (CM-spore zone). This seems to be the time span in which the eroded sediments from the Old Red Continent had been reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel in a proximal position of the Laurussian shelf. The weathering and erosion of the source rocks of the Bruchberg sandstone may have happened under a warm and humid climate under non-alkaline conditions, since considerable amounts of kaolinite are observable in the matrix of the coarser grained sediments as well as in the finer grained ones (compare chapter C 7.3, x-ray diffraction pattern of the pelitic sample AV 50 from the Bruchberg sandstone formation).

Kulm greywacke

Small remnants of Viséan (*Goniatites* III β/γ) greywacke north of Hadamar near Oberzeuzheim had been encountered by HENNINGSEN 1970. These occurrences are situated approx. 9km northwest of an outcrop with Famennian greywacke in the analysed area near Eschenau. Due to HENNINGSEN (1970: 196), these greywackes are identical to the Lower Carboniferous Giessen-greywackes, which are presently interpreted as being part of the Giessen nappe.

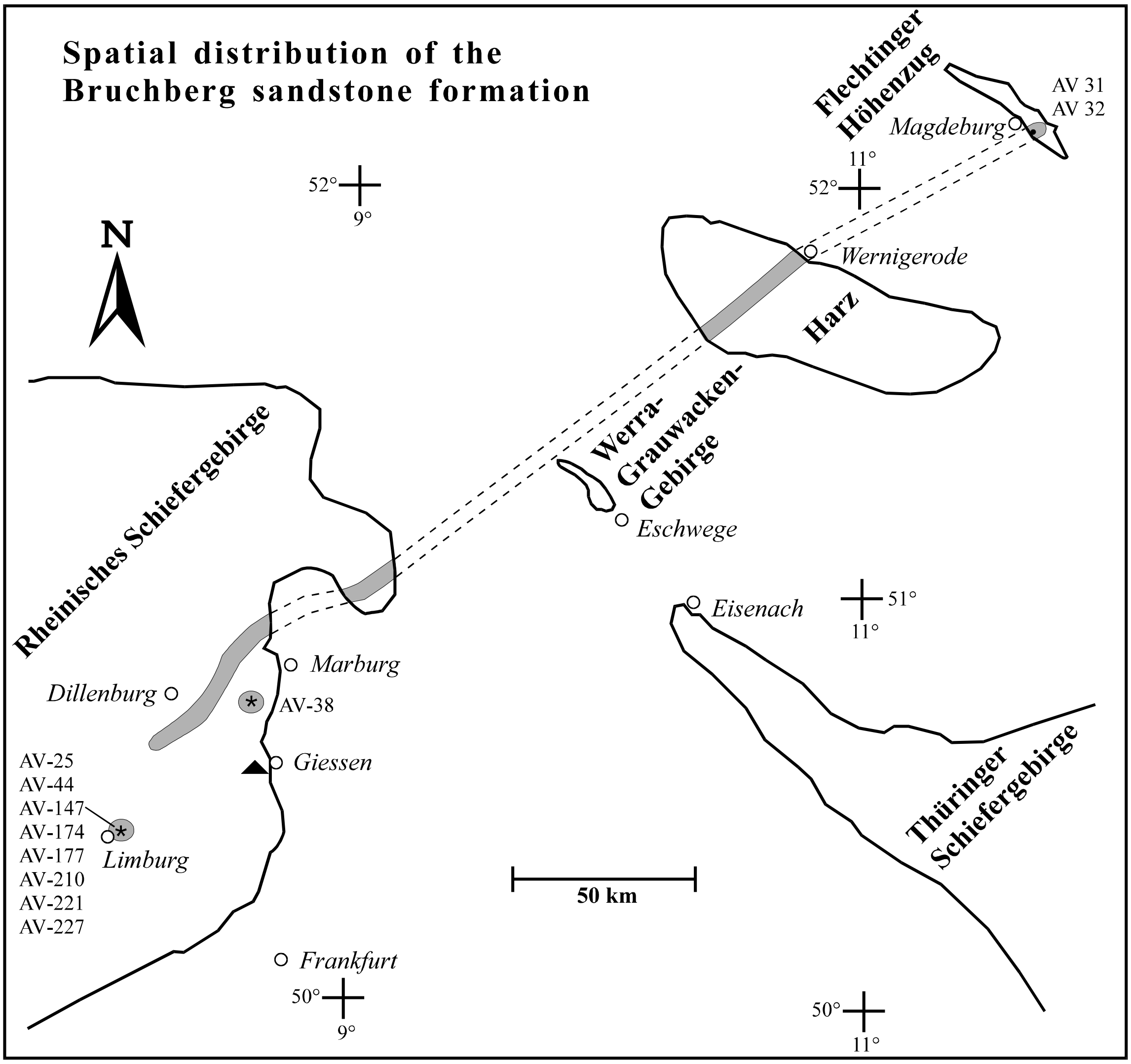


Fig. D 2.12: Spatial distribution (grey shading) of the Bruchberg sandstone formation (modified after WIERICH & VOGT 1997: 103). Stars indicate newly explored occurrences by WIERICH & VOGT 1997. The triangle shows the location of the "Giessen quartzite" (sensu BISCHOFF & STOPPEL 1957), a Lower Devonian sandstone formerly believed to be of Lower Carboniferous age. Rheinisches Schiefergebirge = Rhenish slate mountains. Thüringer Schiefergebirge = Thuringian slate mountains. Werra-Grauwacken-Gebirge = W. greywacke mountains. Harz = Harz or Hercynian mountains. Flechtinger Höhenzug = Flechtingen ridge.

D 3 Synopsis: palaeofacies and palaeoenvironment in Devonian and Lower Carboniferous times

From the Emsian to the Lower Carboniferous, a fully marine environment with pelitic background sedimentation, mostly on a continental shelf, and with water depths seldomly in excess of 200m, prevailed. Up to the Upper Devonian the area underwent topographical changes mainly due to several stages of rift-evolution. Coarser-grained sediments had generally been shed from the Laurussian continent in the North. From this time onwards the northwards prograding front of the Variscan orogen lead to successively more clastic influx from the south, culminating in the deposition of Viséan greywacke.

A regressional trend is documented in the sedimentation of silt-/sandstones during the "middle" Emsian (Emssandstein) and a transgressional trend in the deposition of late Emsian flinty slate (Kieselgallenschiefer). Due to a moderate crustal thinning volcanic magma and pyroclastics also occurred. During the Eifelian moderate motions along preexisting or newly evolving horst and graben structures produced several small-scaled environments at different levels in the water column. The steepened relief allowed for the erosion of siliciclastics or the carbonate production at elevated positions in the evolving rift region. In the Givetian massive basic volcanic magmas and pyroclastic deposits were created in the Lahn-syncline during the active rift generation, forming elongated ridges. From the "middle" Givetian onwards reef-complexes were built-up on top of these ridges until the early Frasnian. The deepening of the environment from the early Frasnian onwards lead to marine erosion of the volcanoes and reef-complexes and subsequently to the formation of detritic limestone-layers and intercalations of limestones with reworked pyroclastic deposits. During the Famennian, carbonate production became periodically possible on submarine highs, which were generated through moderate movements along preexisting horst and graben structures and enhanced volcanic activity with lava outflows and pyroclastic deposits, predominantly from the Hembergian to Wocklumian. The Upper Devonian volcanic rocks are similar in respect to their composition to the ones of the Givetian/Frasnian-phase and, hence, can be treated as rearguard and direct successors to the main phase.

A main result of this study is the detection and description of a nappe structure within the area (see e.g. chapter D2, D4), which comprises at least a Famennian debris flow, probably the condensed Upper Devonian / Lower Carboniferous succession within Steeden (HH 1-24, app. F 1, D 2.4.2.1), presumably all Lower Carboniferous lithologies and probably had been transported several tens of kilometres to the north. The debris flow contains reworked components from the Silurian to Frasnian and also early Famennian greywacke-components. These greywacke -components represent the first hint towards the shed of flysch-deposits from the Variscan orogen.

The Lower Carboniferous envisages a succesively increasing deepening of the marine environment together with reduced clastic influx, which eventually lead to the preservation of flinty slates. Major changes in the topographical situation had only been induced by 3 different phases of Deckdiabas-volcanism, which also allowed for the carbonate-production on top of newly generated or reactivated submarine highs (Erdbacher Kalk I-III, E. limestone I-III). During the Viséan the Bruchberg sandstones were shed into the Kulm-basin from the north, presumably within a relatively narrow submarine canyon-zone, and the Kulm-greywacke prograded on a broad front from the south into the palaeoenvironment.

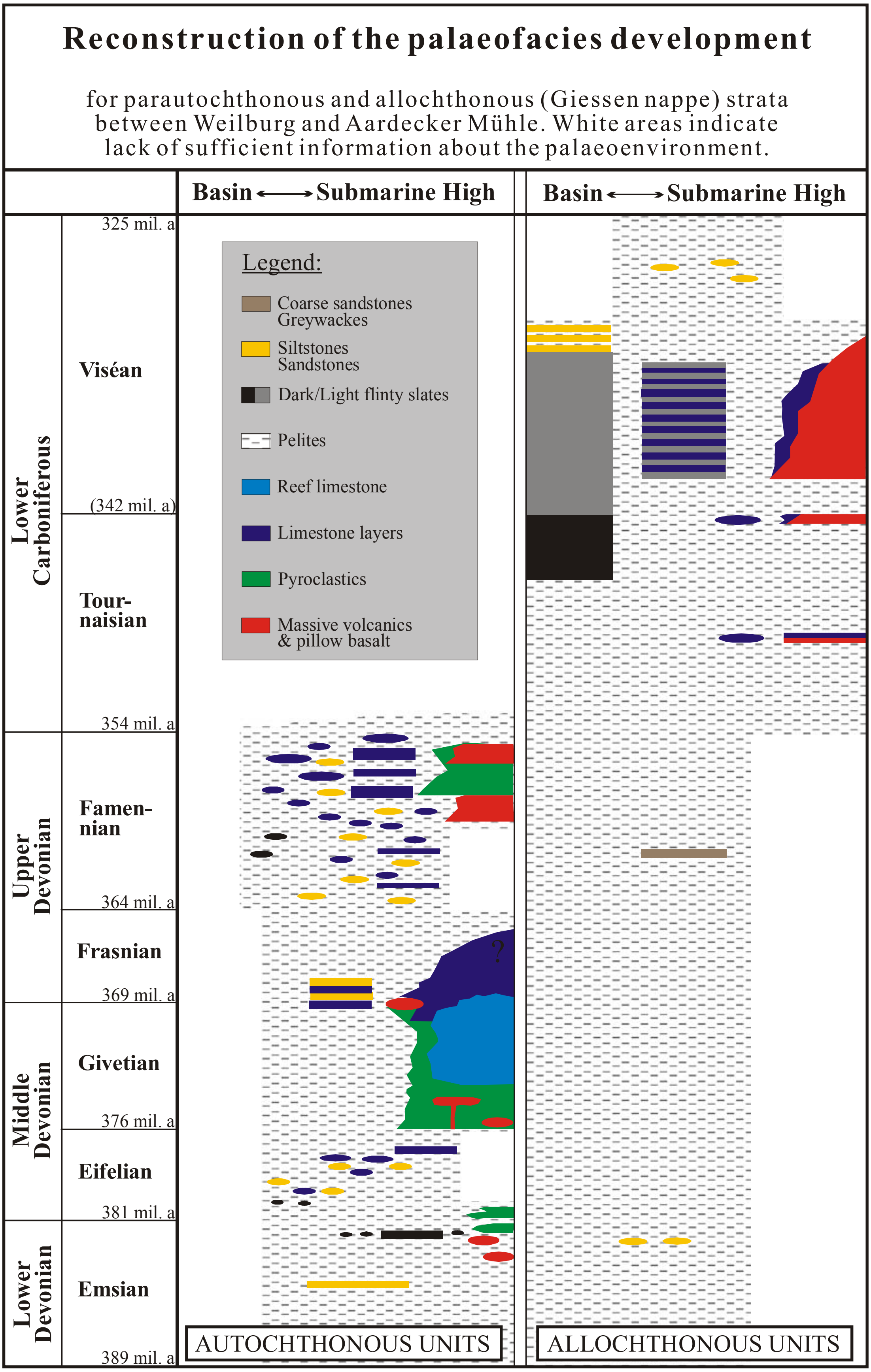


Fig. D 3.1: Stratigraphic correlation chart for the geological situation between Weilburg and Aardecker Mühle

D 4 Structural development

When one is confronted with the necessity to explain the structural development within a distinct area in the Variscides, one has to fight several severe restrictions:

- small outcrops
- insufficient dating
- verbose and often unilateral geological literature
- time (both in geological and in human terms)
- "generally accepted" view vs. "old/unlikely" views, pseudo-war between "autochthonists/fixists" and "allochthonists/mobilists".

Some researchers claim that the Variscides are now "generally accepted" to represent an alpinotype orogen (e.g. FRANKE in FRANKE et al. 1996:1). There exist some good reasons in favour of this opinion, but also some contradictions.

Tab. D 4.1: General comparison between characterizing parameters of the Variszides and Alpides

	VARISCIDES (Portugal - Spain - France - England - Middle Europe)	**Ratio** **Variscides : Alpides** (simplified; rounded)	ALPIDES (incl. Carpathian and Balkan mountains)
Width **&** **lateral extension**	800 - 1000 km x 2600 - 3000 km	6 2	100 - 250 km x 1500 - 1700 km
Maximum thickness of accepted nappe-structures	> 200 m (up to several 100 metres (Ostharz-nappe: > 700 m))	0.1 (0.25)	up to > 3 km
Recent maximum height of variscan outcrops	c. 2000 m (Harz: 1142 m, Rheinisches Schiefergebirge: 880 m, Böhmerwald: 1457 m, Karnische Alpen - Karawanken: > 2000 m, Massif Central: 1886 m, Portugal: 1991 m)	0.4	Montblanc: 4807 m

In tab. D 4.1 a general comparison between characterizing parameters of the Variszides and Alpides is presented. Apart from the fact that in both orogens a continent/continent-collision triggered the orogenesis, some remarkable differences occur. The variances in the thickness of the nappe structures and the recent height of mountains may be solely attributed to the erosion of the much older Variszides. But the width of both orogens is significantly different and the same is still true for the lateral extension. An interesting insight into how to deal with such problems is presented in KLEY & EISBACHER 1999 ("How Alpine or Himalayan are the Central Andes?").

The geodynamic constraints which lead to the development of the Variszides are still subject of thorough disputes. The models concerning the amount and palaeoposition of the continental plates that contributed to the final constellation, the proposed occurrence of microplates and/or terranes and the positions and dip-directions of possible subduction zones, are especially controversial.

A first concise synopsis for all relevant geodynamic models was published in "Intracontinental Fold Belts" (MARTIN & EDER 1983). A short, incomplete, but interesting compilation of published models was presented by RAJPOOT (1991). It contained a process oriented global approach towards a better correlation between regional findings and the general processes that governed the Variscan orogenesis.

In the next paragraphs short summaries for the structural development within certain stages, which lead to the present-day situation in the eastern part of the Rheinisches Schiefergebirge, are presented (mainly with data published by ONCKEN 1987, 1989, 1991, KLÜGEL 1997, FRANKE 1989, FRANKE & ONCKEN 1995, HLADIL 1996, WIERICH 1999, JANSEN 2001). The whole region formed from the Early Devonian to the Lower Carboniferous part of a marine environment with mainly pelitic background sedimentation.

Upper Ordovician - Silurian

Development from andesitic to rhyolitic volcanism with geochemical signature of a magmatic arc. Two explanations exist (KLÜGEL 1997):

a) crustal extension with development of a passive rift due to horizontal lithospheric stresses. Rift stage of the passive rift. Volcanics from late-orogenic collapse-basins, partly with geochemical signature of a magmatic arc. Eppstein-slates, which lie on top of the metavolcanics and inhabit a high feldspar content as well as big lateral differences in thickness, are therefore typical rift sediments. From the Gedinnian onwards northwards progradation of the crustal extension; or:

b) crustal convergence with island arc volcanism. Orogen south of the Rhenohercynian during Silurian and Lower Devonian times, separated by the "Rheic ocean". Parts of this orogen are supposed to be documented within the zone of the recent Mid-German-Crystalline-Rise. No evidence for convergence-magmatism or metamorphosis is documented within the southern Rhenohercynian nor is any hint for a pre-/early Variscan suture detectable. Therefore the Rheic ocean must have been completely subducted, e. g. northwards under the Rhenohercynian (Avalonia). Subduction must have been terminated in the Silurian since no evidence for a collision has been found within the Phyllite zone. Furthermore ample evidence for sedimentary settings similar e. g. to those at a passive continental margin in the Phyllite zone from the upper Lower Devonian onwards is available

Lochkovian

Partitioning of the Cadomian basement due to crustal extension. Transition from rifting to doming stage of a passive rift generation. Development of graben and horst structures, partly with subaerial exposure of some tilted blocks along the margins of the embryonic rift.

Pragian

Northwards propagation of the crustal extension. Doming stage of a passive rift generation. Deposition of well to moderately sorted sands in coast-parallel sand bars (Taunusquarzit). Enhanced shed of Caledonian debris from the Old Red continent into the evolving basins.

Emsian

Further thinning of the continental crust leads to the development of more synsedimentary fault systems within graben and horst structures of the evolving rift. Transitiom from doming to volcanism stage of a passive rift generation. Widespread shallow marine facies with small islands. Partly keratophyr (rhyolite) together with basic volcanism. Small amounts of metabasalts with T- (?N-) MOR-type signatures (only within the REE spectrum) detectable within the Phyllite zone and presumably also within the Giessen nappe. The age correlation for the Giessen metabasalts rests on logical inferences rather than direct dating (compare BIRKELBACH et al. 1988:67 ("Halt 17") and chapter C 2, p. 63f).

Due to the finding of MOR-type metabasalts, together with a) the proposed deposition of "hemipelagic" and/or condensed sediments and b) bimodal volcanism, several geoscientists proposed the onset of the opening of a small, max. 400 km wide, ocean ("Giessen or Rhenohercynian ocean") during the Early Emsian (e. g. FRANKE & ONCKEN 1995:64 (strong support), FRANKE 1995:38 (more moderate formulations) and FLOYD 1995:77-78 (neutral considerations)). The proposed ocean "cannot be recognised in the palaeomagnetic record" (TAIT et al. 1997: 593). Due to newly presented palaeobiogeographical evidence, JANSEN (2001: 74) denies a substantial spatial division between Armorica and Gondwana.

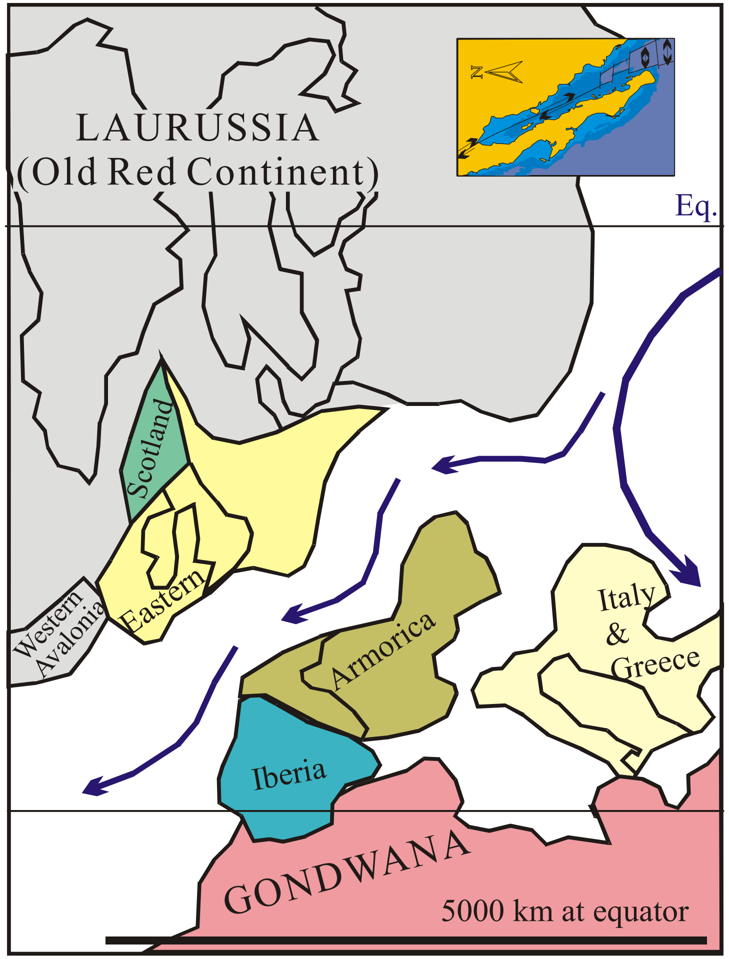
Eifelian
Transition from passive to active rifting. Moderate movements along preexisting horst and graben structures lead to minor carbonate production on top of submarine highs and deposition of tuff layers due to small scale temporary volcanic activity. According to SCHUBERT (1996:112f) the following occasions transformed the former shelf facies towards a dysaerobic, more basinal facies with reduced influx of medium- to coarse-grained clastics: a) shift of the Rhenish shelf towards the north, b) a world-wide Upper Emsian transgression and c) rise of dysaerobic bottom waters.

Givetian
Clockwise rotation of Armorica/Iberia induces widespread rifting (compare fig. D 4.1). Active rifting due to deep-mantle upwelling, with a maximum c. subparallel to the border Rhenohercynian/ Saxothuringian. Doming phase during the late Eifelian to early Givetian with successively increasing amounts of intrusions and submarine outflows of massive volcanics and pillow basalts during transition to the volcanism phase, which has its peak c. in the mid-Givetian. Buildup of reefs on top of the volcano-chains and also on elevated flanks of horst structures, e. g. north and south of the Lahn-syncline volcano-complexes. Even the existence of subaerially exposed landmasses can not be ruled out, since large and diverse mid-Devonian spores have been found as components in early Famennian debris flow deposits (see chapter F 2).
Generation of the Lizard ophiolite complex in S Cornwall (primary igneous cooling age of the gabbro: 375 mio. a (early to mid-Givetian), DAVIES 1984).
Oceanic crust has only been found towards the west (Lizard complex). Such successions have not yet been observed to the east (e. g. Lahn-syncline), nor have time-equivalent MOR-type metabasalts been detected. Therefore, the generation of a failed rift with greatest extension to the west and least extension towards the east is proposed.

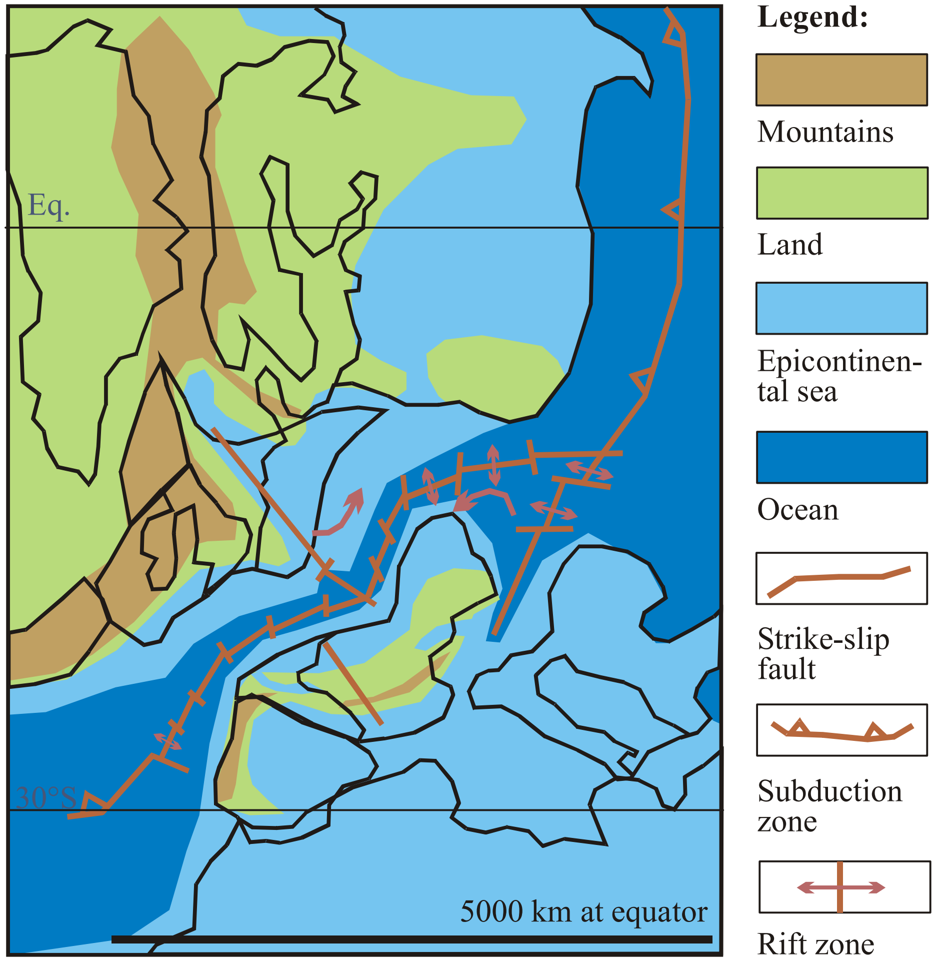
Frasnian
Rift phase of the active rift system. Enhanced partitioning and subsidence due to successive cessation of the mantle upwelling. Fast but short-living movements along preexisting horst and graben structures lead to deposition of a) debris flow deposits, partly with huge (>1m) components (e. g. HUCKRIEDE 1992), b) syn-rift greywacke turbidites south of the recent Phyllite zone along and subparallel to the Rhenohercynian/Saxothuringian borderline from SW-England to Bohemia, c) erosion of former volcano and reef-covered areas within the Lahn-syncline. Proposed obduction of the Lizard complex (369 mio. a, STYLES & RUNDLE 1984).
FRANKE & ONCKEN (1995:64f) place the onset of the closure of the proposed "Rhenohercynian or Giessen ocean" into the early Frasnian. The greywacke turbidites are therefore assumed to represent flysch deposits, derived from thickened and elevated crust (magmatic arc) to the south.

Famennian
Intrusions with petrographical and geochemical signatures of I-type granitoids into the rocks of the Mid-German Crystalline Rise (LIPPOLT 1986, OKRUSCH & RICHTER 1986).
In the middle Lahn-syncline a typical basinal marine palaeoenvironment with pelitic background sedimentation persists. Only on submarine highs carbonate production occurred periodically. Up to the Wocklumian stage an enhanced volcanic activity with lava outflows and pyroclastic deposits emerged. The Upper Devonian volcanic rocks are similar in respect to their composition to those of the Givetian/Frasnian-phase and, hence, can be treated as rearguard of and direct successors to the main phase (HENTSCHEL 1970, BEHNISCH 1993, NESBOR et al. 1993, THEWS 1996).

NEXT PAGE:
Fig. D 4.1: Palaeogeographic and palaeotopographic maps showing the situation between eastern Laurussia and Gondwana during the Middle Devonian



Middle Devonian (Givetian) palaeogeography:
Blue arrows indicate a) possible palaeocurrent directions, b) their relative strength (varying line thickness).
Name, shape, position of continents and terranes mainly due to SCOTESE & MCKERROW (1990) and BLAKEY (1998).



Middle Devonian (Givetian) topography:
Clockwise rotation of Armorica/Iberia induces widespread rifting. Maybe with opening of a small oceanic basin. In the upper right corner of the left picture the recent situation at the Gulf of California (to scale) is shown - an actualistic model for the Middle Devonian situation?

Tournaisian
Southward directed burial of the Phyllite zone within approx. 2-2.5 mio. a (for an assumed velocity of convergence of 14 mm/a and a downthrust angle of 30°) to a final depth of 14-20 km at 4.2-5.8 kb.
During burial internal attachment/ stacking of slices of the downthrusted phyllite zone on to the upper unit (sediments of the later Giessen nappe).

Viséan
It is assumed that an anti-clockwise rotation of Gondwana (+ Armorica) induced strike-slip movements along former rift-related lineaments. The subsequent development of small pull-apart basins and local extension provided space for local magma outflow (Deckdiabas) and turbiditic sedimentation of the Bruchberg sandstone (compare fig. D 4.2 and D 4.3).

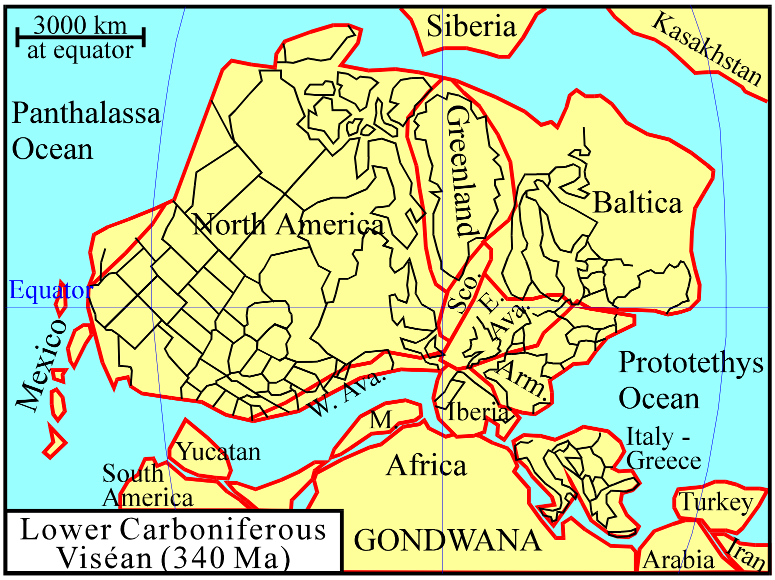
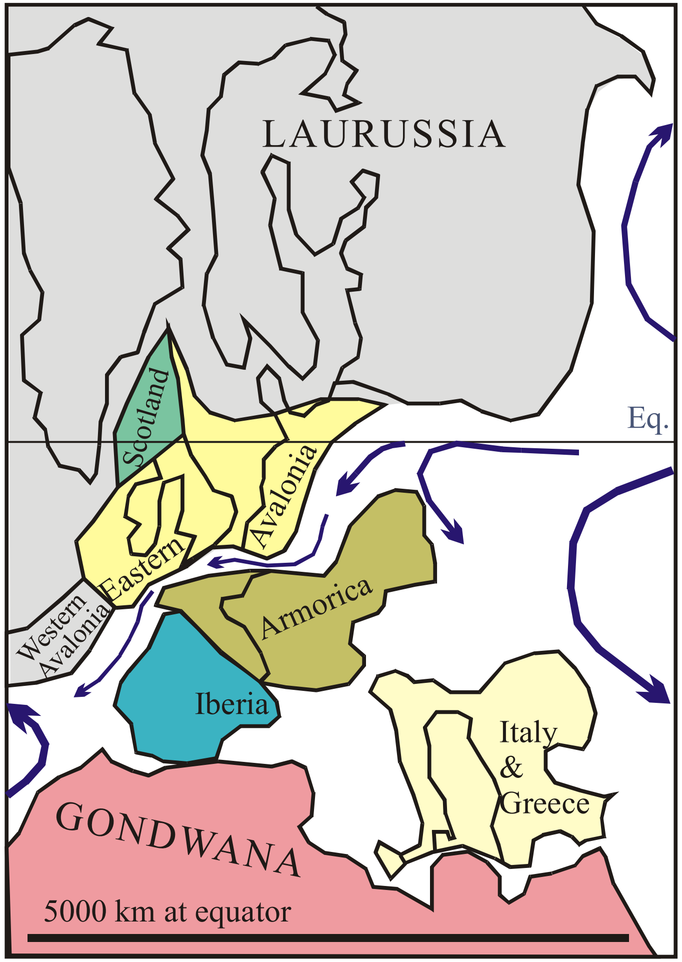


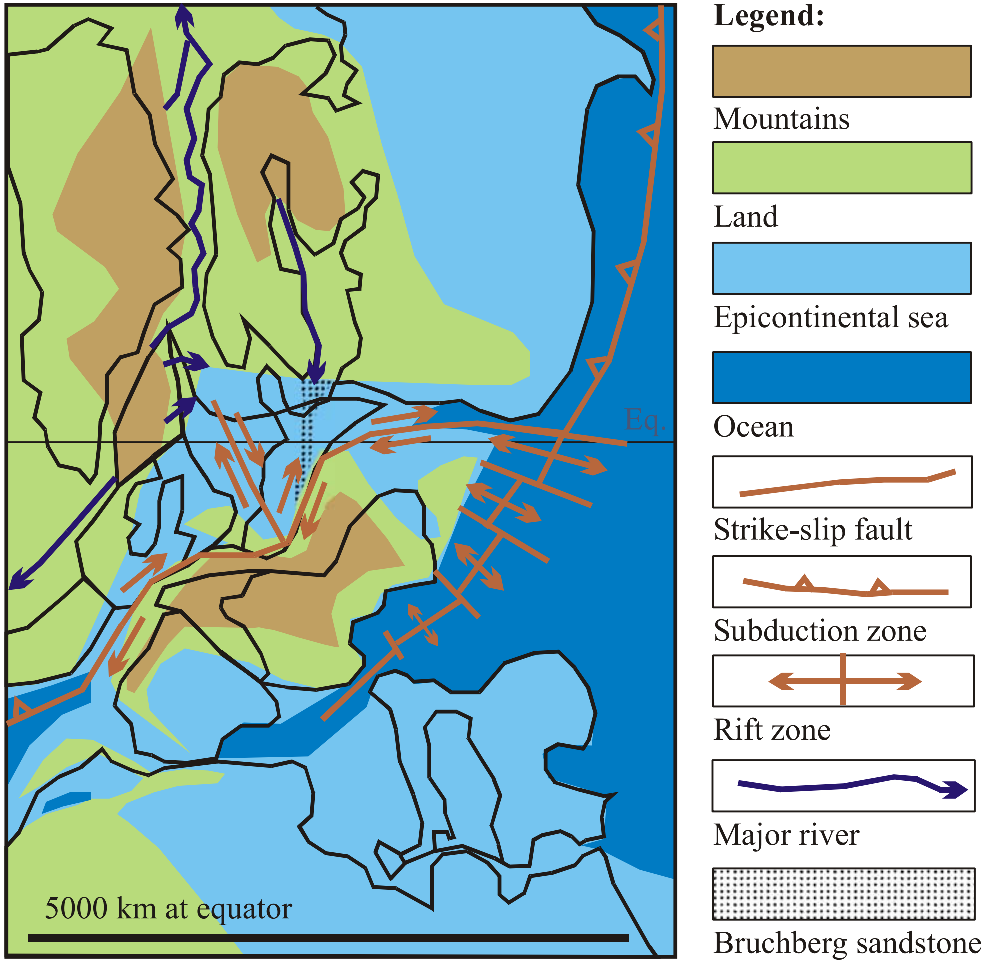
Fig. D 4.2: Palaeogeographic and palaeotopographic map showing the general situation between Laurussia and Gondwana during the Lower Carboniferous (Viséan)

Upper Carboniferous
Subsequent northward directed overthrust of the phyllite zone on the Taunuskamm-unit. Elevation of the whole sequence leads to the exposition of the sediments of the upper unit and subsequent basal detachment with gravity gliding and nappe formation (Giessen nappe).
KLÜGEL (1997: 113+154), who convincingly proposed the above mentioned scenario, explained the burial of the Phyllite unit within a reactivated (?) subduction zone at the position of the former Giessen ocean between the Rhenohercynian (Avalonia) and the Saxothuringian (Armorica). However, the existence of a subduction zone is not an inescapable condition for the scenario shown and can therefore not act as a hitherto evidence for the existence of the Giessen ocean.
WIERICH (1999: 2) presented evidence against the postulation of a subduction zone at the site and time of the proposed closing of the suggested Giessen ocean: "From the lower Devonian until the upper Devonian successively higher grade metamorphic units were uplifted, eroded and supplied [from the orogenically thickened Caledonian crust]. From the younger part of the lower Devonian onwards, another source area in the south is observable. The clastic content of some sediments along the eastem margin of the Rheinisches Schiefergebirge differs eminently from that of the Caledonian debris. Their grainfabrics mirror the evolution of crustal extension of an initial rift. During the Devonian the rifting spread to the north into the formerly deposited Caledonian molasse sediments as well as into the south where it lifted out a Cambro-Ordovician crystalline basement. The sediments of this type were assorted to syn-rift-sediments.

NEXT PAGE:
Fig. D 4.3: Palaeogeographic and palaeotopographic maps showing the situation between eastern Laurussia and Gondwana during the Lower Carboniferous (Viséan)



Lower Carboniferous (Viséan) palaeogeography:
Blue arrows indicate a) possible palaeocurrent directions, b) their relative strength (varying line thickness).
Name, shape, position of continents and terranes mainly due to SCOTESE & MCKERROW (1990) and BLAKEY (1998).



Lower Carboniferous (Viséan) topography:
Anti-clockwise rotation of Gondwana (+ Armorica) induces strike-slip movements along former rift-related lineaments. Subsequent development of small pull-apart basins and local extension provides space for local magma outflow (Deckdiabas) and turbiditic sedimentation of the Bruchberg sandstone.

Due to the beginning of the continent-continent collision of Gondwana in the south with the Old-Red-Continent in the north, supply and sedimentation of flysch sediments starts with the basal upper Devonian. Proven by their grainfabrics, the source of the widespread upper Devonian and lower Carboniferous greywackes was the southern part of the formerly mentioned innercontinental rift and not an active continental margin."

Late Variscan

Due to longer lasting convergence late folding and thrusting of autochthonous and nappe units together. In this way the originally flat discordant contacts become often irregularly shaped and cut by later thrusts - therefore: hard to detect in small outcrops, which are predominant in the Rhenohercynian.

Lahn-syncline

The eastern margin of the Rhenohercynian mountains (Rheinisches Schiefergebirge) consists of two complex structured antiforms (Siegener Sattel and Taunus) and a great, deeply folded, synform inbetween (Dill- and Lahn-syncline; compare fig. B 1.1 and B 1.2). The general style of tectonic deformation changes successively from northwest to southeast. While we can observe in the northwest an open-spaced style of folding with southeastwards dipping axial planes, towards the southeast the intensity of folding and faulting increases up to the creation of isoclinal folds and the development of schuppen-structures (esp. in the Lahn-syncline). Due to this progressive shortening of palaeozoic units a second (and in the Taunus even a third) deformation generated and the intensity of metamorphic overprinting increased (THEWS 1996) towards the southeast.

The basic volcanics of the eastern Rheohercynian mountains represent mainly tholeiitic intraplate meta-basalts. Only in the southeastern part do some volcanics occur with geochemical signatures of mid-ocean-ridge (MOR-) - type-basalts (WEDEPOHL et al. 1983, see also chapter C 2).

Only in the southeastern Rhenohercynian area (southern Taunus) metamorphic recrystallisation of quartz had been possible. ONCKEN (1989) states - especially for the southern Rheinisches Schiefergebirge - the development of thrust sheets that have the geometry of imbricate stacks or, in the south, of a duplex system. The resulting deformational patterns are, therefore, primarily temperature-dependent but not neccessarily depth (pressure)-related. Different modes of deformation had been synchronously activated via coupled motion of different thrust sheets with distinct temperatures.

Arguments in favour of a nappe emplacement ("Giessen nappe") in the area between Weilburg and Limburg

1) The newly explored early Famennian greywackes are petrographically almost identical to Upper Devonian greywackes from the Giessen nappe. They do not contain limestone fragments, nor major amounts of magmatic rocks, as would be expected for sediments locally derived from the only known important submarine highs at that time: the (then tectonically reactivated?) remnants of middle Devonian reefs on top of magmatic ridges. The considerable content of metamorphic rocks (together with other evidence) indicates a source region somewhere in the south in a "mid-German" palaeoposition. The clasts which were shed from there could impossibly be transported directly to their present day position by passing over the remnants of the magmatic ridges of the Lahn-syncline (compare chapter D 2.4.2).
2) The early Famennian debris flow sediment does neither contain considerable amounts of calcareous fragments nor any basalts or pyroclastics - as would be expected if their present position had been identical with their relative palaeoposition. Since the palynological analysis revealed that all - clayey to sandy and only seldomly calcareous - sediments from Emsian to early Famennian times are confined in the debris flow (within less than 20m (condensed?) sediment pile) a palaeoposition relatively far away from the magmatic ridges of the Lahn-syncline is evident (compare chapter D 2.4.2).
3) At least approx. 120m late Viséan Bruchberg sandstone formation has been found on top of the approx. 20m thick Famennian debris flow sediments north of Limburg. Since no concordant succession is detectable, both units are most probably divided by major faults. This is only possible if the original palaeogeographical position of the Bruchberg sandstones had been - even approx. 30 million years later - south of the relative palaeopositon of these debris flows during the Famennian. In turn this implies that the Bruchberg sandstones - at least from the region north of Limburg - must have been transported as younger parts of the Giessen nappe (compare chapter D 2.4.2 & D 2.5.2).
4) The Viséan Erdbach limestone III from an outcrop near Steeden yielded a trilobite fauna which is significantly different to other Erdbach limestone faunas of the eastern Rheinisches Schiefergebirge and reveal closer relations to contemporaneous Harz-faunas from the Winterberg (HAHN, HAHN & MÜLLER (1998: 199), see chapter D 2.5.2).
5) The Deckdiabas as well as parts of the Light flinty slates (Helle Lydite) contain intercalations of Erdbach limestones, but without sufficient faunal evidence for an attribution to a different faunal province. However, both are always in a structural position *without* connection to significantly older, e. g . Upper Devonian strata in concordant succession (see chapter D 2.5.1 & D 2.5.2).
6) Small remnants of Viséan (*Goniatites* III β/γ) greywacke north of Hadamar near Oberzeuzheim had been encountered by HENNINGSEN 1970. These occurrences are situated approx. 9km northwest of an outcrop with Famennian greywacke in the analysed area near Eschenau. Due to HENNINGSEN (1970: 196), these greywackes are identical to the Lower Carboniferous Giessen-greywackes, which are now interpreted as forming a part of the Giessen nappe (see chapter D 2.5.2).

7) A small outcrop with proposed Upper Devonian greywackes north of Hadamar near Elbgrund has been described by HENNINGSEN (1970). The outcrop lies approx. 11km northwest of an outcrop with Famennian greywacke west of Eschenau. Due to HENNINGSEN (1970: 198) these greywackes are similar to the Upper Devonian (Nehdenian - Hembergian) Hörre-greywackes southeast of Nenderoth (see chapter D 2.4.2).

8) Nappe emplacement must have taken place early in the Variscan compressional cycle since no major differences in the tectonic style between autochthonous and allochthonous units are detectable at outcrop scale (compare chapter C 11).

9) The recovered palynomorphs from the Viséan Bruchberg sandstone formation and the Famennian debris flows are slightly less carbonised than the ones from autochthonous units; in both formations even transparent specimens occur. A plausible explanation for this is: The allochthonous units have been overthrust somewhere around the Lower/Upper Carboniferous boundary, thus placed at least several hundred metres on top of the parautochthonous units. Therefore, later (in the course of the Variscan orogeny) they became less deeply buried and hence less thermally altered, probably in the range 10 - 40 °C. That seems to be the most conclusive reason why younger greywacke units of the Famennian are datable at all - with the sometimes good preservation of palynomorphs not significantly limited by thermal alteration but in majority by bacterial attack, weathering and pyritization prior to final deposition (compare chapter C 4 & C 5, appendix F 2).

Part E

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In order to keep in touch with all new methods and hold a satisfying time-plan it is suggested that studies like this should in the future be attributed to a research GROUP.

Part F

Appendix

F 1

Annotated register of former (1918-1997) biostratigraphic results

F 1.1 AHLBURG 1918

Sample: A 1 **Quotation:** AHLBURG 1918, p. 20 middle
Gauss-Kruger-coordinates: [^{34}41130 - ^{55}93150]
Location: southwest of the Kerkerbach-valley, at a forest track; in the geological map marked by a fossil-symbol (geological map 1:25000, 5515 Weilburg).
Lithology: lithologic succession of a) grey to greenish, thin-bedded to flaser-bedded, argillaceous greywackes (which become less frequent towards the top), b) dark slates, partly with intercalations of "Sphärosiderit" (iron-carbonate)-concretions, which become more frequent and bigger towards the top.
Stratigraphic correlation: Upper Koblenzian (uppermost Lower Devonian)
Fossils: (det. by AHLBURG, from the upper parts of lithology b)

Gryphaeus lethaeae KAYSER	
Gryphaeus laciniatus F. ROEMER [1844]	
Homalonotus [KÖNIG 1825] sp.	[Genus: Silurian — Devonian]
Pleurotomaria cf. *subangulata* SOWERBY [1840]	
Tentaculites scalaris SCHLOTHEIM [1820]	[Lower Devonian]
Avicula concentrica A. ROEMER [1840-41]	
Spirifer arduennensis SCHNUR [= *Arduspirifer arduennensis* (SCHNUR 1853)]	[late Lower — middle Upper Emsian]
Spirifer carinatus SCHNUR [= *Brachyspirifer carinatus* (SCHNUR 1853, WEDEKIND 1926) SOLLE 1971]	[frequent: lower — middle Lower Emsian; but *Brachyspirifer carinatus rhenanus* SOLLE 1971: frequent from lower — middle Upper Emsian]
Spirifer aff. *ostiolatus* SCHLOTHEIM [The genus *Spirifer* is nowadays split up into several genera.]	
Spirifer undifer KAYSER	
Athyris caeraesana STEIN.	[Genus: Devonian — ? Triassic]
Cyrtina heteroclita [DAVIDSON 1858] [= *Calceola heteroclita* DEFRANCE 1828]	[frequent: Middle Devonian]
Rynchonella cf. *implexa* SOWERBY [1840] [The genus *Rhynchonella* is nowadays split up into several genera.]	
Rynchonella parallelepipeda BRONN	
Orthis sp.	
Chonetes dilatata v. ROEMER [= *Loreleiella dilatata* (DE KONINCK) = *Eodevonaria dilatata* DE KONINCK]	
Chonetes sarcinulatus (SCHLOTHEIM [1820])	[Emsian — Eifelian]
Chonetes plebejus SCHNUR [= *Plebejochonetes plebejus* (SCHNUR 1853)]	[Emsian]
Streptorhynchus [KING 1850] *umbraculum* SCHLOTHEIM [= *Terebratulites umbraculum* SCHLOTHEIM 1816]	
Craniella [OEHLERT 1888] *crassis* ZEIL [= *Petrocrania* RAYMOND 1911 *crassis* ZEIL]	[Genus: middle Ordovician — ? Permian]
Fenestella [LONSDALE 1839] sp.	[Genus: Ordovician — Permian]
Zaphrentis ovata LUDWIG	
Pleurodictyum sp. cf. *petrii* MAURER	
crinoid remnants	

Remarks: revised stratigraphic range: late Lower — middle Upper Emsian (ca. near base ***excavatus*** — in ***serotinus*** -zone). DK1996: di ca. 11.5 — 17.1. No "greywackes" are observable, only sandstones.
Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (tempestitic) incursions of rapidly deposited silt to finesand. Dominating bedding features are flaser bedding and laminated sand/silt. Wave energy and mud supply control mud abundance. During heavy storms brachiopod shells together with trochites and other above mentioned fossils and calcareous sediments were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds. The small nodules which show a cherty character are probably thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: A 2 **Quotation:** AHLBURG 1918, p. 23 top
Gauss-Kruger-coordinates: [^{34}46310 - ^{55}91030]
Location: southeast of the main entrance of the mine "Georg", in the narrow valley west of the "Wittekind" mine; in the geological map marked by a fossil-symbol (geological map 1:25000, 5515 Weilburg).
Lithology: dark brownred tuffs with "Porphyry-conglomerates (?reworked porphyritic lava).
Stratigraphic correlation: Upper Middle Devonian
Fossils: (det. by AHLBURG)

Phacops breviceps BARRANDÉ	[Genus: Silurian — Devonian]
Proetus crassimargo A. ROEMER [1840-41]	[Genus: Ordovician — Middle Devonian]
Buchiola sp.	
Platyceras (Capulus) compressum A. ROEMER [1840-41] (frequent)	[Genus: Silurian — Permian]
Platyceras (Capulus) conoideum GOLDFUSS (frequent)	[Genus: Silurian — Permian]
Platyceras (Capulus) hainense MAURER (frequent)	[Genus: Silurian — Permian]
Dentalium cf. *robustum* MAURER	[Scaphopoda, Genus: ? Ordovician — recent]
Centronella virgo PHILLIPS [1841]	[Genus: Lower — Middle Devonian]
Pentamerus acutelobatus SANDBERGER [The genus *Pentamerus* is nowadays split up into several genera.]	***
Pentamerus globus SCHNUR	***
Merista plebeja SOWERBY [= *Dicamara plebeia* HALL & CLARKE 1893 = *Atrypa plebeia* SOWERBY 1840]	[Middle Devonian]
Merista lacryma SOWERBY [1840] [The genus *Merista* is nowadays split up into several genera.]	
Rensselaeria [HALL 1859] sp.	
Atrypa reticularis [DALMAN 1828] [= *Anomia reticularis* LINNÉ 1758]	[Lower Silurian (Llandovery) — Upper Devonian (Frasnian)]
Atrypa desquamata SOWERBY [1840]	
Atrypa flabellata ROEMER	***
Atrypa longispina BOUCHARD [1849] (= *hystrix* HALL; very frequent!)	
Atrypa cf. *arimaspus* EICHWALD [1829]	
Spirifer simplex PHILLIPS [1841]	
Spirifer inflatus SCHNUR	***
Spirifer maureri HOLZAPFEL	***
Cyrtina heteroclyta DEFRANCE [1828] [= *Calceola heteroclita* DAVIDSON 1858]	[*** frequent: Middle Devonian]
Cyrtina spec. nov.	
Camarophoria brachypycta SCHNUR [= *Stenocisma* CONRAD 1839 *brachypycta* SCHNUR; *Camarophoria* HERRMANNSEN 1846: nom. van.]	***
Camarophoria cf. *megistana* LE HON. [= *Stenocisma* CONRAD 1839 cf. *megistana* LE HON.; *Camarophoria* HERRMANNSEN 1846: nom. van.]	
Rynchonella triloba SOWERBY [1840] [The genus *Rhynchonella* is nowadays split up into several genera.]	
Rynchonella subcordiformis SCHNUR	***
Rynchonella cf. *acuminata* MARTIN [1809]	
Orthis striatula SCHLOTHEIM	
Orthis eifliensis DEARCHIAC & VERNEUIL [1842]	
Orthis canalicula SCHNUR	
Orthis tetragona F. ROEMER [1844]	
Strophomena cf. *latissima* BOUCHARD [1849] [The genus *Strophomena* is nowadays split up into several genera.]	
Strophomena interstrialis PHILLIPS [1841]	***
Strophomena lepis DEARCHIAC & VERNEUIL [1842]	
Chonetes minuta DEARCHIAC & VERNEUIL [1842] [The genus *Chonetes* is nowadays split up into several genera.]	
Strophalosia productoides MURCHISON [1840]	

Productus subaculeatus MURCHISON [1840] [*** Middle — Upper Devonian (Frasnian)]
[= *Productella subaculeata* HALL 1867]
Productus cf. *scabriculus* MARTIN [1809]
[= *Productella* cf. *scabricula* (MARTIN 1809)]
Davidsonia verneulii BOUCHARD [1849] [Middle Devonian]
Amplexus sp.
Cladochonus cf. *alternans* A. ROEMER [1840-41]
Remarks: revised stratigraphic range: Middle Devonian; with tendencies towards the Givetian. AHLBURG (1918: 34) gives a short list of species recovered from Upper Givetian reef-limestones of Villmar; species that occur in both lists are marked by: ***. (ca. ***partitus*** — ***disparilis*** -zone). DK1996: dm 0 — 20.0; with tendency towards (ca. ***varcus*** — ***disparilis*** -zone): dm ca. 8.2 (12.8) — 20.0.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge which was build up by a (composite?) volcano, however still proximal to the volcanic eruption centre. Main constituent of the sedimentary facies is clay- to silt-sized tuff with intercalations of (reworked?) sand- to boulder-sized pyroclastic deposits ("Keratophyr-conglomerates") from higher parts of the submarine ridge. Glassy components of the tuffs almost entirely altered by oxidation and adsorption of water into yellowish-brown palagonite. During heavy storms brachiopod shells together with other above mentioned fossils were brought in from shallower (max. 75-150m water depth (*Phacops*!)) or epitopographical marine regions and became partly deposited as shell beds.
The term "Keratophyr" describes an altered volcanic rock of the 'spilitic suite'. FLICK (1977) divides the keratophyrs of the Lahn-syncline into two types: (1) bright, Na-enriched albite-porphyric volcanic rock with an accompanying bright Na-enriched quartz-albite-porphyric quartzkeratophyr; (2) albite-porphyric volcanic rock with enriched K-feldspar content, with transitions to K-keratophyrs and K-quartzkeratophyrs.

Sample: A 3 **Quotation:** AHLBURG 1918, p. 38 middle
Gauss-Kruger-coordinates: [around ^{34}45650 - ^{55}91250; in the mine]
Location: In the mine "Georg", north of Wirbelau (geological map 1:25000, 5515 Weilburg).
Lithology: 1-3m Grenzlager ("boundary bed", iron ore deposit) on top of Schalstein (pure & reworked pyroclastics).
Stratigraphic correlation: Upper Middle Devonian, boundary-horizon towards the Upper Devonian.
Fossils: (det. by AHLBURG, from the "Grenzlager")
Orthoceras compressum
Orthoceras vittatum
Anarcestes cancellatus [D´ARCHIAC & VERNEUIL 1842] [Genus: Lower — Middle Devonian]
Anarcestes cf. *karpinskyi* [Genus: Lower — Middle Devonian]
Agoniatites inconstans [Middle Devonian]
[= *Goniatites inconstans* PHILIPPS 1841]
Agoniatites cf. *discoides* [HOLZAPFEL 1895] [Genus: ? Lower — Middle Devonian]
[= *Goniatites* cf. *discoides* WALDSCHMIDT 1885]
Pharciceras [HYATT] *lunulicosta* [(SANDBERGER 1856)] [Genus: upper Middle (17.9) — Upper Devonian (Frasnian)]
[= *Stenopharciceras lunulicosta* (SANDBERGER 1856)
= *Prolecanites* MOJSISOVICS *lunulicosta* SANDBERGER 1856]
Remarks: revised stratigraphic range: upper Middle Devonian; (ca. in lower ***hermanni-cristatus*** — ? in lower ***disparilis*** -zone). DK1996: ds ca. 17.9 — ?19.0. *Stenopharciceras lunulicosta* is the index-fossil of the former *S. lunulicosta*-zone (DK1996: ds 17.9 — 18.6).
Presumable sedimentary environment: The sedimentary inventory points to permanent marine conditions with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. Deposition of pyroclastic deposits on top or at a position proximal to the top of a submarine ridge. Succeeded by a period of strongly reduced production of pyroclastic deposits with build-up of "Grenzlager"-lithology: thin bedded succession of iron oxide, calcareous layers, red slates and tuffs with varying contents. Either a) water column above ridge top too large in order to allow larvae-settlement of shallower water species or b) long-term episodic outflow of toxic waters/gases (which maybe fixed all free oxygen in the water column) from the volcano which build up the ridge, prohibited the settlement of benthic species; maybe the ammonites found in this layers died while they tried to cross this toxic water column. The processes which lead to the deposition of the iron-ore deposits in the Lahn-syncline are still matter of discussion.

Sample: A 4 **Quotation:** AHLBURG 1918, p. 43 bottom, 44 top
Gauss-Kruger-coordinates: [^{34}44070 - ^{55}90870] and [^{34}44130 - ^{55}90940]
Location: abandoned limestone-quarry in the forest ca. 1 km northwest of Wirbelau; in the geological map marked by two fossil-symbols (geological map 1:25000, 5515 Weilburg).
Lithology: "Iberger Kalk", mainly lightgrey, coarser grained lowermost Upper Devonian limestones, which occur (on sheet Weilburg) partly on top of mainly darkgrey, finer grained late Middle Devonian reef-limestones; partly as single intercalations in Upper Devonian deposits.

Stratigraphic correlation: Lowermost Upper Devonian.
Fossils: (det. by AHLBURG, from a ca. 1m thick fossiliferous bed which consists nearly entirely of brachiopods)
Spirifer deflexus A. ROEMER [1840-41]
[The genus *Spirifer* is nowadays split up into several genera.]
Spirifer deflexus var. *laevigata* A. ROEMER [1840-41]
Spirifer verneulii MURCHISON [1840]
Spirifer pachyrhynchus M. V. K.
Spirifer inflatus SCHNUR
Rhynchonella cuboides SOWERBY
[The genus *Rhynchonella* is nowadays split up into several genera.]
Rhynchonella acuminata MARTIN [1809]
Rhynchonella pugnus SOWERBY
Rhynchonella cf. *phillipsi* DAVID
Camarophoria brachypycta SCHNUR
[= *Stenocisma* CONRAD 1839 *brachypycta* SCHNUR; *Camarophoria* HERRMANNSEN 1846: nom. van.]
Terebratula newtonensis DAVID
Merista sp.
Pentamerus globus BRONN
[The genus *Pentamerus* is nowadays split up into several genera.]
Pentamerus acutelobatus SANDBERGER

Atrypa reticularis [DALMAN 1828] [= *Anomia reticularis* LINNÉ 1758]	[Lower Silurian (Llandovery) — Upper Devonian (Frasnian)]
Atrypa reticularis [DALMAN 1828] var. *explanata* SCHLOTHEIM [based on: *Anomia reticularis* LINNÉ 1758]	[Genus: Silurian — Devonian]
Atrypa reticularis [DALMAN 1828] var. *sagitta* MAURER [based on: *Anomia reticularis* LINNÉ 1758]	[Genus: Silurian — Devonian]
Atrypa aspera SCHLOTHEIM	[Genus: Silurian — Devonian]
Atrypa duboisi VERNEUIL	[Genus: Silurian — Devonian]
Atrypa desquamata SOWERBY	[Genus: Silurian — Devonian]
Orthis striatula SCHLOTHEIM (strongly curved form)	
Orthis bistriata TSCHERNYSCHEW [1885]	
Orthis tetragona F. ROEMER [1844]	
Polypora striatella SANDBERGER	
Phillipsastraea hennahi LONSDALE	
Favosites cristatus BLUMBERG	[Genus: Upper Ordovician — ? Middle Devonian]
Alveolites suborbiculares LAMARCK	
Bronteus cf. *granulatus* GOLDFUSS	
Avicula wurmi A. ROEMER [1840-41]	

Remarks: revised stratigraphic range: no useful lifetime-data were available for the above mentioned fossils. Due to fossil evidence obtained by OETKEN (1997: 73 bottom) the stratigraphic range of the limestones in the forest of Wirbelau can be confined to: late Givetian — early Frasnian (Early ***disparilis-*** — Late ***falsiovalis***-zone). DK1996: dm 18.7 — ds 1.1.
Presumable sedimentary environment: debritic limestones, deposited within a fore-reef region. The layers represent probably short-term events, caused by (volcano-tectonically induced ?) instability of accumulated reef-organisms at the 30-35° inclined palaeoslope (OETKEN 1997:72-73).

Sample: A 5 **Quotation:** AHLBURG 1918, p. 20 middle
Gauss-Kruger-coordinates: [^{34}40830 - ^{55}87240]
Location: outermost southwest of map sheet Weilburg, at the eastern slope of the Kerkerbach-valley, ca. 500m westsouthwest of "Forsthaus Runkel", at a forest track; in the geological map not marked by a fossil-symbol (geological map 1:25000, 5515 Weilburg).
Lithology: up to only a few metres thick, light- to darkgrey, dense, flaser- and nodular limestones: "Clymenienkalke" (Clymenia-limestone) at the boundary between "Cypridinenschiefer" (Cypridina (Entomis) -slates) and "Gaudernbacher Schichten".
Stratigraphic correlation: Upper Devonian just below "Gaudernbacher Schichten"

Fossils: (det. by AHLBURG, from the "Clymenienkalke")

Sporadoceras bronni [nom. nud.] MÜNSTER [1839] [= *Sporadoceras münsteri* (BUCH 1832) FRECH 1887 = *Goniatites münsteri* BUCH 1832]	[middle Hembergian; *Prolobites delphinus*-zone; toIIIβ]
Prolobites delphinus SANDBERGER [= *Prolobites delphinus delphinus* FRECH 1902 = *Goniatites bifer* var. *delphinus* SANDBERGER 1850-56]	[middle Hembergian; *Prolobites delphinus*-zone; toIIIβ]

Remarks: revised stratigraphic range: middle Famennian; middle Hembergian, toIIIβ (ca. Late ***trachytera***-zone). DK1996: ds ca. 14.6 — 15.2. The *Prolobites delphinus*-zone terminates at DK1996: ds 14.9; however, due to the rare fauna the range of the contemporaneous conodont-zone is used for correlation. AHLBURG (1918) considers these "Clymenienkalke" to be the top of the "normal" Upper Devonian succession. **Therefore, the base of AHLBURG´s "Gaudernbacher Schichten" can be fixed to DK1996: ds 15.2 (Early *postera*-zone; late Hembergian).**
Presumable sedimentary environment: Deposition of mud from suspension at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of a submarine ridge. The described fauna with prevailing nektonic species indicate a deposition at the base of a submarine slope.

Sample: A 6 **Quotation:** AHLBURG 1918, p. 46 middle; KEGEL 1922, p. 44 middle
Gauss-Kruger-coordinates: presumably ca. 300m around [^{34}43500 - ^{55}91700]
Location: south of Gaudernbach, within the "Gaudernbacher Schichten" (tot); in the geological map not marked by a fossil-symbol. Samples presumably taken from different outcrops (geological map 1:25000, 5515 Weilburg).
Lithology: quite strongly tectonised (fissile) dark slates with rare intercalations of thin fossiliferous beds, which contain badly preserved faunas of very small-sized ("starved") species.
Stratigraphic correlation: Gaudernbacher Schichten, late Upper Devonian.
Fossils: (det. by AHLBURG; badly preserved fauna; difficulties in determining the species)

Buchiola angulifera Ad. ROEMER [= *Cardium anguliferum* Ad. ROEMER]	[?; at least: Frasnian (KEGEL 1922: 38); "Goniatite limestone" (BIGSBY 1878: 66)]
Buchiola cf. *acuticosta* [based on: *Posidoniomya acuticosta* SANDBERGER 1856: 294f; genus *Buchiola* established by BARRANDE 1881]	[Late Viséan]
Cardiola sp.	
diverse very small-sized gastropods (e.g *Platyceras*)	[Genus *Platyceras*: Silurian — Permian]
parts of crinoid stems (trochites)	

Remarks: The only useful stratigraphic range available is that of *B*. cf. *acuticosta*. Its known lifetime would allow for a correlation into the late Viséan. The brothers SANDBERGER (1856: 295) described this species as "Leitmuschel der Posidonomyenschiefer [= characteristic mussel of the Posidonomya-slates]." BIGSBY (1878: 239) mentions the "lower limestone shale", "Posidonia shists", "Culm", "Jüngste Grauwacke" and "Upper Mountain limestone" - all of Carboniferous age - as deposits, from where the species had been reported. However, *Buchiola angulifera* seems to be present (at least) in Frasnian deposits (KEGEL 1922: 38 top). No explanation for these contradictory results are given. So - we have to give due consideration as to what could possibly have been AHLBURG´s motive for his Upper Devonian time correlation. He collected fossil material from different locations in the forest south of Gaudernbach. In the course of the determination of the collected fossils he surely found out that he also got a late Lower Carboniferous mussel. However, at this time he was due to finish several manuscripts on the development of the Lahn-syncline; this assumption is highly significant, since KEGEL (1922) was able to combine these manuscripts to a monograph after AHLBURG's early and sudden death in February 1919. AHLBURG needed approx. two decades in order to establish a new model for the facies-relations in the Lahn syncline. He recognised a general trend to a basinal facies from Emsian to Upper Devonian times within the "syncline", which was divided from the Middle Devonian onwards by the build-up of volcanoes and reefs in the middle. From this time this lead to the subdivision into the "southern [of the volcanic ridges] marginal facies" and "northern marginal facies". The small remnants of basinal facies within the middle volcano-reef facies were attributed by him to the northern marginal facies; but since no direct contact to the latter was observable, he decided to give them a separate name: "Gaudernbacher Schichten". At the peak of his age-long struggle in order to establish these ideas he found *Buchiola (Posidoniomya) acuticosta* within this proposed Upper Devonian "special" facies. Due to the bad preservation of the fossil he could not fully trust his observation - but, on the other hand, this meagre fauna was his only evidence for the proposed Upper Devonian age of the "Gaudernbacher Schichten". Therefore he probably decided to compromise between the presentation of scientific evidence and maintenance of his ideas and presented *Buchiola (Posidoniomya) acuticosta* in its "cf.-form" in order to weaken its significance - maybe as possible predecessor of *B. acuticosta* s. str.
Within the slates around the above mentioned coordinates also thin intercalations of silt-finesand occur, in parts with considerable tuff-content. The whole succession appears similar to the higher parts of the one described by DILLMANN (1952, 1953, compare sample-descriptions D 8-10) and VOGT (appendix F 2.1: AV 10, 11, 275).
Revised stratigraphic range: ?Frasnian (? *Manticoceras*-stage; ?***falsiovalis*** — ?***linguiformis***-zone). DK1996: ds (0 — 6.1). **AND/OR**: late Viséan, *Goniatites*-stage (?***bilineatus*** — ?***nodosus***-zone). LCC2003: ci (17.1 — 20.0).

Presumable sedimentary environment: deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited, partly fossil-bearing, silt-finesand. Appearance of flaser bedding indicate punctuate low-energy to medium-energy bottom currents, which probably often lead to erosion of just before accumulated sediment. Episodic submarine volcanic activity lead to deposition and subsequent redeposition of tuff layers.

F 1.2 BAUMGARTEN 1983/84

Sample: B 1 (= 61) **Quotation:** Baumgarten 1983/84, unpubl. manuscript; Vogt, herewith
Gauss-Kruger-coordinates: ^{34}42390 - ^{55}89640
Location: forest path above east bank of Kerkerbach between Eschenau and Christianshütte.
Lithology: greyblue sandy slates, which appear mostly bright-yellowbrown to dirty-white due to bleaching. Content of mica and sand strongly varying, platy layers in succession with crenulated slates. Intercalations of 5 to 10 cm thick grey to black flinty slates (Lydite), but also cherty nodules (Kieselgallen).
Stratigraphic correlation: Lower Carboniferous: *Pericyclus*-stage, cu IIβ (**upper** *Gnathodus* ***typicus***-zone — *Scaliognathus* ***anchoralis-*** *Doliognathus* ***latus***-zone).
Fossils: conodonts, det. by S. Baumgarten and Dr. P. Bender (on bedding planes, limonitic)
Pseudognathodus cf. *pinnatus* (Voges 1959) [in upper *typicus* — in *anchoralis-latus*]
Pseudognathodus cf. *oxypageus* Lane, Sandberg & Ziegler 1980 [upper *typicus* — in *anchoralis-latus*]
Gnathodus semiglaber Bischoff 1957 [in *isosticha* / upper *crenulata* — *bilineatus*]
Gnathodus punctatus (Cooper 1939) [*isosticha* / upper *crenulata* — lower *typicus*]
Remarks: additional stratigraphic data: upper Tournaisian (Ivorian). LCC2003: ci: 11.1 — 12.5. If the lifetime of *G. punctatus* really terminates in the lower *typicus* zone this conodont must be reworked (LCC2003: ci: 8.3 — 10.6).
Presumable sedimentary environment: Deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited silt to finesand. The flinty slates as well as the cherty nodules are probably products of deposition of primary siliceous oozes which became partly separated during diagenesis and compaction. An alternative origin by deposition of thin finesilt intercalations seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are mostly not observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: B 2 (= 128a) **Quotation:** Baumgarten 1983/84, unpubl. manuscript; Vogt, herewith
Gauss-Kruger-coordinates: ^{34}41080 - ^{55}88140
Location: small outcrop in forest, above east bank of Kerkerbach south of Eschenau.
Lithology: green to yellowbrown, cherty to silty slates with sandy layers.
Stratigraphic correlation: lower Nehdenian (*Palmatolepis* ***crepida***-zone)
Fossils: conodonts, det. by S. Baumgarten and Dr. P. Bender (on bedding planes)
Palmatolepis cf. *tenuipunctata* Sannemann 1955 [Late *triangularis* — Latest *crepida*]
Remarks: revised to lower to middle Nehdenian (**Late** ***triangularis*** **— Latest** ***crepida***-zone). DK1996: ds: 7.5 — 10.5.
Presumable sedimentary environment: Deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited silt to finesand. The described cherty appearance of parts of the slates was not observable by Vogt.

Sample: B 3 (= 139) **Quotation:** Baumgarten 1983/84, unpubl. manuscript; Vogt, herewith
Gauss-Kruger-coordinates: ^{34}40830 - ^{55}88110
Location: forest path east of Kerkerbach south of Eschenau.
Lithology: greengrey to grey, partly platy, partly crenulated slates with sandy to quartzose intercalations (thickness of these layers up to 20 cm).
Stratigraphic correlation: lower Nehdenian (*Palmatolepis* ***crepida***-zone)
Fossils: conodonts, det. by S. Baumgarten and Dr. P. Bender (on bedding planes)
Polygnathus nodocostatus s. str. Branson & Mehl 1934 [Early *crepida* — Late *marginifera*]
Palmatolepis cf. *glabra pectinata* Ziegler 1960 [Latest *crepida* — Late *marginifera*]
Remarks: revised to middle (? lower) to upper Nehdenian (**Early** ***crepida*** **— Late** ***marginifera***-zone). DK1996: ds: 8.1 — 13.3.
Presumable sedimentary environment: Deposition of mud from suspension under reducing conditions within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited silt to finesand.

Sample: B 4 (= 207) **Quotation:** BAUMGARTEN 1983/84, unpubl. manuscript; VOGT, herewith

Gauss-Kruger-coordinates: ^{34}42200 - ^{55}89700

Location: small outcrop next to forest road east of Kerkerbach, between Eschenau and Christianshütte.

Lithology: darkgrey to greygreen, partly greasy lustrous slates, with intercalations of calcareous layers (up to several cm thickness) or small calcareous nodules. Partly intercalated are also platy slates with small cherty nodules (Kieselgallen).

Stratigraphic correlation: Dasbergian (upper *Polygnathus* ***styriacus***-zone)

Fossils: conodonts, det. by S. BAUMGARTEN and Dr. P. BENDER (from the calcareous layers)

Polygnathus styriacus ZIEGLER 1957	[Early *postera* — Early *expansa*]
Polygnathus communis communis BRANSON & MEHL 1934	[Early *postera* — ? in *texanus*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Late *crepida* — Middle *expansa*]
Palmatolepis gracilis gracilis BRANSON & MEHL 1934	[Late *rhomboidea* — in *sulcata*]
Palmatolepis gracilis sigmoidalis ZIEGLER 1962	[Late *trachytera* — Late *praesulcata*]

Remarks: revised to uppermost Hembergian to lower/middle Dasbergian (**Early** (*Pa. perlobata)* ***postera*** — **Early** (*Pa. gracilis)* ***expansa***-zone). DK1996: ds: 15.2 — 17.1.

Presumable sedimentary environment: Deposition of mud from suspension at the slope of a submarine ridge, punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous debris (and maybe of silt) from higher parts of the submarine ridge. The small nodules which show a cherty character are probably thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: B 5 (= 281) **Quotation:** BAUMGARTEN 1983/84, unpubl. manuscript; VOGT, herewith

Gauss-Kruger-coordinates: ^{34}40670 - ^{55}87980 [probably identical to sample location AV 293: ^{34}40675 - ^{55}87990]

Location: on same forest road as for sample-locations B 139 and B 302.

Lithology: greengrey to grey, micaceous sandy slates, which split up preferably along bedding planes.

Stratigraphic correlation: lower Nehdenian (*Palmatolepis* ***crepida***-zone)

Fossils: conodonts, det. by S. BAUMGARTEN and Dr. P. BENDER (on bedding planes)

Palmatolepis minuta minuta BRANSON & MEHL 1934	[Late *triangularis* — Latest *marginifera*]
Palmatolepis glabra prima ZIEGLER & HUDDLE	[Late *crepida* — Late *marginifera*]
Palmatolepis cf. *subperlobata* BRANSON & MEHL 1934	[Early *triangularis* — Latest *crepida*]
Palmatolepis tenuipunctata SANNEMANN 1955	[Late *triangularis* — Latest *crepida*]

Remarks: revised to upper lower to middle Nehdenian (Late ***crepida*** — Latest ***crepida*** - zone). DK1996: ds: 9.4 — 10.6.

Presumable sedimentary environment: Deposition of mud from suspension under reducing conditions within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited silt to finesand.

Sample: B 6 (=302) **Quotation:** BAUMGARTEN 1983/84, unpubl. manuscript; VOGT, herewith

Gauss-Kruger-coordinates: ^{34}40760 - ^{55}88040

Location: on top of a coarsegrained intrusive diabas, on the same forest road as for sample-location B 139.

Lithology: greenish, sandy, micaceous slates, which may become greyish towards the top. Content of sand strongly varying. Shales near the diabas appear quartzose.

Stratigraphic correlation: lower Nehdenian (*Palmatolepis* ***crepida***-zone)

Fossils: conodonts, det. by S. BAUMGARTEN and Dr. P. BENDER (on bedding planes)

Palmatolepis crepida SANNEMANN 1955	[(in Late *triangularis)* Early — Latest *crepida*]
Palmatolepis glabra prima ZIEGLER & HUDDLE	[Late *crepida* — Late *marginifera*]
Palmatolepis cf. *gracilis* BRANSON & MEHL 1934	[*Pa. gracilis gracilis*: Late *rhomboidea* — in *sulcata*]

Remarks: revised to upper lower to middle Nehdenian (Late ***crepida*** — Latest ***crepida*** - zone). DK1996: ds: 9.4 — 10.6.

Presumable sedimentary environment: Deposition of mud from suspension under reducing conditions within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited silt to finesand.

Sample: B 7 (= 322) **Quotation:** BAUMGARTEN 1983/84, unpubl. manuscript; VOGT, herewith
Gauss-Kruger-coordinates: ^{34}42400 - ^{55}90360
Location: north of Christianshütte.
Lithology: bright-yellowbrown, sandy to quartzose, partly laminated slates with intercalations of brightgrey quartzose layers.
Stratigraphic correlation: upper Nehdenian to lowermost Hembergian (upper *Palmatolepis* ***crepida***-zone — *Palmatolepis marginifera* ***marginifera***-zone)
Fossils: conodonts, det. by S. BAUMGARTEN and Dr. P. BENDER (on bedding planes)

Palmatolepis glabra prima ZIEGLER & HUDDLE	[Late *crepida* — Late *marginifera*]
Palmatolepis cf. *glabra pectinata* ZIEGLER 1960	[Latest *crepida* — Late *marginifera*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Late *crepida* — Middle *expansa*]
Palmatolepis cf. *minuta minuta* BRANSON & MEHL 1934	[Late *triangularis* — Latest *marginifera*]

Remarks: revised to middle to upper Nehdenian (**Late/Latest** ***crepida*** **— Late** ***marginifera***-zone). DK1996: ds: 9.4 — 13.4.
Presumable sedimentary environment: Deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited silt to finesand.

F 1.3 DILLMANN 1952

Sample: D 1 **Quotation:** DILLMANN 1952, p. 92
Gauss-Kruger-coordinates: ^{34}42400 - ^{55}90840 [^{34}42380 - ^{55}90880]
Location: southern end of big outcrop in slates, southeast of former Schupbach railway station. Sample taken from one of the packets of slates, which are stacked together as small schuppen. See appendix F.2.1, fig. F 2.2.
Lithology: black to darkbluegrey slates, partly with minor intercalations of quartzose beds.
Stratigraphic correlation: uppermost lower Koblenzian
Fossils: (mostly brachiopods; from a quartzose bed in the slates; det. by DILLMANN with confirmation from: R. RICHTER, E. RICHTER, HERM. SCHMIDT, G. SOLLE, G. DAHMER, H. HENTSCHEL)

Stropheodonta explanata (SOWERBY) [= *Leptostrophia explanata* (SOWERBY)]	[SMF-XVII 1229; Lower Devonian?]
Orthothetina hipponyx cf. *maior* (FUCHS) [= *Irichistrophia hipponyx* cf. *maior* (FUCHS) = *Schellwienella hipponyx* cf. *maior* (FUCHS)	[SMF-XVII 1230; Devonian — Carboniferous]
Eodevonaria dilatata (F. A. ROEMER) [= *Loreleiella dilatata* (F. A. ROEMER)]	[SMF-XVII 1226; Emsian]
Atrypa cf. *lorana* FUCHS	[SMF-XVII 1236]
Spirifer arduennensis cf. *latestriatus* (MAURER 1886, DREVERMANN 1902) [= *Arduspirifer arduennensis* cf. *latestriatus* (MAURER 1886, DREVERMANN 1902)]	[SMF-XVII 1228; Lower Emsian]
Spirifer arduennensis s. l. [= *Arduspirifer arduennensis* s. l.]	[SMF-XVII 1227 a+b; late Lower — middle Upper Emsian]
Trochites	[SMF-P.K. 884]

Remarks: stratigraphic range confirmed to upper Lower Emsian (Zlichovian, Vallendarian, ca. Late (*Po.)* ***excavatus*** -zone — ***nothoperbonus*** -zone). DK1996: di: ca. 12.8 — 14.3.
Presumable sedimentary environment: Marine (outer) shelf. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt to finesand. Dominating bedding features are lenticular bedding and laminated sand/silt/mud. Wave energy and mud supply control mud abundance.

Sample: D 2 **Quotation:** DILLMANN 1952, p. 93
Gauss-Kruger-coordinates: ^{34}4287 - ^{55}9080
Location: east of point 176.5, southeast of the former Schupbach railway station, at the hillside next to the forest road.
Lithology: Very micaceous, fine-grained, quartzite-like greywackes, with intercalations of very thin plated, very micaceous greywackesandstones and micaceous clayey slates.
Stratigraphic correlation: uppermost lower Koblenzian
Fossils: (mostly brachiopods; from the quartzose greywackes; det. by DILLMANN with confirmation from: R. RICHTER, E. RICHTER, HERM. SCHMIDT, G. SOLLE, G. DAHMER, H. HENTSCHEL)

Gastropoda	[SMF-P.K. 878]
Platyceras sp.	[SMF-XII 3307]
Orthoceras sp.	[SMF-P.K. 879]
Chonetes sarcinulatus (SCHLOTHEIM 1820)	[SMF-XVII 1235; Emsian — Eifelian]
Spirifer cf. *pellico* (D´ARCHIAC & DE VERNEUIL) [= *Euryspirifer* cf. *pellicoi* (D´ARCHIAC & DE VERNEUIL)]	[SMF-XVII 1231]

Spirifer arduennensis cf. *latestriatus* (Maurer 1886, Drevermann 1902) [= *Arduspirifer arduennensis* cf. *latestriatus* (Maurer 1886, Drevermann 1902)]	[SMF-XVII 1234; Lower Emsian]
Spirifer arduennensis s. l. [= *Arduspirifer arduennensis* s. l.]	[SMF-XVII 1232; upper Lower — middle Upper Emsian]
Trochites	[SMF-P.K. 879]

Remarks: stratigraphic range confirmed to upper Lower Emsian (Zlichovian, Vallendarian, ca. Late (*Po.)* ***excavatus*** -zone — ***nothoperbonus*** -zone). DK1996: di: ca. 12.8 — 14.3. The lithologic succession consist of clayey-silty slates with turbiditic finesand intercalations. No greywackes are observable.

Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. Dominating bedding features are graded bedding and laminated sand/silt. Wave energy and mud supply control mud abundance.

Sample: D 3 **Quotation:** Dillmann 1952, p. 93
Gauss-Kruger-coordinates: ^{34}4266 - ^{55}9060
Location: Outcrop in forest northeast of Christianshütte.
Lithology: medium to thick bedded, fine-grained, micaceous, grey sandstones, partly intercalated with flaser-like, micaceous sandy slates.
Stratigraphic correlation: uppermost lower Koblenzian
Fossils: (mostly brachiopods; det. by Dillmann with confirmation from: R. Richter, E. Richter, Herm. Schmidt, G. Solle, G. Dahmer, H. Hentschel)

Orthis (Dalmanella) cf. *circularis* (Sowerby) [= *Platyorthis* cf. *circularis* (Sowerby)]	[SMF-XVII 1241; Upper Silurian — Middle Devonian]
Eodevonaria dilatata (F. A. Roemer) [= *Loreleiella dilatata* (F. A. Roemer)]	[SMF-P.K. 888]
Spirifer cf. *pellico* (D´Archiac & de Verneuil) [= *Euryspirifer* cf. *pellicoi* (D´Archiac & de Verneuil)]	[SMF-XVII 1239]
Spirifer arduennensis cf. *latestriatus* (Maurer 1886, Drevermann 1902) [= *Arduspirifer arduennensis* cf. *latestriatus* (Maurer 1886, Drevermann 1902)]	[SMF-XVII 1238; late Lower Emsian]
Spirifer arduennensis s. l. [= *Arduspirifer arduennensis* s. l.]	[SMF-XVII 1237; upper Lower — middle Upper Emsian]
Spirifer cf. *carinatus* (Schnur 1853) [= *Brachyspirifer* cf. *carinatus* (Schnur 1853, Wedekind 1926) Solle 1971]	[SMF-XVII 1240; frequent: lower — middle Lower Emsian; but *Brachyspirifer carinatus rhenanus* Solle 1971: frequent from lower — middle Upper Emsian]
Trochites	[SMF-P.K. 880]
Pleurodictyum problematicum Goldfuss 1829	[SMF-XXV 330; Lower Devonian]

Remarks: stratigraphic range confirmed to upper Lower Emsian (Zlichovian, Vallendarian, ca. Late (*Po.)* ***excavatus*** -zone — ***nothoperbonus*** -zone). DK1996: di: ca. 12.8 — 14.3.

Presumable sedimentary environment: Transition zone between coastal environment and inner shelf. Deposition of fine sand and mud from suspension along protected low-energy coast or on open coasts. Wave energy and supply control mud abundance. Dominating bedding features are flaser and lenticular bedding and laminated sand. During heavy storms brachiopod shells together with trochites and *P. problematicum* were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds.

Sample: D 4 **Quotation:** Dillmann 1952, p. 94 bottom
Gauss-Kruger-coordinates: ^{34}4283 - ^{55}9083
Location: southeast of former railway station Schupbach, 650 m eastwards point 176.5
Lithology: alternation of: a) slightly sandy, greygreen, partly yellowishgrey, micaceous flaser bedded sandy slates, b) platy greygreenish slates, c) thinly plated bluegreen slates. Within these platy slates intercalations of more competent grey sandy beds and pseudonodules.
Stratigraphic correlation: lower to middle upper Koblenzian (Lahnstein- to Laubach-Group)
Fossils: (mostly brachiopods; high populations but lack of different species; det. by Dillmann with confirmation from: R. Richter, E. Richter, Herm. Schmidt, G. Solle, G. Dahmer, H. Hentschel)
Gastropoda
Orthis sp.
Dalmanella sp.

Stropheodonta of the *sedgwicki* - group [= *Fascistropheodonta* sp.]	[SMF-XVII 1221]
Orthothetina hipponyx (Schnur) [= *Irichistrophia hipponyx* (Schnur)]	[SMF-XVII 1214]
Eodevonaria dilatata (F. A. Roemer) [= *Loreleiella dilatata* (F. A. Roemer)]	[SMF-XVII 1215 a+b]
Chonetes sarcinulatus (Schlotheim 1820)	[SMF-XVII 1217; Emsian — Eifelian]
Atrypa reticularis (v. Linné)	[SMF-XVII 1219; Silurian — Emsian]
Athyris cf. *concentrica* (v. Buch 1834)	[SMF-XVII 1220; Lower Devonian — Triassic]
Spirifer cf. *paradoxus* (Schlotheim 1813) [= *Euryspirifer* cf. *paradoxus* (Schlotheim 1813)]	[SMF-P.K. 875; lower Upper Emsian (lower Lahnsteinian)]
Spirifer arduennensis arduennensis (Schnur 1853) [= *Arduspirifer arduennensis arduennensis* (Schnur 1853) = *Acrospirifer arduennensis arduennensis* (Schnur 1853)]	[SMF-XVII 1210 a-d; lower-middle Upper Emsian, Lahnsteinian — Laubachian]
Spirifer cf. *carinatus* (Schnur 1853) [= *Brachyspirifer* cf. *carinatus* (Schnur 1853, Wedekind 1926) Solle 1971]	[SMF-XVII 1211; frequent: lower — middle Lower Emsian; but *Brachyspirifer carinatus rhenanus* Solle 1971: frequent from lower — middle Upper Emsian]
Spirifer subcuspidata s. l. (Schnur 1854) [= *Subcuspidella subcuspidata* s. l. (Schnur 1854) Mittmeyer 1972]	[SMF-XVII 1213]
Spirifer cf. *mediorhenanus* (Fuchs) [= *Alatiformia* cf. *mediorhenana* (Fuchs)]	[SMF-P.K. 877]
Uncinulus pila (Schnur)	[SMF-XVII 1216]
Anoplotheca venusta (Schnur 1853)	[SMF-XVII 1218 a+b; Emsian (Ulmenian — Upper Emsian; frequent: Laubachian)]
Trochites	
Pleurodictyum problematicum Goldfuss 1829	[SMF-XXV 329; Lower Devonian]
Zaphrentis sp.	[SMF-P.K. 877]
Olkenbachia hirsuta (Solle 1938) [= *Clionolithes* Clarke 1908 *hirsutus*]	[SMF-XXVI 187 b]

Remarks: stratigraphic range revised to lower Upper Emsian (lower Lahnsteinian, with all precaution for such an exact comparison: ca. Early ***inversus*** -zone). DK1996: di: ca. 14.3 — 15.4. A) material almost identical to specimens collected by Wroost, SMF-885, Gauss-Kruger-coordinates: ^{34}4283 - ^{55}908[1]; B) Dillmann relates this locality to locality "Fundpunkt (FP) 4" [KR 1, this paper] of Krekeler (1929:83).

Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. Dominating bedding features are graded bedding and laminated sand/silt. Wave energy and mud supply control mud abundance. During heavy storms brachiopod shells together with trochites and *P. problematicum* were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds.

Sample: D 5 **Quotation:** Dillmann 1952, p. 95 top

Gauss-Kruger-coordinates: ^{34}4286 - ^{55}9088

Location: southeast of former railway station Schupbach, 700 m eastwards 176.5 in a small slope near the forest.

Lithology: alternation of: a) slightly sandy, greygreen, partly yellowishgrey, micaceous flaser bedded sandy slates, b) platy greygreenish slates, c) thinly plated bluegreen slates. Within these platy slates intercalations of more competent grey sandy beds and pseudonodules.

Stratigraphic correlation: upper Lower Devonian

Fossils: (mostly brachiopods; bad preservation; det. by Dillmann with confirmation from: R. Richter, E. Richter, Herm. Schmidt, G. Solle, G. Dahmer, H. Hentschel)

Schizophoria sp.	[SMF-XVII 1243]
Eodevonaria dilatata (F. A. Roemer) [= *Loreleiella dilatata* (F. A. Roemer)]	[SMF-XVII 1223]
Spirifer arduennensis arduennensis (Schnur 1853) [= *Arduspirifer arduennensis arduennensis* (Schnur 1853) = *Acrospirifer arduennensis arduennensis* (Schnur 1853)]	[SMF-XVII 1222; Early — middle Upper Emsian, Lahnsteinian — Laubachian]
Trochites	
Zaphrentis sp.	
Olkenbachia hirsuta (Solle 1938) [= *Clionolithes* Clarke 1908 *hirsutus*]	[SMF-XXVI 187 b]

Remarks: stratigraphic range revised to lower — middle Upper Emsian (Lahnsteinian — Laubachian, ca. ***inversus*** — Early ***serotinus*** -zone). DK1996: di: ca. 14.3 — 17.1.
Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. Dominating bedding features are graded bedding and laminated sand/silt. Wave energy and mud supply control mud abundance. During heavy storms brachiopod shells together with trochites and *Zaphrentis* were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds.

Sample: D 6 **Quotation:** DILLMANN 1952, p. 95 top
Gauss-Kruger-coordinates: ^{34}4246 - ^{55}9096
Location: southeast of former railway station Schupbach, 250 m northeast of point 176.5.
Lithology: yellowishgrey weathered slates. See appendix F 2.1, fig. F 2.2
Stratigraphic correlation: upper Lower Devonian (due to lithology presumably upper Koblenzian)
Fossils: (rare; only parts of fossils; det. by DILLMANN with confirmation from: R. RICHTER, E. RICHTER, HERM. SCHMIDT, G. SOLLE, G. DAHMER, H. HENTSCHEL)

Spirifer cf. *arduennensis* SCHNUR [= *Arduspirifer* cf. *arduennensis* (SCHNUR 1853)]	[SMF-XVII 1224; upper Lower — middle Upper Emsian]
Chonetes sp.	
parts of brachiopods	
Trochites	

Remarks: stratigraphic range revised to Lower Emsian — middle Upper Emsian (Ulmenian — Laubachian, ca. ***excavatus*** — Early ***serotinus*** -zone). DK1996: di: ca. 11.3 — 17.1. No further temporal subdivision is possible.
Presumable sedimentary environment: Marine (outer) shelf. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: D 7 **Quotation:** DILLMANN 1952, p. 95 top
Gauss-Kruger-coordinates: ^{34}4214 - ^{55}9058
Location: north of Christianshütte
Lithology: darkbluegrey slates with cherty nodules (Kieselgallen)
Stratigraphic correlation: Lower Devonian (due to lithology presumably upper Koblenzian)
Fossils: (in cherty nodules (Kieselgallen); det. by DILLMANN with maintainance of: R. RICHTER, E. RICHTER, HERM. SCHMIDT, G. SOLLE, G. DAHMER, H. HENTSCHEL)

Spirifer cf. *arduennensis* SCHNUR [= *Arduspirifer* cf. *arduennensis* (SCHNUR 1853)]	[SMF-XVII 1250; upper Lower — middle Upper Emsian]
? *Pleurotomaria* sp.	
Trochites	

Remarks: stratigraphic range revised to Lower Emsian — middle Upper Emsian (Ulmenian — Laubachian, ca. ***excavatus*** — Early ***serotinus*** -zone). DK1996: di: ca. 11.3 — 17.1. No further temporal subdivision is possible.
Presumable sedimentary environment: Marine (outer) shelf. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited finesilt. Dominating bedding features are lenticular bedding and laminated finesilt or mud. Wave energy and mud supply control mud abundance. The small nodules which show a cherty character are probably thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: D 8 **Quotation:** DILLMANN 1952, p. 100 top
Gauss-Kruger-coordinates: ^{34}4413 - ^{55}9234
Location: east of Gaudernbach.
Lithology: dark, blackblue, thin laminated slates with tuff intercalations
Stratigraphic correlation: Lower Carboniferous: Kulm (base of Kulm-Posidonienschiefer)
Fossils: (very badly preserved, very small parts of fossils; det. by DILLMANN with confirmation from: R. RICHTER, E. RICHTER, HERM. SCHMIDT, G. SOLLE, G. DAHMER, H. HENTSCHEL)

Aviculopecten MCCOY 1851 sp.	[SMF-P.K. 893]
Bellerophon sp.	[SMF-P.K. 893]
Pleurotomaria sp.	[SMF-P.K. 893]
Chonetes (Chonetes) cf. *laguessianus angustus* PAECKELMANN [= *Rugosochonetes* cf. *laguessianus* (DE KONINCK 1843; BRAND 1970: nomen dubium) *angustus* PAECKELMANN 1930]	[SMF-XVII 1249, frequent: Pe II δ — Go III α_1]
Chonetes (Chonetes) cf. *longispinus* F. A. ROEMER [1850] [= *Rugosochonetes* cf. *longispinus* PAECKELMANN 1930]	[SMF-XVII 1248, rare: Go III α, frequent: Go III β-γ]

Chonetes (Chonetes) cf. *kayseri* Paeckelmann [1930]	[SMF-XVII 1247; Go III β (Aprath, Germany)]
Zaphrentis sp.	[SMF-P.K. 893]
Favosites sp.	[SMF-P.K. 893]
Pleurodictyum cf. *dechenianum* Kayser	[SMF-XXV 332 a+b]
Trochites	

Remarks: Fossil list (only "cf."-determinations!) gives no sure evidence for Lower Carboniferous age. But a) absence of brachiopods of the "Spirifer"-group and b) different lithologic character seem to exclude Lower Devonian age. Lithology and fossil remnants similar to that from location D 9 (Dillmann 1952), which is surely correlated to the Lower Carboniferous (Viséan). *Chonetes (Chonetes) kayseri* Paeckelmann 1930 is due to Paeckelmann 1930:253 probably wider distributed within the Lower Carboniferous and not restricted to Go III β. That is because of obviously frequent wrong determinations of *Chonetes (Orthis) hardrensis* (Philipps 1841) and *Chonetes perlatus* (McCoy 1844), which are similar to *C. kayseri*. LCC2003: ci: (17.1 — 20.0).

Presumable sedimentary environment: Deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited silt. Episodic submarine volcanic activity lead to deposition of tuff layers.

Sample: D 9 **Quotation:** Dillmann 1952, p. 101/102
Gauss-Kruger-coordinates: ^{34}4466 - ^{55}9326
Location: "Am Kahlhau" north of Gaudernbach: along the road Weilburg - Runkel, 220 m west of point 340.1
Lithology: Kulm-Posidonia-slate: dark, blackblue, bluegrey to grey slates, partly flaser bedding, with mica-sheets and some thin manganese precipitates; partly "Liesegang´sche Ringe". Intercalations of brightgrey to yellowishgrey sandy slates.
Stratigraphic correlation: Lower Carboniferous: Kulm, *Goniatites* IIIβ.
Fossils: (from two horizons, 1 m apart; det. by Dillmann with confirmation from: R. Richter, E. Richter, Herm. Schmidt, G. Solle, G. Dahmer, H. Hentschel)

Phillibole aprathensis Rud. & E. Richter [1937] [= *Archegonus (Phillibole) aprathensis* Hahn 1965]	[SMF-X 785 g-n, o-q; Upper Viséan (Go III α)]
Orthoceras scalare Goldfuss [1844] [= *Brachycycloceras scalare* H. Schmidt 1956 = *Orthoceras scalare* d´Archiac & Verneuil 1842]	[SMF-XI 1282; frequent: Go III α_4]
Orthoceras striolatum H. v. Meyer [1831] [= *Mitorthoceras striolatum* Brauckmann 1982]	[SMF-XI 1279, 1281; Go III α-β]
Stroboceras sulcatum sulcatum Sowerby	[SMF-XI 1259; Lower Carboniferous, Upper Mississipian; Viséan — Lower Namurian]
Münsteroceras truncatum (Phillips [1836])	[SMF-P. 892, XI 1278 a+b; Go III α_1 — Go III β_2]
Merocanites sp.	[SMF-XI 1280]
Posidonia becheri Bronn [= *Posidoniomya becheri* Bronn 1828]	[SMF-XV 1945, 1946; (late Pe IIδ —) Go IIIβ; rare Go IIIγ]
Posidonia cf. *membranacea* McCoy [1844]	[SMF-XV 1947; Warnantian — Upper Carboniferous; frequent: Go III α]
Aviculopecten [McCoy 1851] sp.	[SMF-P. 892]
Pleurotomaria cf. *nöggerathi* Goldfuss [1844]	[SMF-XII 3308; Viséan due to Kühne 1930]
Schellwienella cf. *crenistria* (Phillips [1836]) [= *Schellwienella* cf. *crenistria* Paeckelmann 1930]	[SMF-XVII 1246; uppermost Upper Devonian — Viséan]
Chonetes (Chonetes) longispinus (F. A. Roemer [1850] [= *Rugosochonetes longispinus* Paeckelmann 1930]	[SMF-XVII 1243, rare: Go III α, frequent: GoIIIβ-γ]
Chonetes (Chonetes) cf. *longispinus* (F. A. Roemer [1850] [= *Rugosochonetes* cf. *longispinus* Paeckelmann 1930]	[SMF-XVII 1244, rare: Go III α, frequent: GoIIIβ-γ]
Chonetes (Chonetes) cf. *kayseri* Paeckelmann [1930]	[SMF-XVII 1245; Go III β (Aprath, Germany)]
Chonetes sp.	[SMF-P.K. 892]
Pleurodictyum dechenianum Kayser	
Fenestella sp.	[SMF-P.K. 891]
Trochites	[SMF-P.K. 891, 892]
parts of brachiopods	[SMF-P.K. 891]
plant remnants (wood)	[SMF-P.K. 891, 892]

Remarks: Upper Viséan age correlation confirmed, but for further temporal subdivision no sufficient evidence is put forward by Dillmann. *Archegonus (Phillibole) aprathensis* is the first occurrence zone-fossil for the *aprathensis*-trilobite-zone (and has its acme there), which correlates with the *Goniatites* IIIα-zone (compare Hahn & Hahn 1969: 93-94). But known lifetime of *A. (P.) aprathensis* (synonym before 1937: *Phillipsia aequalis*) prolongs into the *Goniatites* IIIβ-zone. This fact was surely known by R. & E. Richter, who established the species. Kulick (1960:281) believed to see in this fossil list a mere *Goniatites* IIIα3 -age (he quotes Nicolaus (1958: unpubl. PhD-thesis, published 1963) who stated that *Phillibole (Phillibole) aprathensis* and *Münsteroceras truncatum* are most frequent in IIIα3), but no further evidence or explanation was given. Paproth (1963) in her statement concerning the Lower Carboniferous parts of the "Gaudernbacher Schichten" in the Lexique Stratigraphique International

(Carbonifère de Allemagne), quoted KULICK 1960 and accepted his age correlation without further comment. Due to the above listed lifetime ranges for the different species, an age correlation to the Late Go IIIα — Early Go IIIβ seems most probable: LCC2003: ci: 17.3 — 18.3.
Presumable sedimentary environment: deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited, partly fossil-bearing, silt-finesand. Appearance of flaser bedding indicates punctuate low-energy to medium-energy bottom currents, which probably often lead to erosion of sediment accumulated just before. Occurrence of plant remnants indicates a position near a subaerial environment (?island). Episodic submarine volcanic activity lead to deposition of tuff layers.

Sample: D 10 **Quotation:** DILLMANN 1953, p. 154/159
Gauss-Kruger-coordinates: ^{34}4471 - ^{55}9334
Location: "Am Kahlhau" north of Gaudernbach: 200 m west of point 340.1 - between street-km 2.7 and 2.8 - 28 m east of the road Weilburg - Runkel, at the hillside. Artificial temporary outcrop, prospection pit (Schurf: 8.0m x 0.8m x 2.6m (max.)) in order to detect the border between Deckdiabas (basalt) and overlying slates.
Lithology: Succession of Deckdiabas ("sheet-basalt", partly with calcareous void fillings), crinoid-limestone and Kulm-Posidonienschiefer (dark, blackblue, bluegrey to grey slates, partly flaser bedding, with mica-sheets and some thin manganese precipitates. Intercalations of brightgrey to yellowishgrey sandy slates.).
Stratigraphic correlation: Lower Carboniferous: Kulm, *Pericyclus* II — *Goniatites* (III α ? —) IIIβ.
Fossils: (from six fossiliferous horizons within a 2.6 m (concordant, net ca. 1.4 m) thick succession; det. by DILLMANN together with R. RICHTER)
Horizon 1 (25-42 cm): ca. 11 cm above Diabas; probably *Pericyclus* II
crinoid stems (trochites)
ostracods
brachiopods
Pleurodictyum cf. *dechenianum* KAYSER
trilobite remnants
Horizon 2 (20-39 cm): ca. 53 cm above Diabas
internal moulds of ostracods (only!)
Horizon 3 (0-8 cm): ca. 73 cm above Diabas
crinoid remnants
Horizon 4 (5-9 cm): ca. 97 cm above Diabas; presumably *Goniatites* III α ?
crinoids
trilobite remnants (badly preserved)
brachiopod remnants
bryozoans
crinoid stems (trochites)
wood remnants
Horizon 5 (10-13 cm): ca. 106 cm above Diabas
Chonetes sp.
brachiopod remnants
crinoid stems (trochites)
Horizon 6 (7-11 cm): ca. 129 cm above Diabas; presumably *Goniatites* IIIβ
Posidonia becheri BRONN [(late Pe IIδ —) Go IIIβ; rare Go IIIγ]
[= *Posidoniomya becheri* BRONN 1828]
goniatite remnants
brachiopod remnants
Remarks: fossil preservation sufficient but stratigraphic correlation due to above given fossil evidence insufficient. DILLMANN and R. RICHTER wanted to publish a more detailed fossil list later on, but did not manage to do so. The fossil material was reposited at the SMF, Frankfurt. KEGLER (1967:32) tried to recover conodonts from crinoid limestone-material found by him on the heap near the pit (the pit itself was completely elapsed) but failed. KREBS (1968) described 3 types of Erdbacher Kalk (crinoid limestone) which are lithologically variable but in their timing of deposition generally restricted to the *anchoralis* zone (type I = early part; type II = late part) and to the *anchoralis-bilineatus*-interregnum (type III, cu II γ-δ). By assuming the crinoid limestones mentioned above to be equal to the ones described by KREBS, the deposition presumably did not start before the beginning of the *anchoralis-latus*-zone (late cu IIβ). If the following assumptions are true that a) the succession is concordant, b) the age of the upper parts is *Goniatites* III α ? — IIIβ (which is supported by sample D 9, found nearby), c) the Deckdiabas-volcanism terminates everywhere in the Lahn- and Dill-syncline within the *anchoralis-bilineatus*-interregnum (WALLISER 1960: 230), then the above mentioned crinoid limestone represents the "Erdbacher Kalk III" sensu KREBS (1968). Therefore the time range covered by the above described succession is in a first approximation restricted to LCC2003: ci: 13.3 — 19.0 (but compare for samples AV 10, 11 and 275).
Presumable sedimentary environment: basinal marine (offshore shelf?) environment. Succession of
a) submarine basaltic magma outflow;
b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris (and maybe of finesand) from higher parts of a submarine ridge. Redeposited fossils indicate a former depositional

region at a higher position of the slope near or on top of the ridge; the sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed; repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, is reflected by the concentration of the fossils on the bedding planes, which are separated by mm to cm thick layers of clay to silt or calcareous debris; this interpretation is in accordance with results obtained by BLESS (1992:204) for a contemporary succession at the Velbert anticline, near Aprath (Germany);

c) deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited, partly fossil-bearing, silt-finesand. Appearance of flaser bedding indicate punctuate low-energy to medium-energy bottom currents, which probably often lead to erosion of sediment accumulated just before. Occurrence of wood remnants indicate a position near a subaerial environment (?island). Episodic submarine volcanic activity lead to deposition of tuff layers.

F 1.4 FEY 1983

Sample: F 1 **Quotation:** FEY 1983, p. 78, 84, 86-96; FEY 1985
Gauss-Kruger-coordinates: ^{34}37670 - ^{55}87430
Location: at the western exit of the village Steeden, in the southern part of the old Massenkalk-quarry; section at the street (geological map 1:25000, 5514 Hadamar).
Lithology: uppermost part of the Upper Devonian — Lower Carboniferous sedimentary succession described by HENNINGSEN (1965). "Erdbacher Kalk": Greyred limestone with wheat-like finegrained calcareous concretions which contain mostly moulds of ostracods and often remarkably small pygidians of trilobites (gl), intercalated by redbrown, clayey-marly layers (cml); section from down to top: 0.8m gl - 0.03m cml - 0.07m gl - 0.02m cml - 0.06m gl - 0.02m cml - min. 0.6m gl [total min. 1.60m].
Stratigraphic correlation: cu II γ, time-equivalent to the Erdbacher Kalk from the Liebstein near Erdbach-Breitscheid (upper part of ***anchoralis-latus***-zone)
Fossils: (rich fauna; det. by FEY, from the calcareous layers)
Quite frequent: conodonts, crinoids, ostracods. Frequent: trilobites, remnants of fish-form vertebrates, inarticulate brachiopods, cephalopods. Rare: bivalvia, articulate brachiopods, anthozoa, rostrochonchia, gastropods.

Trilobites:	
Archegonus (Phillibole) nitidus nitidus (HOLZAPFEL 1889)	
Liobole subaequalis (HOLZAPFEL 1889)	
Liobole n. sp.	
Carbonocoryphe (Winterbergia) hahnorum MILLER 1973	
Pseudowaribole (Geigibole) n. sp.	
Liobolina submonstrans sculptilis G. HAHN 1967	
Bollandia cf. *tisiphone* G. & R. HAHN 1970	
Cystispina (Spatulina) sp.	
Archegonus (Waribole) steedenensis FEY 1985	[SMF 367 55-66]
Archegonus (Weania) neso FEY 1985	[SMF 3676 7-9, 3677 0-5]
Conodonts:	
Bispathodus stabilis (BRANSON & MEHL 1934)	[Late *marginifera* — in *texanus*]
Elictognathus laceratus (BRANSON & MEHL 1934)	[in *duplicata* — ? in *sandbergi*]
Eotaphrus [PIERCE & LANGENHEIM 1974] sp.	[Germany: only *anchoralis-latus*; in USA: in upper *typicus* — in *texanus*]
Gnathodus cuneiformis MEHL & THOMAS 1947	[? lower *typicus* — ? *anchoralis-latus*]
Gnathodus punctatus (COOPER 1939)	[upper *crenulata* — in lower *typicus*]
Gnathodus pseudosemiglaber THOMPSON & FELLOWS 1970	[in *anchoralis-latus* — in *bilineatus*]
Gnathodus semiglaber BISCHOFF 1957	[in upper *crenulata* — in *bilineatus*]
Polygnathus bischoffi RHODES, AUSTIN & DRUCE 1969	[*anchoralis-latus* — in *texanus*]
Protognathodus praedelicatus LANE, SANDBERG & ZIEGLER 1980	[in lower *crenulata* — ? in *anchoralis-latus*]
Pseudopolygnathus pinnatus (VOGES 1959)	[in upper *typicus* — in *anchoralis-latus*]
Scaliognathus anchoralis BRANSON & MEHL 1941	[*anchoralis-latus*]

Anthozoa: "of zaphrentid type"
Brachiopods:
Lingula sp.
Orbiculoidea sp.
Schizophoria resupinata (MARTIN 1809)
Rostrochonchia: *Conocardium aliforme* (SOWERBY 1815)
Bivalvia:

Nucolopsis ?
Posidonia ?
Gastropoda: *Soleniscus* ?
Cephalopoda: *Dolorthoceras* ?
Crinoids: 2 types of parts of stems (trochites)
Ostracods: only internal moulds
Remnants of fish-form vertebrates:
"*Cladodus*" AGASSIZ 1843
parts of fam.: *Ischnacanthidae* WOODWARD 1891
Remarks: preliminary revised stratigraphic range: uppermost Tournaisian (cu II β ; base to near the top of ***anchoralis-latus***-zone). LCC2003: ci: (11.7 — 12.5). HENNINGSEN (1965, samples H 23 + 24) presented two fossil lists for the limestones from this locality which indicate a depositional age of **LCC2003: ci: 13.3 — 17.5** (cu II γ, "Erdbacher Kalk III"). The fossil lists of FEY and HENNINGSEN share 3 conodont species: *G. punctatus, P. pinnatus* and *S. anchoralis*. It is to be assumed, that FEY didn´t recognise the conodonts which indicate the youngest age; however, in her discussion concerning the relative age of the deposits she proposed (due to facies-relations) this limestone to be at least time-equivalent to the Erdbacher Kalk, type II [KREBS (1968) described 3 types of Erdbacher Kalk (crinoid limestone) which are lithologically variable but in their timing of deposition generally restricted to the *anchoralis* zone (type I = early part; type II = late part) and to the *anchoralis-bilineatus*-interregnum (type III, cu II γ-δ).]. Compare also HAHN & HAHN 1982 (sample HH 1).
Presumable sedimentary environment: Deposition near the base of a basinal slope. Main constituent of the sedimentary facies is clay-silt with intercalations of (turbiditic) calcareous debris (whose fossil-content is described above) from higher (max. water depth 75-150m, FEY 1983: 101) parts of the submarine ridge.

F 1.5 HAHN & HAHN 1982

Sample: HH 1 **Quotation:** HAHN & HAHN 1982, p. 430 bottom, 432-438
Gauss-Kruger-coordinates: ^{34}37670 - ^{55}87430
Location: at the western exit of the village Steeden, in the southern part of the old Massenkalk-quarry; section at the street (geological map 1:25000, 5514 Hadamar).
Lithology: uppermost part of the Upper Devonian — Lower Carboniferous sedimentary succession described by HENNINGSEN (1965). Grey to greyred limestones (Erdbacher Kalk).
Stratigraphic correlation: cu II β/γ, time-equivalent to the Erdbacher Kalk (***anchoralis***-zone)
Fossils: (rich fauna; det. by HAHN & HAHN, from the calcareous layers)
Trilobites (first description of two new species, work in progress):
Xenadoche dido HAHN & HAHN 1982 [SMF 36 686-689]
Cystispina (Spatulina?) sp., aff. *diversa* HAHN & HAHN 1971 [SMF 36 690]
Remarks: preliminary revised stratigraphic range: uppermost Tournaisian (cu II β ; base to near the top of ***anchoralis-latus***-zone). LCC2003: ci: 11.7 — 13.2. Compare descriptions for F1 (FEY 1983, 1985) and H 23 + 24 (HENNINGSEN 1965). HENNINGSEN presented two fossil lists for the limestones from this locality which indicate a depositional age of **LCC2003: ci: 13.3 — 17.5** (cu II γ, "Erdbacher Kalk III").
HAHN, HAHN & MÜLLER (1998) described several new trilobite taxa from this location and presented the following conclusion in their english abstract (p. 199): "Palaeogeographically, the fauna of Steeden is in a relatively isolated position: 10 taxa [all new species, ...] are endemic, and this situation is even more accentuated if the *Cystispinae* are taken into consideration. Among the remaining taxa, 6 of them [...] show palaeogeographic connections to the Winterberg. But only two taxa [...] are known from the region of Erdbach. The reasons for this peculiar geographical distribution are unknown." And on page 164 of the german text it is mentioned "in spite of the geographical position at the SE margin of the range of distribution of the Erdbach limestones the relations of Steeden to the more distant Harz are closer than to the nearer located sample points in the Erdbach region."
Presumable sedimentary environment: Deposition near the base of a basinal slope. Main constituent of the sedimentary facies is clay-silt with intercalations of (turbiditic) calcareous debris (whose fossil-content is described above) from higher (max. water depth 75-150m, FEY 1983: 101) parts of the submarine ridge.

F 1.6 HENNINGSEN 1965

Sample: H 1-24 **Quotation:** HENNINGSEN 1965, p. 620-621, tab. 1 and 2
Gauss-Kruger-coordinates: ^{34}37670 - ^{55}87430
Location: at the western exit of the village Steeden, in the southern part of the old Massenkalk-quarry; section at the street (geological map 1:25000, 5514 Hadamar).
Lithology: Famennian: greenish to reddish, partly tuff-bearing slates with intercalations of marls, limestones, calcareous nodules and reworked pyroclastic deposits. Lower Carboniferous: grey to black slates, partly with phosphatic concretions, towards the top intercalated by crinoid limestone beds. **See fig. D 2.8.**
Stratigraphic correlation: concordant succession from Upper Devonian (to III) — Lower Carboniferous (cu II)
Fossils: (conodonts, det. by HENNINGSEN; ammonoids, det. by BLIND)

<u>H 24: LCC2003: ci 13.3 — 17.5 (+ reworked LCC2003: ci 11.7 — 12.5)</u>
Compare also HAHN & HAHN 1982 (sample HH 1) and FEY 1983 (sample F 1).

Gnathodus texanus ROUNDY 1926	[*texanus* — in *bilineatus*]
Polygnathus inornatus BRANSON 1934	[in Early *expansa*— *anchoralis-latus*]
Pseudopolygnathus (triangulus) pinnatus VOGES 1959	[in upper *typicus* — in *anchoralis-latus*]
Scaliognathus anchoralis BRANSON & MEHL 1941	[base to near the top of *anchoralis-latus*]

<u>H 23: LCC2003: ci 13.3 — 17.5 (+ reworked LCC2003: ci 11.7 — 12.5 and ci 8.3 — 9.1)</u>
Compare also HAHN & HAHN 1982 (sample HH 1) and FEY 1983 (sample F 1).

Gnathodus punctatus (COOPER 1939)	[*isosticha* / upper *crenulata* — in lower *typicus*]
Gnathodus texanus ROUNDY 1926	[*texanus* — in *bilineatus*]
Pseudopolygnathus (triangulus) pinnatus VOGES 1959	[in upper *typicus* — in *anchoralis-latus*]
Scaliognathus anchoralis BRANSON & MEHL 1941	[base to near the top of *anchoralis-latus*]
Siphonodella obsoleta HASS	[in upper *duplicata* — ?in *isosticha* / upper *crenulata*]

<u>H 22: LCC2003: ci (8.3 — 10.0 (— ?Upper Carboniferous + reworked *Siphonodella* sp.))</u>

Gnathodus sp.	[? *isosticha*/ upper *crenulata* — early Namurian B ?]
Siphonodella sp.	[? Early *praesulcata* — ? *isosticha* / upper *crenulata*]
Posidonia sp.	

numerous other fossil remnants on bedding planes

---------- **Gap ? Firstly**, a facies change from deposition of debritic limestones/marls towards black shales with phosphate concretions occurs. **Secondly**, the facies change takes place within a (nowadays preserved) few cm compacted pelitic sediment pile. **Thirdly**, SANDBERG & GUTSCHICK 1984 established a model for the sedimentation of Lower Carboniferous deposits of the USA. They proposed the following environment/conditions for the genesis of marine phosphate-concretions: a) formation at or within the uppermost metres of the seafloor, b) water depth 30-500m, c) high P_2O_5-content of the pore-water, d) pH 7-8 and negative to enhanced negative Eh, e) at upper and lower boundaries of oxygen-minimum layers, f) enhanced salinity, g) reduced sedimentation rates within the basin (8.9-11.5 m / m.y.), h) warm, semi-arid to arid climate. Although sedimentation rates during the lowermost Lower Carboniferous within the eastern parts of the Rhenohercynian basin (generally 3-5m compacted sediment pile documented) seem to have been comparable to these in the USA, at this outcrop only 50cm are preserved. By assuming a concordant lithologic succession this fact would indicate a depositional environment at a slope of a submarine ridge within a starved basin during the whole lower Lower Carboniferous (at least till LCC2003: ci (8.3 — 10.0)). WALLISER (1996: 241) describes the pure Hangenberg shale as "very smooth and typically shows evidence of ductile deformation which suggests that the load by following sedimentation exceeded the degree of stabilization within the shale. By such slidings a mixture of different aged sediments and fossils may occur." This behaviour of the pelitic sediment pile would explain the apparent unconformities (undulating, differently dipping base) towards the bottom of the dark slates.

<u>H 21: LCC2003: ci 5.8 (5.0 — 6.7)</u>

Polygnathus purus purus VOGES 1959	[in *sulcata*— *sandbergi*]
? *Polygnathus radinus* COOPER 1939	[?]
Pseudopolygnathus cf. *fusiformis* BRANSON & MEHL	[? lower *crenulata* ?]
Pseudopolygnathus triangulus inaequalis VOGES 1959	[in lower *duplicata* — in *sandbergi*]
Pseudopolygnathus triangulus triangulus VOGES 1959	[in *sandbergi* — lower *crenulata*]

---------- **Fault ?** HENNINGSEN, 1965: 619 bottom, described a concordant succession: "While the upper limestone-beds at the [morphological] cliff as well as the uppermost layers at the quarry wall dip with ca. 20° towards the east, the lower beds of the cliff show a dip towards the north. In this way the impression is generated that there exists an angular unconformity between the lithologies of the lower and upper parts of the cliff. However, this discordance only apparently exists; it is generated by bending of the beds of the lower lithologies and slowly terminates towards the top of the succession." HENNINGSEN's observation concerning the different dip direction is confirmed by VOGT, but the interpretation as (?synsedimentary) bending of the lower lithologies without tectonic influence lacks proper evidence. What happens between H 20b and H 21? **Firstly**, there is an overlap in lifetime ranges for the conodont assemblages in both samples, so no biostratigraphic gap is evidencable. **Secondly**, during depositioning time of the whole succession from sample H 8 to H 19 sediment accumulation took place at a position proximal to the top of a submarine slope under a generally regressive trend; with deposition rates that succeed over erosion rates at the top of the submarine ridge (= former reef complex?; only interrupted by episodic submarine volcanic activity), since no reworked conodonts are observable in the samples. **Thirdly**, reworked conodonts from sediments deposited just before the deposition time of samples H 20 - 20b occur within the preserved conodont assemblage in grey marls. This is interpreted herein as documenting a sudden sea-level fall just before ("Hangenberg event", see below), inducing short-term conditions where erosion succeeds slightly over deposition; followed by a transgressive impulse (sea-level rise) with subsequent termination of biogenic limestone production at the top of the ridge and change from medium to low energy-environment (compare GIRARD 1994).

H 20b: DK1996: ds 19.6 — LCC2003: ci 6.7 (+ reworked (?) DK1996: ds 17.8 — 19.3)

Polygnathus [*communis*] *communis* BRANSON & MEHL 1934	[Early *postera* — ? in *texanus*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Polygnathus inornatus BRANSON 1934	[in Early *expansa*— *anchoralis-latus*]
Protognathodus (Gnathodus) kockeli BISCHOFF 1956	[Late *praesulcata* — in lower *crenulata*]
? *Spathognathodus stabilis* (BRANSON & MEHL 1934) [= ? *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus strigosus (BRANSON & MEHL 1934) [= *Mehlina strigosa* (BRANSON & MEHL 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]
? *Spathognathodus supremus* (ZIEGLER 1962) [= ? *Branmehla suprema* (ZIEGLER 1962)]	[near base Late *expansa* — near top Middle *praesulcata*]

H 20a: DK1996: ds 19.6 — LCC2003: ci 6.7 (+ reworked DK1996: ds 17.4 — 19.3)

Polygnathus [*communis*] *communis* BRANSON & MEHL 1934	[Early *postera* — ? in *texanus*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
? *Polygnathus inornatus* BRANSON 1934	[in Early *expansa*— *anchoralis-latus*]
Protognathodus (Gnathodus) kockeli BISCHOFF 1956	[Late *praesulcata* — in lower *crenulata*]
? *Spathognathodus aculeatus* (BRANSON & MEHL 1934) [= ? *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus inornatus (BRANSON & MEHL 1934) [= *Branmehla inornata* (BRANSON & MEHL 1934)]	[in Late *marginifera* — in Middle *expansa*]

H 20: DK1996: ds 19.6 — LCC2003: ci 4.1 (? 6.7) (+ reworked DK1996: ds 17.4 — 19.3)

Polygnathus [*communis*] *communis* BRANSON & MEHL 1934	[Early *postera* — ? in *texanus*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Polygnathus inornatus BRANSON 1934	[in Early *expansa*— *anchoralis-latus*]
? *Polygnathus purus subplanus* VOGES 1959	[in Late *praesulcata*— in upper *duplicata*]
Protognathodus (Gnathodus) kockeli BISCHOFF 1956	[Late *praesulcata* — in lower *crenulata*]
Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
? *Spathognathodus costatus costatus* (BRANSON 1934) [= ? *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus strigosus (BRANSON & MEHL 1934) [= *Mehlina strigosa* (BRANSON & MEHL 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]

---------- Hangenberg Event (not visible; compare WALLISER 1996:239-241). Sudden sea-level fall followed by a transgressive impulse (GIRARD 1994) with inflow of anoxic bottom waters. Termination of conodont genus *Palmatolepis*.

H 19: DK1996: ds 17.8 — 18.9

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis (deflectens) [*gracilis*] *sigmoidalis* (ZIEGLER 1962)	[in Late *trachytera* — in *sulcata*]
Polygnathus [*communis*] *communis* BRANSON & MEHL 1934	[Early *postera* — ? in *texanus*]
Pseudopolygnathus [*marburgensis*] *trigonicus* ZIEGLER 1962	[near base Late *expansa* — Early *praesulcata*]
? *Spathognathodus aculeatus* (BRANSON & MEHL 1934) [= ? *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]

Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus costatus spinulicostatus (BRANSON 1934) [= *Bispathodus costatus spinulicostatus* (BRANSON 1934)]	[in Middle *expansa* — Lower Carboniferous]
Spathognathodus (costatus) ultimus (BISCHOFF 1957) [= *Bispathodus ultimus* (BISCHOFF 1957)]	[near base mid. *expansa* — near top mid. *praesulcata*]
Spathognathodus supremus (ZIEGLER 1962) [= *Branmehla suprema* (ZIEGLER 1962)]	[near base Late *expansa* — near top Middle *praesulcata*]

<u>H 18: DK1996: ds 17.1 (?17.8) — 19.5</u>

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
? *Spathognathodus supremus* (ZIEGLER 1962) [= ? *Branmehla suprema* (ZIEGLER 1962)]	[near base Late *expansa* — near top Middle *praesulcata*]

<u>H 17: DK1996: ds 17.4 (?18.4) — 19.3</u>

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Pelekysgnathus sp.	[?]
? *Palmatolepis* [*gracilis*] *gonioclymeniae* (MÜLLER 1956)	[Late *expansa* — in Middle *praesulcata*]
Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
? *Spathognathodus costatus costatus* (BRANSON 1934) [= ? *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
? *Spathognathodus stabilis* (BRANSON & MEHL 1934) [= ? *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Kalloclymenia sp.	[?Middle — ? Late *expansa*]
Kalloclymenia pessoides FRECH	[?Middle — ? Late *expansa*]

<u>H 16: DK1996: ds 18.4 — 18.9</u>

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis (deflectens) [*gracilis*] *sigmoidalis* (ZIEGLER 1962)	[in Late *trachytera* — in *sulcata*]
Palmatolepis [*gracilis*] *gonioclymeniae* (MÜLLER 1956)	[Late *expansa* — in Middle *praesulcata*]
Polygnathus inornatus BRANSON 1934	[in Early *expansa* — *anchoralis-latus*]
Pseudopolygnathus [*marburgensis*] *trigonicus* ZIEGLER 1962	[near base Late *expansa* — Early *praesulcata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus costatus spinulicostatus (BRANSON 1934) [= *Bispathodus costatus spinulicostatus* (BRANSON 1934)]	[in Middle *expansa* — Lower Carboniferous]
Spathognathodus (costatus) ultimus (BISCHOFF 1957) [= *Bispathodus ultimus* (BISCHOFF 1957)]	[near base mid. *expansa* — near top mid. *praesulcata*]
Spathognathodus supremus (ZIEGLER 1962) [= *Branmehla suprema* (ZIEGLER 1962)]	[near base Late *expansa* — near top Middle *praesulcata*]

<u>H 15: DK1996: ds 17.4 (17.1 — 17.7)</u>

Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus inornatus (BRANSON & MEHL 1934) [= *Branmehla inornata* (BRANSON & MEHL 1934)]	[in Late *marginifera* — in Middle *expansa*]
Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Polygnathus [*communis*] *communis* BRANSON & MEHL 1934	[Early *postera* — ? in *texanus*]

---------- End of concordant succession; section prolonged at outcrop ca. 5m eastwards (HENNINGSEN 1965: 617)

<u>H 14: DK1996: ds 17.7 — 19.3</u>

Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]

? *Spathognathodus supremus* (Ziegler 1962) [= ? *Branmehla suprema* (Ziegler 1962)]	[near base Late *expansa* — near top Middle *praesulcata*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis [*gracilis*] *gonioclymeniae* (Müller 1956)	[Late *expansa* — in Middle *praesulcata*]
Polygnathus [*communis*] *communis* Branson & Mehl 1934	[Early *postera* — ? in *texanus*]

<u>H 13: DK1996: ds 17.4 — 19.3</u>

Spathognathodus costatus costatus (Branson 1934) [= *Bispathodus costatus costatus* (Branson 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus stabilis (Branson & Mehl 1934) [= *Bispathodus stabilis* (Branson & Mehl 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus strigosus (Branson & Mehl 1934) [= *Mehlina strigosa* (Branson & Mehl 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Polygnathus [*communis*] *communis* Branson & Mehl 1934	[Early *postera* — ? in *texanus*]

<u>H 12: DK1996: ds 16.8 — 18.4</u>

Spathognathodus jugosus (Branson & Mehl 1934) [= *Bispathodus jugosus* (Branson & Mehl 1934)]	[in Early — (?in) Late *expansa*]
Spathognathodus stabilis (Branson & Mehl 1934) [= *Bispathodus stabilis* (Branson & Mehl 1934)]	[Late *marginifera* — ?in *texanus*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]

<u>H 11: DK1996: ds 15.2 — 17.1</u>

Spathognathodus stabilis (Branson & Mehl 1934) [= *Bispathodus stabilis* (Branson & Mehl 1934)]	[Late *marginifera* — ?in *texanus*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi Müller 1956	[Latest *crepida* — Late *expansa*]
Polygnathus styriacus Ziegler 1957	[Early *postera* — Early *expansa*]

<u>H 10: DK1996: ds 13.6 (?16.8) — 16.8</u>

? *Spathognathodus jugosus* (Branson & Mehl 1934) [= ? *Bispathodus jugosus* (Branson & Mehl 1934)]	[in Early — (?in) Late *expansa*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis minuta n . subsp. Ziegler 1962	[Early *rhomboidea* — Late *postera*]
Palmatolepis perlobata schindewolfi Müller 1956	[Latest *crepida* — Late *expansa*]
Polygnathus granulosus Ulrich & Bassler 1926	[in Latest *marginifera* — in Early *expansa*]

<u>H 9: DK1996: ds 15.2 — 16.5</u>

Palmatolepis minuta n . subsp. Ziegler 1962	[Early *rhomboidea* — Late *postera*]
Palmatolepis perlobata schindewolfi Müller 1956	[Latest *crepida* — Late *expansa*]
Polygnathus styriacus Ziegler 1957	[Early *postera* — Early *expansa*]

<u>H 8: DK1996: ds 11.9 — 13.9</u>

? *Palmatolepis* [*glabra*] *distorta* (Branson & Mehl 1934)	[Early *marginifera* — in Early *trachytera*]
Polygnathus diversus Helms 1961	[Early — Latest *marginifera*]

---------- Fault (Henningsen 1965: 617)

<u>H 7: DK1996: ds 13.9 — 15.2</u>

Palmatolepis minuta minuta Branson & Mehl 1934	[Late *triangularis* — Latest *marginifera*]
Palmatolepis perlobata (rugosa) grossi (Ziegler 1960)	[in Late *marginifera* — Late *trachytera*]
Palmatolepis perlobata schindewolfi Müller 1956	[Latest *crepida* — Late *expansa*]
Palmatolepis rugosa trachytera Ziegler 1960	[Early — Late *trachytera*]
Polygnathus sp.	[?]

<u>H 6: DK1996: ds 13.6 — 13.9 (? + reworked DK1996: ds 11.9 — 12.6)</u>

Spathognathodus inornatus (Branson & Mehl 1934) [= *Branmehla inornata* (Branson & Mehl 1934)]	[in Late *marginifera* — in Middle *expansa*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis minuta minuta Branson & Mehl 1934	[Late *triangularis* — Latest *marginifera*]
Palmatolepis perlobata schindewolfi Müller 1956	[Latest *crepida* — Late *expansa*]
? *Polygnathus foliatus* Bryant 1921	[upper Middle Devonian — Latest *crepida*]

Polygnathus granulosus Ulrich & Bassler 1926	[in Latest *marginifera* — in Early *expansa*]
? *Polygnathus pennatuloideus* Holmes 1928	[Early *marginifera* — near base Late *marginifera*]

H 5: DK1996: ds 12.9 (?13.6) — 15.2 (+ reworked DK1996: ds 10.6 — 12.6)

Henningsen lists **?** *P. r. ampla* and **cf.** *P. (c.) communis*, 2 conodonts which would indicate an age of: ds 15.5 — 18.0 and therefore declare all other listed conodonts to be reworked.

Spathognathodus stabilis (Branson & Mehl 1934) [= *Bispathodus stabilis* (Branson & Mehl 1934)]	[Late *marginifera* — ?in *texanus*]
? *Spathognathodus bohlenanus* (Helms 1961) [= ? *Branmehla bohlenana* (Helms 1961)]	[in Latest *marginifera* — in Early *expansa*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata (rugosa) grossi (Ziegler 1960)	[in Late *marginifera* — Late *trachytera*]
Palmatolepis perlobata schindewolfi Müller 1956	[Latest *crepida* — Late *expansa*]
? *Palmatolepis rugosa ampla* Müller 1956	[in Early *postera* — in Late *expansa*]
cf. *Polygnathus* [*communis*] *communis* Branson & Mehl 1934	[Early *postera* — ? in *texanus*]
Polygnathus glabra glabra Ulrich & Bassler 1926	[Early *rhomboidea* — Early *marginifera*]
Polygnathus nodoundatus Helms 1961	["middle *Prolobites* substage, middle toIII", Late *trachytera*, only preliminary stratigraphic data from Helms 1961 were available]
Polygnathus pennatuloideus Holmes 1928	[Early *marginifera* — near base Late *marginifera*]
Pseudopolygnathus sp.	[?]

---------- Fault ? (Henningsen 1965: 617)

H 4: DK1996: ds 15.2 — 16.5

Spathognathodus stabilis (Branson & Mehl 1934) [= *Bispathodus stabilis* (Branson & Mehl 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus werneri (Ziegler 1962) [= *Branmehla werneri* (Ziegler 1962)]	[Early *marginifera* — Early *expansa*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis minuta n . subsp. Ziegler 1962	[Early *rhomboidea* — Late *postera*]
cf. *Palmatolepis* [*perlobata*] *helmsi* (Ziegler 1962)	[Early *trachytera* — in Middle *expansa*]
Polygnathus styriacus Ziegler 1957	[Early *postera* — Early *expansa*]

H 3: DK1996: ds 17.8 — 18.9

Spathognathodus aculeatus (Branson & Mehl 1934) [= *Bispathodus aculeatus* (Branson & Mehl 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus costatus costatus (Branson 1934) [= *Bispathodus costatus costatus* (Branson 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus stabilis (Branson & Mehl 1934) [= *Bispathodus stabilis* (Branson & Mehl 1934)]	[Late *marginifera* — ?in *texanus*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Pseudopolygnathus [*marburgensis*] *trigonicus* Ziegler 1962	[near base Late *expansa* — Early *praesulcata*]

H 2: DK1996: ds 17.4 — 19.3

Spathognathodus (costatus) ultimus (Bischoff 1957) [= *Bispathodus ultimus* (Bischoff 1957)]	[near base mid. *expansa* — near top mid. *praesulcata*]
Spathognathodus costatus costatus (Branson 1934) [= *Bispathodus costatus costatus* (Branson 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Palmatolepis (deflectens) [*gracilis*] *sigmoidalis* (Ziegler 1962)	[in Late *trachytera* — in *sulcata*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Polygnathus [*communis*] *communis* Branson & Mehl 1934	[Early *postera* — ? in *texanus*]

H 1: DK1996: ds 17.4 — 19.3

Spathognathodus costatus costatus (Branson 1934) [= *Bispathodus costatus costatus* (Branson 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Polygnathus [*communis*] *communis* Branson & Mehl 1934	[Early *postera* — ? in *texanus*]

Remarks: revised stratigraphic range: assumed concordant lithologic succession from the late Famennian to the early Viséan (Early ***marginifera*** — in ***bilineatus***-zone). DK1996: ds: 11.9 — LCC2003: ci 17.5 (in parts with reworked late Famennian and Lower Carboniferous faunas; see above).

Presumable sedimentary environment: Deposition at a proximal position of the slope of a submarine ridge. Main constituent of the sedimentary facies within the late Famennian is clay-silt (greenish and reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (marls, limestones, calcareous nodules). Repeated (discyclic?) influx of fine-grained reworked tuffs and reworked pyroclastic deposits, due to episodic submarine volcanic activity. Moderate late Famennian regressive trend evidenced by continuous carbonate production at the ridge top in spite of apparently constant subsidence rates with no reworking of older conodont-bearing deposits. Short-termed rapid sea-level fall during Middle *praesulcata* zone, followed by (?sudden) influx of anoxic bottom waters (Hangenberg event). Continuous sea-level rise during the lower Lower Carboniferous within a starved basin. Due to submarine volcanic activity buildup of new (or reactivation of old) submarine ridges in the *anchoralis*-*latus*-zone and in the early Viséan with carbonate production at the tops. Subsequent deposition of crinoid-limestone debris in the form of turbidites at the slope or within the basin.

F 1.7 KEGLER 1967

Sample: K 0 **Quotation:** KEGLER 1967c, p. 27 bottom
Gauss-Kruger-coordinates: ^{34}31445 - ^{55}80240
Location: west of Holzheim, geological map 1:25000, 5614 Limburg.
Lithology: nodules of a black, medium-grained limestone in bluegrey to black, fissile slates, which also contain sandstone beds and cherty nodules (Kieselgallen). See fig. F 1.1 and F 1.2.
Stratigraphic correlation: Middle Adorfian
Fossils: (det. by KEGLER)

Entomis [= *Entomozoe*] *(Nehdentomis) pseudorichterina* (MATERN 1929) RABIEN 1954	[*Bertilonella (Waldeckella)* ***cicatricosa/*** *Ungerella (Franklinella)* ***torleyi*** — ? *Entomoprimitia* ***splendens***]
Richterina (Volkina) zimmermanni (VOLK 1939) RABIEN 1954	[*Bertilonella (Waldeckella)* ***cicatricosa*** — *Entomoprimitia* ***splendens***]
Spathognathodus sannemanni sannemanni (BISCHOFF & ZIEGLER 1957) [= *Ozarkodina sannemanni sannemanni* (BISCHOFF & ZIEGLER 1957)]	[(uppermost Givetian —) *falsiovalis* — in *punctata*]

Ostracodes and styliolins are pyritised.
Remarks: revised to ***punctata*** (— **Early *hassi*** ?) -zone (DK1996: ds: 1.7 — 2.3 (— 2.9 ?)). By assuming that *Ozarkodina sannemanni sannemanni* is not reworked and by considering the lifetime of the ostracodes. Due to improper information KEGLERs sample location could not be recovered. It has to be reminded that silt/sand-sized reworked pyroclastic deposits are not uncommon in the whole region. A similar lithologic succession directly at the street shows at its northern end also minor intercalations of small calcareous nodules - but no sandstone beds. Cherty parts in these slates show - due to their massive appearance - striking similarities to finegrained quartzose sandstone pseudonodules.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge.

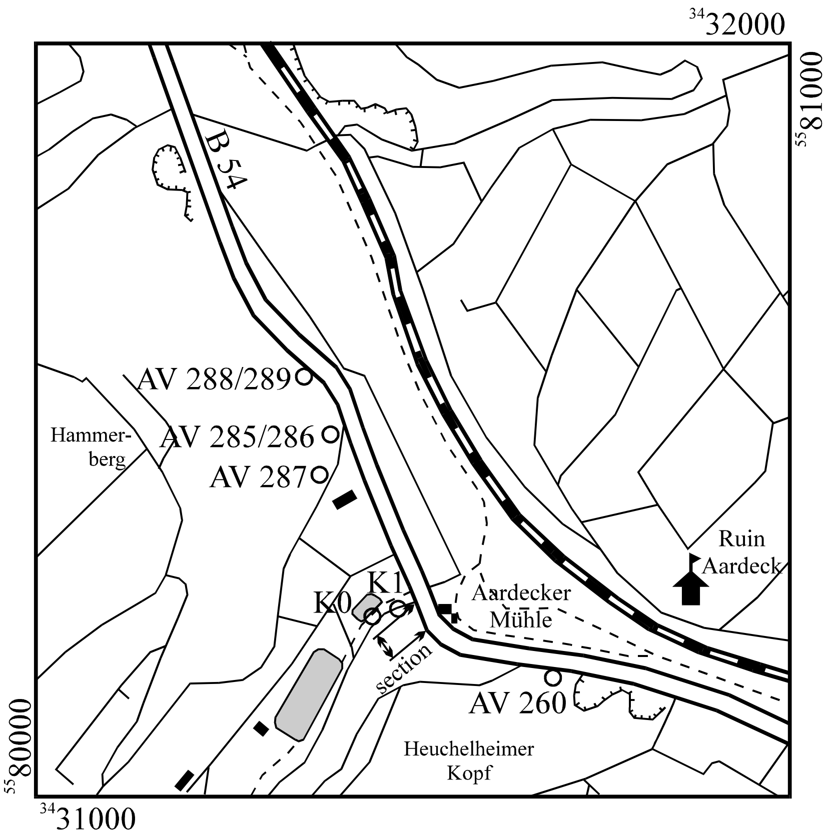


Fig. F 1.1: Topographical map 1:10000, showing the locations for samples K0 and K1, for samples taken by VOGT (AV) and the position of the geological section used for the fractal analysis (see chapt. C 11). Magnification of the topographical map 1:25000, TK 5614 Limburg.

Sample: K 1 **Quotation:** KEGLER 1967c, p. 28 top + table p. 37
Gauss-Kruger-coordinates: $^{34}31480$ - $^{55}80250$
Location: west of Holzheim, geological map 1:25000, 5614 Limburg.
Lithology: Bluegrey to black, fissile slates, with intercalations of calcareous nodules/limestone beds, sandstone beds and cherty nodules (Kieselgallen). Sample was taken from a 15 - 20 cm thick, darkgrey, fine- to medium grained limestone bed, which follows above the sandstone bed. See fig. F 1.1 and F 1.2.
Stratigraphic correlation: lower *crepida* ***crepida*** - zone (to II α [Nehdenian]?)
Fossils: (conodonts, det. by KEGLER)

Polygnathus glabra glabra ULRICH & BASSLER 1926	[Early *rhomboidea* — Early *marginifera*]
Palmatolepis quadrantinodosalobata SANNEMANN 1955	[Early *crepida* — in Early *rhomboidea*]
Palmatolepis minuta minuta BRANSON & MEHL 1934	[Late *triangularis* — Latest *marginifera*]
Palmatolepis cf. *regularis* (COOPER 1931, ZIEGLER 1962)	[Late *triangularis* — Late *marginifera*]
Palmatolepis crepida crepida SANNEMANN 1955	[(in Late *triangularis)* Early — Latest *crepida*]
Palmatolepis perlobata perlobata ULRICH & BASSLER 1926	[Late *triangularis* — Latest *crepida*]
Icriodus cornutus SANNEMANN 1955	[in Middle *triangularis* — Latest *crepida*]
Ancyrognathus sinelaminus (BRANSON & MEHL 1934) ZIEGLER 1962	[Middle *triangularis* — Latest *crepida*]
Palmatolepis subperlobata BRANSON & MEHL 1934	[in Early *triangularis* — Latest *crepida*]
Palmatolepis triangularis SANNEMANN 1955	[Early *triangularis* — Early *crepida*]
Polygnathus normalis MILLER & YOUNGQUIST 1947	[upper Middle Devonian — Late *triangularis*]
Ancyrodella curvata (BRANSON & MEHL 1934) ZIEGLER 1958	[Early *hassi* — in *linguiformis*]
Palmatolepis [*gigas*] *gigas* MILLER & YOUNGQUIST 1947	[in Early *rhenana* — in *linguiformis*]

Remarks: revised to middle Nehdenian (**Early *rhomboidea*-**zone, DK1996: ds: 10.5 — 11.3). With two redeposited ghost-faunas from the A) lower Nehdenian, (**Late *triangularis* — Early *crepida*** -zone, DK1996: ds: 7.5 — 8.7) and B) upper Adorfian (toI γ/δ, **Early *rhenana* — *linguiformis*** zone, DK1996: ds: 4.2 — 6.1). Due to improper information KEGLERS sample location was difficult to recover (compare fig. F 1.2 and chapt. C 7, AV 301). It has to be reminded that silt/sand-sized reworked pyroclastic deposits are not uncommon in the whole region. A similar lithologic succession directly at the street shows at its northern end also minor intercalations of small calcareous

nodules - but no sandstone beds. Cherty parts in these slates show - due to their massive appearance - striking similarities to finegrained quartzose sandstone pseudonodules.
Compare description and interpretation for thin section AV 301.
Presumable sedimentary environment: Deposition near the base of a basinal slope (basinal palmatolepid biofacies). Erosion of lower Nehdenian and upper Adorfian deposits nearby. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge. Redeposited conodonts like *A. curvata, P. normalis* perhaps indicate a former depositional region at a higher position of the slope (? polygnathid-ancyrodellid biofacies).

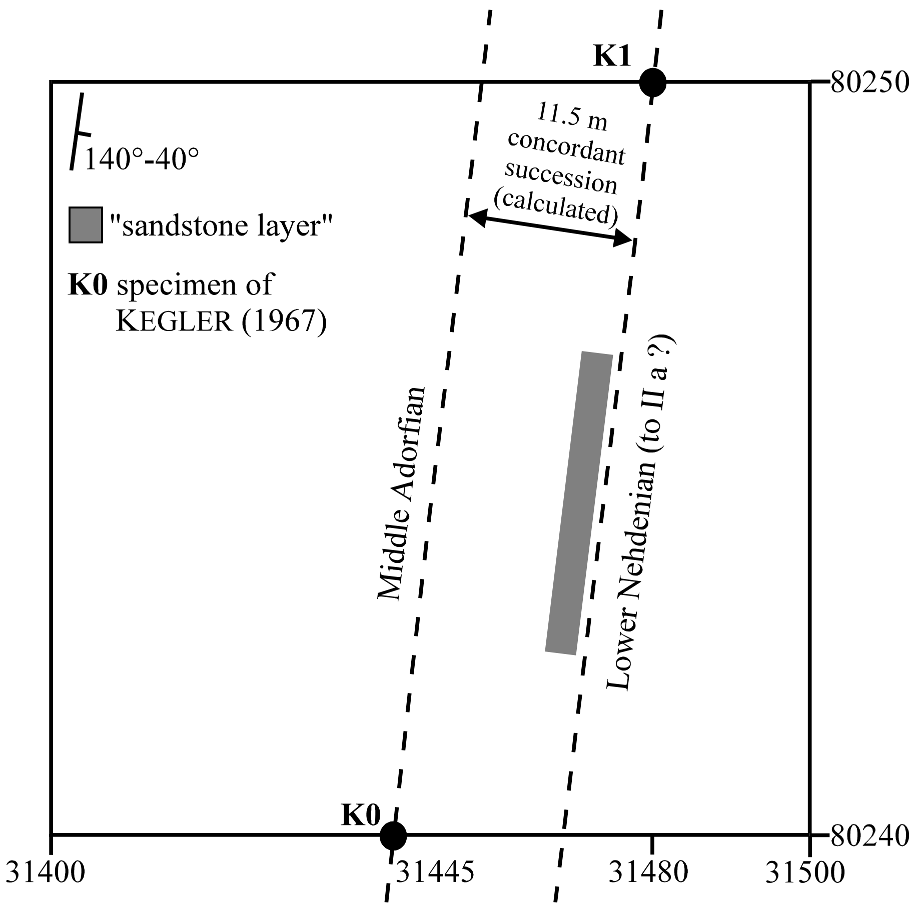


Fig. F 1.2: Sketch map 1:10000, showing the reconstructed locations for samples K0 and K1 with their relative position to each other in order to find the "sandstone layer" mentioned by KEGLER 1967 (K1).

Sample: K 2 **Quotation:** KEGLER 1967c, p. 28 top + table p. 37
Gauss-Kruger-coordinates: ^{34}34020 - ^{55}83590
Location: Eastern hillside of Greifenberg, geological map 1:25000, 5614 Limburg.
Lithology: Bluegrey to black, fissile slates, with intercalations of calcareous nodules/limestone beds, sandstone beds and cherty nodules (Kieselgallen). Besides of black finegrained calcareous nodules also brightgrey dense calcareous nodules occur.
Stratigraphic correlation: upper *Palmatolepis crepida* ***crepida***-zone — **lower** *Palmatolepis* ***quadrantinodosa***-zone (high to II [Nehdenian] - III [Hembergian])
Fossils: (conodonts, det. by KEGLER, from the brightgrey calcareous nodules)

Palmatolepis glabra glabra ULRICH & BASSLER 1926	[Early *rhomboidea* — Early *marginifera*]
Palmatolepis glabra pectinata ZIEGLER 1960	[Latest *crepida* — Late *marginifera*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]

From the black calcareous nodules only indeterminable remnants of *Icriodus* sp. and *Spathognathodus* [= *Ozarkodina /Bispathodus*] sp. had been gained.

Remarks: revised to middle — early upper Nehdenian (**Early *rhomboidea* — Early *marginifera*** -zone, DK1996: ds: 10.5 — 12.6). Gauss-Kruger-coordinates indicate a sample location at the southwest hillside. Due to improper information and renaturation measures in this former mining area KEGLERS sample location could not be recovered. Ca. 30m uphill this location along a Kreuzweg (pilgrims path) Lower Carboniferous (cu I) slates (compare sample AV 297) appear near the Kreuz-Chapel. Since KEGLER assumes the lithology at this locality to be equal to that of K0 and K1.
Presumable sedimentary environment: Deposition near the base of a basinal slope (basinal palmatolepid biofacies). Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris and finesand from higher parts of the submarine ridge.

Sample: K 3 **Quotation:** KEGLER 1967c, p. 28 mid
Gauss-Kruger-coordinates: ^{34}37810 - ^{55}87200
Location: within the village Steeden, behind the bus stop, near the pub (geological map 1:25000, 5514 Hadamar).
Lithology: fissile, greyblack slates, which sometimes also show greenish and reddish colours. Therein nodules of a grey, dense limestone.
Stratigraphic correlation: *Polygnathus* ***styriacus*** - zone (to IV/V [upper Hembergian/Dasbergian])
Fossils: (conodonts, det. by KEGLER, from the calcareous nodules)

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Palmatolepis [*perlobata*] *(rugosa) postera* (ZIEGLER 1960)	[Early *postera* — Early *expansa*]
Polygnathus styriacus ZIEGLER 1957	[Early *postera* — Early *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934)	[Late *marginifera* — in *texanus*]
[= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	

Remarks: stratigraphic correlation confirmed as uppermost Hembergian — Dasbergian (**Early** *Pa. perlobata)* ***postera*** — **Early** (*Pa. gracilis)* ***expansa*** -zone, DK1996: ds: 15.2 — 17.1). KEGLER 1967 interpreted these slates as time-equivalent transitional (slope-) facies between the Schalstein-Massenkalk (pyroclastic deposits-reef limestone)-ridge near Steeden and the Gaudernbach "special" basin. The ridge facies, which had been firstly described by HENNINGSEN 1965, should be represented by a succession of fossiliferous, coloured (red-green-grey) limestones and greenish-reddish lutites (slates & marls). Due to KEGLER the deepest part of the basinal facies ought to consist of dark slaty, sandy and cherty sediments which occur along the street between the village Steeden and the creek Kerkerbach.
In 1929 MICHELS interpreted the slates from this location as part of the Upper Devonian "Cypridinenschiefer"-formation. KEGLER 1967 related the term "Cypridinenschiefer" (at least at this location) only to its lithological appearance as typical slope facies; no clear stratigraphic correlation should therefore be obtainable. The lithological succession at this location was supposed to show facies transitions between "Cypridinenschiefer" and the "Gaudernbacher Schichten".
A new investigation of the outcrop by VOGT lead to a revised interpretation. At this location mostly reddish, partly greyblack and some greenish slates occur. Up to ca. 20 cm thick grey, dense cherty nodules and limestone nodules of sometimes more than 1 m lateral extension are intercalated in this succession.
The slaty succession between Steeden and Kerkerbach, which should - in the eyes of KEGLER - represent the deepest parts of the basinal facies, is mostly of Lower Devonian (Emsian) age.
Presumable sedimentary environment: Deposition of clay in an iron-rich water column (due to enhanced volcanic activity) near the base of a slope with turbiditic intercalations of carbonate mud from higher parts of the slope - maybe even from the top of the submarine ridge.

Sample: K 4 **Quotation:** KEGLER 1967c, p. 28 bottom
Gauss-Kruger-coordinates: ^{34}37940 - ^{55}85430
Location: left steep bank of the river Lahn, ca. 100 m westwards of railway bridge (geological map 1:25000, 5514 Hadamar).
Lithology: strongly folded, greyblack banded slates with calcareous nodules, which are partly regularly distributed within the succession in that way, that one can call them "Kalkknotenschiefer" ("limestone-knots slate"). Towards the top of the succession appear ca. 1 m thick black flinty pelites.
Stratigraphic correlation: lower *Palmatolepis crepida* ***crepida*** - zone (to II α [Nehdenian] ?)
Fossils: (conodonts, det. by. KEGLER, from the calcareous nodules)

Ancyrolepis cruciformis ZIEGLER 1959	[Early — in Middle *crepida*]
Palmatolepis crepida crepida SANNEMANN 1955	[(in Late *triangularis)* Early — Latest *crepida*]
Palmatolepis minuta minuta BRANSON & MEHL 1934	[Late *triangularis* — Latest *marginifera*]
Palmatolepis quadrantinodosalobata SANNEMANN 1955	[Early *crepida* — in Early *rhomboidea*]
Palmatolepis subperlobata BRANSON & MEHL 1934	[in Early *triangularis* — Latest *crepida*]
Palmatolepis tenuipunctata SANNEMANN 1955	[Late *triangularis* — Latest *crepida*]
Palmatolepis triangularis SANNEMANN 1955	[Early *triangularis* — Early *crepida*]

Remarks: stratigraphic correlation confirmed as lower Nehdenian (**Early *crepida*** -zone, DK1996: ds: 8.0 — 8.7). Strongly tectonised/faulted lithologic succession. Since no concordant lithologic succession is provable the correlation of the deposition-time for the flinty pelites into the Nehdenian is out of evidence. Late Tournaisian flinty slates acted often as fault/thrust-planes ("facies-bound tectonics") in the vicinity of the Dietkirchen-Schupbach Massenkalk-zone.

Presumable sedimentary environment: Deposition near the base of a basinal slope (basinal palmatolepid biofacies). Main constituent of the sedimentary facies is clay-silt with frequent intercalations of calcareous debris from higher parts of the submarine ridge.

Sample: K 5 **Quotation:** Kegler 1967c, p. 28 bottom
Gauss-Kruger-coordinates: ^{34}42400 - ^{55}89730
Location: left bank of Kerkerbach between Eschenau and Christianshütte (geological map 1:25000, 5515 Weilburg).
Lithology: grey to deepblack calcareous nodules and thin limestone beds up to 10 cm thickness in dark, brownish weathering slates, which bear sandy intercalations.
Stratigraphic correlation: lower *Scaphignathus velifer* ***velifer*** - zone (high to III α [Hembergian])
Fossils: (conodonts, det. by Kegler, from the limestones)

Palmatolepis rugosa ampla Müller 1956	[in Early *postera* — in Late *expansa*]
Palmatolepis [*perlobata*] *(rugosa) postera* (Ziegler 1960)	[Early *postera* — Early *expansa*]
Polygnathus perplexus (Thomas 1949)	[Late *trachytera* — in Late *expansa*]
Polygnathus nodoundatus Helms 1961	["middle *Prolobites* substage, middle toIII", Late *trachytera*, only preliminary stratigraphic data from Helms 1961 were available]
Polygnathus granulosus Ulrich & Bassler 1926	[in Latest *marginifera* — in Early *expansa*]
Scaphignathus [*velifer*] *velifer* Ziegler 1960	[Latest *marginifera* — Late *trachytera*]
Palmatolepis perlobata (rugosa) grossi (Ziegler 1960)	[in Late *marginifera* — Late *trachytera*]
Spathognathodus stabilis (Branson & Mehl 1934) [= *Bispathodus stabilis* (Branson & Mehl 1934)]	[Late *marginifera* — in *texanus*]
Polygnathus glabra bilobata Ziegler 1962	[Late *marginifera* — in Early *trachytera*]
Palmatolepis glabra elongata Holmes 1928	[Early *marginifera* — ? in Late *trachytera*]
Palmatolepis [*glabra*] *distorta* (Branson & Mehl 1934)	[Early *marginifera* — in Early *trachytera*]
Palmatolepis deflectens deflectens Müller 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi Müller 1956	[Latest *crepida* — Late *expansa*]
Palmatolepis minuta minuta Branson & Mehl 1934	[Late *triangularis* — Latest *marginifera*]
Palmatolepis perlobata perlobata Ulrich & Bassler 1926	[Late *triangularis* — Latest *crepida*]

Remarks: revised to "uppermost Hembergian", (to IV, **Early** (*Pa. rugosa)* ***postera*** -zone, DK1996: ds: 15.2 — 15.8). With two ghost faunas: A) middle Hembergian, to III/IV (**Latest *marginifera* — Early** (*Pa. rugosa)* ***trachytera*** - zone, DK1996: ds: 13.3 — 14.5) and B) lower Nehdenian (**Late *triangularis* — Latest *crepida*** -zone, DK1996: ds: 7.5 — 10.5).
Presumable sedimentary environment: Deposition near the base of a basinal slope (? basinal palmatolepid biofacies). Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (which was probably reworked several times at the slope due to seismic activity) and fine-grained pyroclastic deposits from higher parts of the submarine ridge.

Sample: K 6 **Quotation:** Kegler 1967c, p. 32 mid
Gauss-Kruger-coordinates: ^{34}41180 - ^{55}88820
Location: small outcrop in the forest above the forest path between Hofen and Eschenau, at the left bank of the Kerkerbach (geological map 1:25000, 5515 Weilburg).
Lithology: platy to bedded grey crinoid limestone.
Stratigraphic correlation: *Scaliognathus* ***anchoralis*** - zone (cu II β/γ)
Fossils: (conodonts, det. by Kegler)

Gnathodus commutatus commutatus (Branson & Mehl 1941) [= *Paragnathodus commutatus commutatus* Higgins 1975]	[in *texanus* — in *bilineatus*]
Gnathodus [*commutatus*] *homopunctatus* (Ziegler)	[in *anchoralis* — in *bilineatus*]
Gnathodus delicatus Branson & Mehl 1938	[*isosticha* / upper *crenulata* — ? in *anchoralis-latus*]
Gnathodus punctatus (Cooper 1939)	[*isosticha* / upper *crenulata* — in lower *typicus*]

Remarks: revised stratigraphic range: lower Viséan (cu II γ -— cu III α; Arundian — Asbian; Erdbacher Kalk type III sensu Krebs (1968); in (*Gnathodus)* ***texanus*** -zone — in ***bilineatus*** -zone). LCC2003: ci: 14.1 — 17.5. *Gnathodus delicatus* and *Gnathodus punctatus* are probably reworked and redeposited specimens with a lifetime in cu II α-β (Ivorian, LCC2003: ci: 8.3 — 10.3.).
Presumable sedimentary environment: Deposition near the base of a basinal slope. Main constituent of the sedimentary facies is clay-silt with intercalations of (turbiditic) calcareous debris from higher parts of the submarine ridge. Since reworked conodonts with a lifetime well before the first described occurrence of "Erdbacher Kalk, type I" appear within the calcareous debris, it seems probable that unlithified sediments of that age were incorporated into the calcareous debris flow on its way downslope.

Sample: K 7 **Quotation:** KEGLER 1967c, p. 33 mid
Gauss-Kruger-coordinates: ^{34}40870 - ^{55}88710
Location: C. 200 m westwards of Kerkerbach between Hofen and Eschenau (geological map 1:25000, 5515 Weilburg). Equivalent sample-locality "Eschenau 1" of WALLISER 1960.
Lithology: bright flaser-limestone, partly with chilled margins, as fillings in interstitials of (Deck-) pillow-diabas-breccias.
Stratigraphic correlation, fauna I: upper *Palmatolepis* ***triangularis*** — **Middle** *Palmatolepis crepida* ***crepida*** - zone (toI/II — to IIα [Adorfian/Nehdenian])
Fossils: (conodonts, det. by KEGLER, from bright flaser-limestone with a 2-3 mm thick chilled margin)
Palmatolepis cf. *regularis* (COOPER 1931, ZIEGLER 1962) [Late *triangularis* — Late *marginifera*]
Palmatolepis tenuipunctata SANNEMANN 1955 [Late *triangularis* — Latest *crepida*]
Palmatolepis triangularis SANNEMANN 1955 [Early *triangularis* — Early *crepida*]
Polygnathus normalis MILLER & YOUNGQUIST 1947 [upper Middle Devonian — Late *triangularis*]
Stratigraphic correlation, fauna II: ***anchoralis*** - zone (cu II β/γ)
Fossils: (conodonts from bright flaser-limestone without chilled margin)
Gnathodus texanus ROUNDY 1926 [*texanus* — in *bilineatus*]
Gnathodus semiglaber (BISCHOFF 1957) [in *isosticha* / upper *crenulata* — in *bilineatus*]
Remarks: A) revised stratigraphic range for fauna I: lowermost Nehdenian (to IIα; **Late *triangularis*** -zone, DK1996: ds: 7.5 — 8.0), B) revised stratigraphic range for fauna II: lower Viséan (cu II γ -— cu III α; Chadian — Asbian; (*Gnathodus)* ***texanus*** -zone — in (*Gnathodus)* ***bilineatus*** -zone). LCC2003: ci: 13.3 — 17.5.
Presumable sedimentary environment: submarine basic volcanic activity, development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments.

Sample: K 8 **Quotation:** KEGLER 1967c, p. 33 bottom
Gauss-Kruger-coordinates: ^{34}41020 - ^{55}88740
Location: C. 100 m westwards of the Kerkerbach, at the street between Eschenau and Hofen (geological map 1:25000, 5515 Weilburg). Equivalent to sample-locality "Eschenau 2" of WALLISER 1960.
Lithology: limestone fragment in pillow-diabas-breccia.
Stratigraphic correlation: *Scaliognathus* ***anchoralis*** - zone (cu II β/γ)
Fossils: (conodonts, det. by KEGLER, from the limestone fragments)
Gnathodus texanus ROUNDY 1926 [*texanus* — in *bilineatus*]
Gnathodus semiglaber (BISCHOFF 1957) [in *isosticha* / upper *crenulata* — in *bilineatus*]
Hindeodella segaformis (BISCHOFF 1957) [base to near the top of *anchoralis-latus* zone]
Palmatolepis deflectens deflectens MÜLLER 1956 [*rhomboidea* — ? in *praesulcata*]
Remarks: revised stratigraphic range: lower Viséan (cu II γ -— cu III α; Chadian — Asbian; (*Gnathodus)* ***texanus*** -zone — in (*Gnathodus)* ***bilineatus*** -zone). LCC2003: ci: 13.3 — 17.5. Due to KEGLER *Palmatolepis deflectens deflectens* MÜLLER 1956 (DK1996: ds: 10.5 — ? 19.5) is reworked. If the lifetime of *Hindeodella segaformis* really terminates just below the top of the *anchoralis-latus* zone (cu II β; LCC2003: ci: 11.7 — 13.1) this conodont also must have been reworked.
Presumable sedimentary environment: submarine basic volcanic activity, development of pillow basalts with inclusions of syngenetic soft sediments.

Sample: K 9 **Quotation:** KEGLER 1967c, p. 33 top
Gauss-Kruger-coordinates: ^{34}40970 - ^{55}88380
Location: at the right bank of the Kerkerbach (geological map 1:25000, 5515 Weilburg).
Lithology: dark slates with black calcareous nodules.
Stratigraphic correlation: cu II β/γ-δ
Fossils: (conodonts, det. by KEGLER, from the calcareous nodules)
Gnathodus commutatus commutatus (BRANSON & MEHL 1941) [in *texanus* — in *bilineatus*]
[= *Paragnathodus commutatus commutatus* HIGGINS 1975]
Gnathodus [*commutatus*] *homopunctatus* (ZIEGLER) [in *anchoralis-latus* — in *bilineatus*]
Remarks: revised stratigraphic range: lower Viséan (cu II γ -— cu III α; Arundian — Asbian; in (*Gnathodus)* ***texanus*** -zone — in ***bilineatus*** -zone). LCC2003: ci: 14.1 — 17.5.
Presumable sedimentary environment: Deposition near the base of a basinal slope. Main constituent of the sedimentary facies is clay-silt with intercalations of (turbiditic) calcareous debris from higher parts of the submarine ridge.

Sample: K 10 **Quotation:** KEGLER 1967c, p. 32 middle
Gauss-Kruger-coordinates: ^{34}40980 - ^{55}88480
Location: at the right bank of the Kerkerbach (geological map 1:25000, 5515 Weilburg).
Lithology: ca. 2m thick grey crinoid limestone with high content of volcano-clastic material. The limestone is situated within a diabas-pillow breccia and therefore maybe an allochthonous fragment.
Stratigraphic correlation: cu II β/γ
Fossils: (conodonts, det. by KEGLER, from the calcareous nodules)

Geniculatus glottoides VOGES 1959	[?]
Gnathodus commutatus commutatus (BRANSON & MEHL 1941) [= *Paragnathodus commutatus commutatus* HIGGINS 1975]	[in *texanus* — in *bilineatus*]
Gnathodus [*commutatus*] *homopunctatus* (ZIEGLER)	[in *anchoralis-latus* — in *bilineatus*]

Remarks: revised stratigraphic range: lower Viséan (cu II γ -— cu III α; Arundian — Asbian; Erdbacher Kalk type III; in (*Gnathodus) **texanus*** -zone — in ***bilineatus*** -zone). LCC2003: ci: 14.1 — 17.5.
Presumable sedimentary environment: Deposition near the base of a basinal slope. Main constituent of the sedimentary facies is clay-silt with intercalations of (turbiditic) calcareous debris from higher parts of the submarine ridge. Submarine basic volcanic activity, development of pillow-basalts with inclusions of (?) syngenetic soft sediments.

Sample: K 11 **Quotation:** KEGLER 1967c, p. 33 bottom
Gauss-Kruger-coordinates: ^{34}41110 - ^{55}88610
Location: C. 100 m eastwards of the Kerkerbach, near the forest track between Eschenau and Hofen (geological map 1:25000, 5515 Weilburg). Equivalent to sample-locality "Eschenau 3" of WALLISER 1960.
Lithology: red flaser-bedded limestone fragments (of cephalopod-limestone type) up to ca. 30 cm as ejecta in pyroclastic deposits (Bombenschalstein = "bomb-pyroclastics").
Stratigraphic correlation: *Scaliognathus* ***anchoralis*** - zone (cu II β/γ)
Fossils: (conodonts, det. by KEGLER, from the limestone fragments)

Gnathodus delicatus BRANSON & MEHL 1938	[*isosticha* / upper *crenulata* — ? in *anchoralis-latus*]
Gnathodus texanus ROUNDY 1926	[*texanus* — in *bilineatus*]
Hindeodella segaformis (BISCHOFF 1957)	[base to near the top of *anchoralis-latus* zone]
Pseudopolygnathus (triangulus) pinnatus VOGES	[in upper *typicus* — in *anchoralis-latus*]
Scaliognathus anchoralis BRANSON & MEHL 1941	[base to near the top of *anchoralis-latus*]

Remarks: revised stratigraphic range: lower Viséan (cu II γ -— cu III α; Chadian — Asbian; (*Gnathodus) **texanus*** -zone — in (*Gnathodus) **bilineatus*** -zone), due to *G. texanus*. LCC2003: ci: 13.3 — 17.5. With reworked conodonts from the *anchoralis-latus* zone (cu II β; LCC2003: ci: 11.7 — 13.1).
Presumable sedimentary environment: submarine basic volcanic activity, explosive ejection of pyroclastic deposit material with inclusions of contemporary and older soft calcareous sediments.

Sample: K 12 **Quotation:** KEGLER 1967c, p. 32 middle
Gauss-Kruger-coordinates: ^{34}41050 - ^{55}88350
Location: small quarry ca. 100 m eastwards of the Kerkerbach, near the forest track between Eschenau and Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: grey, sparitic, slighly dolomitised platy limestone beds which are embedded in black-grey to greenish slates.
Stratigraphic correlation: cu II γ
Fossils: (conodonts, det. by KEGLER, from the calcareous layers)

Gnathodus bilineatus (ROUNDY 1926)	[*bilineatus* — Upper Carboniferous]
Gnathodus texanus ROUNDY 1926	[*texanus* — in *bilineatus*]
Gnathodus commutatus commutatus (BRANSON & MEHL 1941) [= *Paragnathodus commutatus commutatus* HIGGINS 1975]	[in *texanus* — in *bilineatus*]
Gnathodus [*commutatus*] *homopunctatus* (ZIEGLER)	[in *anchoralis-latus* — in *bilineatus*]

Remarks: revised stratigraphic range: lower Viséan (cu II δ -— cu III α; Arundian — Asbian; ***bilineatus*** -zone — in ***bilineatus*** -zone). LCC2003: ci: 16.7 — 17.5.
Presumable sedimentary environment: Deposition near the base of a basinal slope. Main constituent of the sedimentary facies is clay-silt with intercalations of (turbiditic) calcareous debris from higher parts of a submarine ridge.

Sample: K 13 **Quotation:** KEGLER 1967c, p. 32 top
Gauss-Kruger-coordinates: [^{34}41100 - ^{55}88600]
Location: small quarry ca. 100 m eastwards of the Kerkerbach, near the forest track between Eschenau and Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: redgrey tuff-bearing crinoid limestone beds up to 30 cm thickness, embedded in red cherty slates.
Stratigraphic correlation: cu II γ
Fossils: (conodonts, det. by KEGLER, from the calcareous layers)

Gnathodus semiglaber BISCHOFF 1957	[in *isosticha* / upper *crenulata* — *bilineatus*]
Gnathodus texanus ROUNDY 1926	[*texanus* — in *bilineatus*]
Gnathodus commutatus commutatus (BRANSON & MEHL 1941) [= *Paragnathodus commutatus commutatus* HIGGINS 1975]	[in *texanus* — in *bilineatus*]
Gnathodus [*commutatus*] *homopunctatus* (ZIEGLER)	[in *anchoralis-latus* — in *bilineatus*]

Remarks: revised stratigraphic range: lower Viséan (cu II γ -— cu III α; Arundian — Asbian; Erdbacher Kalk type III; in (*Gnathodus) **texanus*** -zone — in ***bilineatus*** -zone). LCC2003: ci: 14.1 — 17.5.
Presumable sedimentary environment: Deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous and fossiliferous debris. The cherty/flinty slates are probably products of deposition of primary siliceous oozes which became partly separated during diagenesis and compaction. An alternative origin by deposition of thin finesilt intercalations seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are mostly not observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: K 14 **Quotation:** KEGLER 1967c, p. 34 middle
Gauss-Kruger-coordinates: ^{34}41200 - ^{55}88950
Location: great diabas-quarry at the right bank of the Kerkerbach, ca. 300 southward of Eschenau (geological map 1:25000, 5515 Weilburg).
Lithology: > 10m thick pillow-diabas with interstitials of tuff material and sediment fragments. At the surface of the pillows almost ever a millimetre-thick micritic red limestone.
Stratigraphic correlation: mixed fauna of cu II γ ? and cu II β/γ
Fossils: (conodonts, det. by KEGLER, from the red limestone rims)

Doliognathus latus BRANSON & MEHL 1941	[base to near (?) the top of *anchoralis-latus*]
Gnathodus semiglaber BISCHOFF 1957	[in *isosticha* / upper *crenulata* — *bilineatus*]
Pseudopolygnathus (triangulus) pinnatus VOGES	[in upper *typicus* — in *anchoralis-latus*]
<u>reworked conodonts:</u>	
Palmatolepis marginata clarki ZIEGLER	[in Middle — Late *triangularis*]
Palmatolepis marginata marginata STAUFFER	[Middle *triangularis*]

Remarks: revised stratigraphic range: uppermost Tournaisian (cu II β ; base to near the top of ***anchoralis-latus***-zone). LCC2003: ci: 11.7 — 13.2. Location identical to Eschenau 3 of WALLISER (1960:235). Reworked conodonts indicate an age of Middle to Late *triangularis*-zone: DK1996: ds: 7.1 — 8.0.
Presumable sedimentary environment: submarine basic volcanic activity, development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments.

Sample: K 15 (A_1) **Quotation:** KEGLER 1967a, p. 6 bottom
Gauss-Kruger-coordinates: ^{34}31715 - ^{55}80400
Location: from fissile black slates north of ruin Aardeck (geological map 1:25000, 5614 Limburg).
Lithology: black to grey, mostly fissile slates with sandy intercalations. Therein seldomly concretions of a black, pyrite-enriched limestone.
Stratigraphic correlation: middle to late Eifelian
Fossils: (det. by KEGLER)

Polygnathus angustipennatus BISCHOFF & ZIEGLER 1957	[in *australis* (4.0) — near top of lower *kockelianus* (6.4)]
Polygnathus linguiformis HINDE 1879	[Emsian — *punctata*]
Belodus sp.	
pyritised: ostracods, styliolines, tentaculites, gastropods and bivalves	

Remarks: revised stratigraphic range: middle to late Eifelian (in ***australis*** — near the top of lower ***kockelianus*** zone). DK1996: cm: 4.0 — 6.4. KEGLER notices, that the above mentioned fauna from the Aar-valley was the only one he was able to recover from presumed Eifelian rocks of the map sheets Hadamar and Limburg.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris and finesand from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, is reflected by the concentration of the fossils on the bedding planes, which are separated by mm to cm thick layers of shale or limestone.

Sample: K 16 (E_1) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 1"
Gauss-Kruger-coordinates: $^{34}38760$ - $^{55}82880$
Location: Emsbach-valley (geological map 1:25000, 5614 Limburg).
Lithology: black, rough slates with sandy intercalations and dark calcareous concretions.
Stratigraphic correlation: lower Givetian (*eiflia*-zone)
Fossils: (det. by KEGLER)

Icriodus obliquimarginatus BISCHOFF & ZIEGLER 1957	[within *kockelianus* (6.4) — near top Middle *varcus* (16.5)]
Polygnathus eiflius BISCHOFF & ZIEGLER 1957	[near base *kockelianus* (5.0) — within *hemiansatus* (9.4)]
Polygnathus linguiformis linguiformis HINDE 1879	[in *costatus* — *punctata*]
Polygnathus pseudofoliatus WITTEKINDT 1966	[near base *kockelianus* (5.2) — lower *varcus* (14.1)]
Polygnathus? *variabilis* BISCHOFF & ZIEGLER 1957 [= *Tortodus variabilis* WEDDIGE 1977]	[within *hemiansatus* (8.8) — in lower *varcus* (13.5)]
Polygnathus xylus STAUFFER 1940	[within *kockelianus* (6.4) — in *transitans* (ds 1.3)]

Remarks: revised stratigraphic range: lower Givetian (within ***hemiansatus***-zone). DK1996: dm: 8.8 — 9.4.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris and finesand from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites.

Sample: K 17 (E_2) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 1"
Gauss-Kruger-coordinates: $^{34}38310$ - $^{55}83610$
Location: Emsbach-valley (geological map 1:25000, 5614 Limburg).
Lithology: red to magenta slates with calcareous concretions.
Stratigraphic correlation: middle to upper Givetian
Fossils: (det. by KEGLER)

Icriodus obliquimarginatus BISCHOFF & ZIEGLER 1957	[within *kockelianus* (6.4) — near top Middle *varcus* (16.5)]
Polygnathus kluepfeli WITTEKINDT 1966	[in *hemiansatus* (10.5) — in lower *varcus* (13.5)]
Polygnathus linguiformis linguiformis HINDE 1879	[in *costatus* — *punctata*]
Polygnathus xylus STAUFFER 1940	[within *kockelianus* (6.4) — in *transitans* (ds 1.3)]

Remarks: revised stratigraphic range: middle Givetian (in ***hemiansatus*** — in lower ***varcus*** -zone). DK1996: dm: 10.5 — 13.5.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment, but enriched iron content (due to volcanic activity?) in the water column.

Sample: K 18 (B_1) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 1"
Gauss-Kruger-coordinates: $^{34}29920$ - $^{55}78750$
Location: Holzheim forest, "Forstort 10" (geological map 1:25000, 5614 Limburg).
Lithology: calcareous nodules in black, weathered yellowish, slates.
Stratigraphic correlation: lower Givetian
Fossils: (det. by KEGLER)

Icriodus obliquimarginatus BISCHOFF & ZIEGLER 1957	[within *kockelianus* (6.4) — near top Middle *varcus* (16.5)]
Polygnathus eiflius BISCHOFF & ZIEGLER 1957	[near base *kockelianus* (5.0) — within *hemiansatus* (9.4)]
Polygnathus linguiformis linguiformis HINDE 1879	[in *costatus* — *punctata*]
Polygnathus? *variabilis* BISCHOFF & ZIEGLER 1957 [= *Tortodus variabilis* WEDDIGE 1977]	[within *hemiansatus* (8.8) — in lower *varcus* (13.5)]

Remarks: revised stratigraphic range: lower Givetian (within ***hemiansatus***-zone). DK1996: dm: 8.8 — 9.4.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed.

Sample: K 19 (B_2) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 1"
Gauss-Kruger-coordinates: ^{34}29940 - ^{55}78980
Location: Holzheim forest, "Runse" 80m northeast of the hunting cottage (geological map 1:25000, 5614 Limburg).
Lithology: succession of black slates with calcareous concretions and sandy intercalations.
Stratigraphic correlation: upper Givetian (*robusticostata*-zone)
Fossils: (det. by KEGLER)

Polygnathus kluepfeli WITTEKINDT 1966	[in *hemiansatus* (10.5) — in lower *varcus* (13.5)]
Polygnathus varcus STAUFFER 1940	[in lower *varcus* (13.5) — lower *hermanni-cristatus* (18.3)]
Polygnathus xylus STAUFFER 1940	[within *kockelianus* (6.4) — in *transitans* (ds 1.3)]

Remarks: revised stratigraphic range: middle Givetian (lower ***varcus***-zone). DK1996: dm: 13.5 (12.8 — 14.1).
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris and finesand from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites.

Sample: K 20 (A_3) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 1"
Gauss-Kruger-coordinates: ^{34}31740 - ^{55}80160
Location: Aar-valley, opposite of ruin Aardeck (geological map 1:25000, 5614 Limburg).
Lithology: calcareous tuff-bearing slates.
Stratigraphic correlation: tmo — to Iα
Fossils: (det. by KEGLER)

Polygnathus linguiformis linguiformis HINDE 1879	[in *costatus* — *punctata*]
Polygnathus varcus STAUFFER 1940	[in lower *varcus* (13.5) — lower *hermanni-cristatus* (18.3)]
Polygnathus webbi STAUFFER 1938	[Lower Devonian — Late *marginifera* (ds13.3)]

Remarks: revised stratigraphic range: middle to upper Givetian (in lower ***varcus***— lower ***hermanni-cristatus*** -zone). DK1996: dm: 13.5 — 18.3.
Presumable sedimentary environment: Deposition of mud from suspension within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited tuff-bearing silt due to episodic submarine volcanic activity.

Sample: K 21 (A_5) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 1"
Gauss-Kruger-coordinates: ^{34}31840 - ^{55}80260
Location: Aar-valley, below ruin Aardeck (geological map 1:25000, 5614 Limburg).
Lithology: Grey, bedded limestone.
Stratigraphic correlation: upper Givetian
Fossils: (det. by KEGLER)
Belodus triangularis (STAUFFER 1940)
[= *Belodella triangularis* (STAUFFER 1940)]

Polygnathus pennatus HINDE 1879	[within *kockelianus* (ca. 6.4) — in *punctata* (ds2.0)]
Polygnathus varcus STAUFFER 1940	[in lower *varcus* (13.5) — lower *hermanni-cristatus* (18.3)]

Remarks: revised stratigraphic range: middle to upper Givetian (in lower ***varcus*** — lower ***hermanni-cristatus*** -zone). DK1996: dm: 13.5 — 18.3.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is calcareous debris from higher parts of the submarine ridge. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of turbidites.

Sample: K 22 (A_6) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 1"
Gauss-Kruger-coordinates: ^{34}31840 - ^{55}80260
Location: Aar-valley, below ruin Aardeck (geological map 1:25000, 5614 Limburg).
Lithology: black slates with calcareous layers.
Stratigraphic correlation: upper Givetian
Fossils: (det. by KEGLER)

Polygnathus linguiformis linguiformis HINDE 1879	[in *costatus* — *punctata*]
Polygnathus varcus STAUFFER 1940	[in lower *varcus* (13.5) — lower *hermanni-cristatus* (18.3)]

Remarks: revised stratigraphic range: middle to upper Givetian (in lower ***varcus*** — lower ***hermanni-cristatus*** -zone). DK1996: dm: 13.5 — 18.3.
Presumable sedimentary environment: Deposition near the base of a basinal slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of (turbiditic?) calcareous debris from higher parts of the submarine ridge.

Sample: K 23 (A_2) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 2"
Gauss-Kruger-coordinates: $^{34}32000$ - $^{55}80380$
Location: Aar-valley, north of ruin Aardeck (geological map 1:25000, 5614 Limburg).
Lithology: tuff-bearing slates with calcareous nodules.
Stratigraphic correlation: lower to I α (older *asymmetricus*-time)
Fossils: (det. by KEGLER)

Polygnathus decorosus STAUFFER 1938 [?upper *hermanni-cristatus* (?18.3) — ?in *crepida*]
Polygnathus asymmetricus asymmetricus (BISCHOFF & ZIEGLER 1957) [Late *falsiovalis* (0.5) — near top Early *hassi* (2.8)]
[= *Mesotaxis asymmetricus asymmetricus* SANDBERG, ZIEGLER & BULTYNCK 1989]

Remarks: revised stratigraphic range: lowermost Frasnian (Late ("Middle") ***falsiovalis*** — near top Early ***hassi***-zone). DK1996: ds: 0.5 — 2.8.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris and finesand from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity.

Sample: K 24 (A_4) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 2"
Gauss-Kruger-coordinates: $^{34}31740$ - $^{55}80140$
Location: Aar-valley, rifle-range Holzheim (geological map 1:25000, 5614 Limburg).
Lithology: tuff-bearing sand- and calcareous sandstones.
Stratigraphic correlation: lower to I α (older *asymmetricus*-time)
Fossils: (det. by KEGLER)

Belodus sp. [= *Belodella* sp.]
Polygnathus linguiformis linguiformis HINDE 1879 [in *costatus* (2.0) — *punctata* (ds2.3)]
Polygnathus? *variabilis* BISCHOFF & ZIEGLER 1957 [within *hemiansatus* (8.8) — in lower *varcus* (13.5)
[= *Tortodus variabilis* WEDDIGE 1977]

Remarks: revised stratigraphic range: middle Givetian (within *hemiansatus* — in lower *varcus*-zone). DK1996: dm: 8.8 — 13.5. *T. (P.?) variabilis* prolongs maybe at least to the lowermost Frasnian (min. ds 0.2; compare K 25). "Sandstones" are mainly reworked pyroclastic deposits.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is silt-finesand with intercalations of calcareous debris from higher parts of the submarine ridge where "pure" pyroclastic deposits were deposited and subsequently reworked and transported downslope. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity.

Sample: K 25 (L_{1+2}) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 2"
Gauss-Kruger-coordinates: $^{34}35010$ - $^{55}82960$
Location: southwest of the Eichelberg (E.-hill; geological map 1:25000, 5614 Limburg).
Lithology: a) syngenetic calcareous interstitials in pillow-diabas; b) tuff-bearing lime- and sandstones.
Stratigraphic correlation: lower to I α (older *asymmetricus*-time)
Fossils: (det. by KEGLER)

<u>from lithology a)</u>
Belodus sp. [= *Belodella* sp.]
Icriodus nodosus HUDDLE 1934 [Lower Devonian — ?in *crepida*]
Icriodus symmetricus BRANSON & MEHL 1934 [in Early *falsiovalis* (0.2) — Late *rhenana* (5.5)]
Polygnathus decorosus STAUFFER 1938 [?upper *hermanni-cristatus* (?18.3) — ?in *crepida*]
Polygnathus normalis MILLER & YOUNGQUIST 1947 [in Early *falsiovalis* (0.2) — ?in *crepida*]
Polygnathus ordinatus BRYANT 1921 [upper *hermanni-cristatus* (18.3) — in *transitans* (ds1.4)]
Spathognathodus sannemanni sannemanni (BISCHOFF & ZIEGLER 1957) [upper *varcus* (17.0) — near top of *punctata* (ds2.2)]
[= *Ozarkodina sannemanni sannemanni* (BISCHOFF & ZIEGLER 1957)]

<u>from lithology b)</u>
Belodus sp. [= *Belodella* sp.]
Icriodus nodosus HUDDLE 1934 [Lower Devonian — ?in *crepida*]
Icriodus symmetricus BRANSON & MEHL 1934 [in Early *falsiovalis* (0.2) — Late *rhenana* (5.5)]
Polygnathus cristatus HINDE 1879 [upper *hermanni-cristatus* (18.3) — *punctata* (2.3)]
Polygnathus decorosus STAUFFER 1938 [?upper *hermanni-cristatus* (?18.3) — ?in *crepida*]
Polygnathus normalis MILLER & YOUNGQUIST 1947 [in Early *falsiovalis* (0.2) — ?in *crepida*]
Polygnathus ordinatus BRYANT 1921 [upper *hermanni-cristatus* (18.3) — in *transitans* (ds1.4)]

Polygnathus pennatus HINDE 1879	[within *kockelianus* (c. 6.4) — in *punctata* (ds2.0)]
Polygnathus varcus STAUFFER 1940	[in lower *varcus* (13.5) — lower *hermanni-cristatus* (18.3)]
Polygnathus? *variabilis* BISCHOFF & ZIEGLER 1957 [= *Tortodus variabilis* WEDDIGE 1977]	[within *hemiansatus* (8.8) — in lower *varcus* (13.5)
Polygnathus webbi STAUFFER 1938	[Lower Devonian — Late *marginifera* (ds13.3)]
Spathognathodus sannemanni sannemanni (BISCHOFF & ZIEGLER 1957) [= *Ozarkodina sannemanni sannemanni* (BISCHOFF & ZIEGLER 1957)]	[upper *varcus* (17.0) — near top of *punctata* (ds2.2)]

Remarks: revised stratigraphic range: fauna a) lowermost Frasnian (in Early ***falsiovalis*** — in ***transitans*** -zone). DK1996: ds: 0.2 — 1.4; fauna b) lowermost Frasnian (in Early ***falsiovalis*** — in ***transitans*** -zone). DK1996: ds: 0.2 — 1.4, maybe with one reworked species *T. (P.?) variabilis* (DK1996: dm: 8.8 — 13.5)."Sandstones" are mainly reworked pyroclastic deposits.

Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is silt-finesand with intercalations of calcareous debris from higher parts of the submarine ridge where "pure" pyroclastic deposits were deposited and subsequently reworked and transported downslope. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity. Also submarine basaltic magma outflow into the slope-deposits.

Sample: K 26 (A_{7-11}) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 3"
Gauss-Kruger-coordinates: ^{34}32200 - ^{55}79770
Location: abandoned limestone-quarry north of Flacht (geological map 1:25000, 5614 Limburg).
Lithology: allodapic limestones: ca. 18 m succession of a) biosparitic-/biosparruditic-limestones (dm-cm bedding), b) micritic-/microsparitic-limestones (dm-cm bedding), c) dark slates (up to 30 cm thick layers).
Stratigraphic correlation: to I α (older *asymmetricus*-time) — to I (β)γ (upper *asymmetricus*-time)
Fossils: (det. by KEGLER)

sample from the field nearby quarry-top (A_{11}): DK1996: dm 18.3 — ds 0.7 (with reworked DK1996: dm: 8.8 — 13.5)

Polygnathus cristatus HINDE 1879	[upper *hermanni-cristatus* (18.3) — *punctata* (2.3)]
Polygnathus ordinatus BRYANT 1921	[upper *hermanni-cristatus* (18.3) — in *transitans* (ds1.4)]
Polygnathus webbi STAUFFER 1938	[Lower Devonian — Late *marginifera* (ds13.3)]
Schmidtognathus (Polygnathus) peracutus (BRYANT 1921) ZIEGLER 1965	[upper *hermanni-cristatus* (18.3) — in Late *falsiovalis* (ds0.7)]
Polygnathus? *variabilis* BISCHOFF & ZIEGLER 1957 [= *Tortodus variabilis* WEDDIGE 1977]	[within *hemiansatus* (8.8) — in lower *varcus* (13.5)

18.2 m upwards from base of quarry-wall = top (A_7): DK1996: ds: 1.1 — 1.4 (with reworked DK1996: dm: 13.5 — 15.5)

Polygnathus asymmetricus asymmetricus (BISCHOFF & ZIEGLER 1957) [= *Mesotaxis asymmetricus asymmetricus* SANDBERG, ZIEGLER & BULTYNCK 1989]	[Late *falsiovalis* (0.5) — near top Early *hassi* (2.8)]
Palmatolepis transitans MÜLLER 1956	[*transitans* (1.1) — near top Late *hassi* (3.5)]
Polygnathus beckmanni BISCHOFF & ZIEGLER 1957	[in lower *varcus* (13.5) — in Middle *varcus* (15.5)]
Polygnathus cristatus HINDE 1879	[upper *hermanni-cristatus* (18.3) — *punctata* (2.3)]
Polygnathus decorosus STAUFFER 1938	[?upper *hermanni-cristatus* (?18.3) — ?in *crepida*]
Polygnathus ordinatus BRYANT 1921	[upper *hermanni-cristatus* (18.3) — in *transitans* (ds1.4)]

16.2 m upwards from base of the quarry-wall (A_8): DK1996: ds: 0.5 — 2.8 (with reworked DK1996: dm: 13.5 — 18.3)

Polygnathus asymmetricus asymmetricus (BISCHOFF & ZIEGLER 1957) [= *Mesotaxis asymmetricus asymmetricus* SANDBERG, ZIEGLER & BULTYNCK 1989]	[Late *falsiovalis* (0.5) — near top Early *hassi* (2.8)]
Polygnathus varcus STAUFFER 1940	[in lower *varcus* (13.5) — lower *hermanni-cristatus* (18.3)]
Polygnathus normalis MILLER & YOUNGQUIST 1947	[in Early *falsiovalis* (0.2) — ?in *crepida*]

6 m upwards from base of the quarry-wall (A_9): DK1996: dm: 18.3 (17.7 — 18.7)

Schmidtognathus (Polygnathus) peracutus (BRYANT 1921) ZIEGLER 1965	[upper *hermanni-cristatus* (18.3) — in Late *falsiovalis* (ds0.7)]
Polygnathus varcus STAUFFER 1940	[in lower *varcus* (13.5) — lower *hermanni-cristatus* (18.3)]

4 m upwards from base of the quarry-wall (A_{10}): DK1996: dm: 18.3 (17.7 — 18.7)

Ancyrodella sp.	
Polygnathus asymmetricus ovalis ZIEGLER & KLAPPER	[upper *hermanni-cristatus* (18.3) — *punctata* (2.3)]
Polygnathus varcus STAUFFER 1940	[in lower *varcus* (13.5) — lower *hermanni-cristatus* (18.3)]

Remarks: revised stratigraphic range: succession from upper Givetian to lowermost Frasnian (upper ***hermanni-cristatus*** (dm 18.3) — in ***transitans*** (ds1.4)-zone). DK1996: dm 18.3 — ds 1.4 (with reworked faunas from DK1996: dm 8.8 — 13.5 and dm 13.5 — 15.5). The sample from the field nearby the top of the quarry (A_{11}) was attributed by KEGLER to the lower Adorfian, to I (β)γ (upper *asymmetricus*-time); but the described conodont assemblage indicates a time of deposition around the Givetian/Frasnian-boundary. Due to the results obtained by KEGLER during detailed inspection of the quarry (KEGLER 1967a: 25, fig. 7: sedimentary log; also 1968: 351, fig. 5: sedimentary log), the whole ca.18m thick succession contains a) 11 beds/layers of biosparitic/biosparruditic lime-stones, b) 46 beds/layers of micritic/microsparitic limestones, c) 52 beds/layers of dark slates, partly with calcareous nodules. **Hence, this fossil-bearing (conodonts, "planktonic" organisms) sedimentary succession could act as an excellent and easily accessible locality for further detailed studies on the Givetian-Frasnian boundary.** A similar lithologic succession is described in OETKEN 1997:84 (= sample O 10) from the drilling "Georg 3".

Presumable sedimentary environment: Due to KEGLER (1967a:352; translation): "The lithologic succession is characterized by a permanent change between autochthonous and allochthonous facies [...]. The autochthonous part consists of clayey material, which separates the limestone beds and varies in thickness from very thin layers up to 25 cm. The thicker layers, which are nowadays slates, contain horizontally consistent arranged nodules of a dark micritic limestone. The bigger, autochthonous part is build up of bituminous micritic limestones with bed thicknesses of 2 to 50 cm. Nearly all micrites are recrystallised to microsparites. Sometimes a fine banding is observable. These limestones have originated by precipitation. Fossils are quite numerous in several layers. They are exclusively remnants of planktonic organisms. Therefore we can deduce a low-energy facies, which depositional position has not only lain below a possible reef-growth environment, but also prevented the necessary life conditions for benthic organisms due to a H_2S-poisoned milieu.

Within this facies described above repeatedly allochthonous limestones are intercalated, biosparites and biosparrudites, which origin is deducible from reefs. They can build up single beds or alternate with autochthonous micritic limestones [...]. Many beds show graded bedding. The biotic components consist of rounded broken pieces of branching coral- and stromatopore-colonies. Shells of brachiopods and molluscs as well as crinoid-debris are less frequent."

Deposition at the slope of a submarine ridge (reef). Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge (?polygnathid-ancyrodellid biofacies-zone). The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, is reflected by frequent concentration of fossils on the bedding planes, which are separated by mm to cm thick layers of limestone.

Sample: K 27 (Gf_{1-10}, Gfs_{13}) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 9, 12"
Gauss-Kruger-coordinates: [^{34}33960 - ^{55}83650] (main entrance of abandoned mine "Grube Wilhelm")
Location: depot of the company "Scheid" in Limburg (former mine "Wilhelm"); detailed sketch map in KEGLER (1967a: fig. 14) and KEGLER (1968:354); (geological map 1:25000, 5614 Limburg).
Lithology: ca. 120m succession of a) "Schalstein", original and reworked pyroclastic deposits, b) nodular/concretionary and flaser-bedded limestone, c) tuff-bearing limestones, partly siliceous, d) reddish slates with calcareous nodules, e) ca. 1m iron-enriched horizon.
Stratigraphic correlation: to IV/toV (lower *styriacus*-zone) — to V/toVI (Middle *costatus*-zone)

Fossils: (conodonts, det. by KEGLER, from the calcareous layers)

main entrance of mine "Wilhelm" (Gf$_{13}$): DK1996: ds 17.8 — 18.9

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis [*gracilis*] *gonioclymeniae* (MÜLLER 1956)	[Late *expansa* — in Middle *praesulcata*]
Polygnathus communis BRANSON & MEHL 1934	[Early *postera* — ?Middle *praesulcata*]
Pseudopolygnathus [*marburgensis*] *trigonicus* ZIEGLER 1962	[near base Late *expansa* — Early *praesulcata*]
Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]

12m northwest of the main entrance of mine "Wilhelm" (Gf$_{7}$): DK1996: ds 17.4 — 18.4

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus costatus spinulicostatus (BRANSON 1934) [= *Bispathodus costatus spinulicostatus* (BRANSON 1934)]	[in Middle *expansa* — Lower Carboniferous]
Spathognathodus jugosus (BRANSON & MEHL 1934) [= *Bispathodus jugosus* (BRANSON & MEHL 1934)]	[in Early — (?in) Late *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

18m northwest of the main entrance of mine "Wilhelm" (Gf$_{6}$): DK1996: ds 17.1 — 18.4

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis (rugosa) [*perlobata*] *postera* (ZIEGLER 1960)	[Early *postera* — ? in Late *expansa*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

26m northwest of the main entrance of mine "Wilhelm" (Gf$_{5}$): DK1996: ds 16.8 — 18.0

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Pseudopolygnathus brevipennatus ZIEGLER 1962	[Early — in Late *expansa*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Spathognathodus jugosus (BRANSON & MEHL 1934) [= *Bispathodus jugosus* (BRANSON & MEHL 1934)]	[in Early — (?in) Late *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus strigosus (BRANSON & MEHL 1934) [= *Mehlina strigosa* (BRANSON & MEHL 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]

32m northwest of the main entrance of mine "Wilhelm" (Gf$_{4}$): DK1996: ds 16.8 — 18.4

Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Spathognathodus jugosus (BRANSON & MEHL 1934) [= *Bispathodus jugosus* (BRANSON & MEHL 1934)]	[in Early — (?in) Late *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus strigosus (BRANSON & MEHL 1934) [= *Mehlina strigosa* (BRANSON & MEHL 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]

40m northwest of the main entrance of mine "Wilhelm" (Gf$_{3}$): DK1996: ds 16.5 — 17.7 (+ reworked DK1996: ds 8.1 — 13.9)

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Palmatolepis (rugosa) [*perlobata*] *postera* (ZIEGLER 1960)	[Early *postera* — ? in Late *expansa*]
Polygnathus nodocostatus BRANSON & MEHL 1934	[Early *crepida* — Latest *marginifera*]
Polygnathus obliquicostatus ZIEGLER 1962	[Early *postera* — Middle *expansa*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

52m northwest of the main entrance of mine "Wilhelm" (Gf_2): DK1996: ds 15.2 — 17.7 (+ reworked DK1996: ds 8.1 — 13.9)

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Palmatolepis (rugosa) [*perlobata*] *postera* (ZIEGLER 1960)	[Early *postera* — ? in Late *expansa*]
Polygnathus nodocostatus BRANSON & MEHL 1934	[Early *crepida* — Latest *marginifera*]
Polygnathus obliquicostatus ZIEGLER 1962	[Early *postera* — Middle *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

70m northwest of the main entrance of mine "Wilhelm" (Gf_1): DK1996: ds 17.7 — 19.2

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis [*gracilis*] *gonioclymeniae* (MÜLLER 1956)	[Late *expansa* — in Middle *praesulcata*]
Polygnathus communis BRANSON & MEHL 1934	[Early *postera* — ?Middle *praesulcata*]
Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

36m southeast of the main entrance of mine "Wilhelm" (Gf_8): DK1996: ds 16.8 — 17.1

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Polygnathus styriacus ZIEGLER 1957	[Early *postera* — Early *expansa*]
Spathognathodus jugosus (BRANSON & MEHL 1934) [= *Bispathodus jugosus* (BRANSON & MEHL 1934)]	[in Early — (?in) Late *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus strigosus (BRANSON & MEHL 1934) [= *Mehlina strigosa* (BRANSON & MEHL 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]

15m above (direction 10:30) main entrance of mine "Wilhelm" (Gf_{10}): DK1996: ds 16.8 — 18.4

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Spathognathodus jugosus (BRANSON & MEHL 1934) [= *Bispathodus jugosus* (BRANSON & MEHL 1934)]	[in Early — (?in) Late *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus strigosus (BRANSON & MEHL 1934) [= *Mehlina strigosa* (BRANSON & MEHL 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]

15m above (direction 14:00) main entrance of mine "Wilhelm" (Gf_9): DK1996: ds 15.2 — 17.1

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Polygnathus obliquicostatus ZIEGLER 1962	[Early *postera* — Middle *expansa*]
Polygnathus styriacus ZIEGLER 1957	[Early *postera* — Early *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

Remarks: revised stratigraphic range: late Famennian succession from upper Hembergian to middle Wocklumian (Early ***postera*** — in Middle ***praesulcata***-zone). DK1996: ds 15.2 — 19.2 (in parts with reworked faunas from DK1996: ds 8.1 — 13.9; middle Nehdenian — lowermost Hembergian). From 52m northwest of the main entrance of mine "Wilhelm" (sample Gf_2) to the main entrance (sample Gf_{13}) ca. 40m concordant sedimentary succession is assumable, although some fault planes are observable. Within these 40 m compacted sediment pile a total of ca. 28m pyroclastic deposits ("Schalstein"), 11m flaser-bedded limestone and 1m reddish slates occur. Sample Gf_5 is taken from a zone with ?synsedimentary folded (?slump-structures) flaser-limestone within the pyroclastic deposits.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt (reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (flaser-limestones). Due to episodic submarine volcanic activity "pure" pyroclastic deposits were deposited. Also pyroclastic deposits which were firstly deposited at/near the top of the ridge are observable in the form of subsequently reworked and downslope transported sediments.

Sample: K 28 (Gf_{11-14}) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 9"
Gauss-Kruger-coordinates: [^{34}33870 - ^{55}83640]
Location: small abandoned quarry in the garden of the company "Koch" in the western prolongation of the depot of the company "Scheid" (K 27). Samples are taken from the base (Gf_{11}) to the top (Gf_{14}) of the outcrop (geological map 1:25000, 5614 Limburg).
Lithology: succession from base to top: a) grey to reddish nodular limestone (Gf_{11}), b) platy black limestone with slate intercalations (Gf_{12}), c) dark nodular limestone with slate intercalations (Gf_{13}), d) red nodular limestone (Gf_{14}).
Stratigraphic correlation: a) Gf_{11}: to IV (upper *velifer* — lower *styriacus*-zone), b) Gf_{12}: late to V (upper *styriacus* — lower *costatus*-zone), c) Gf_{13}: middle to V (upper *styriacus*-zone), d) Gf_{14}: middle to V (upper *styriacus*-zone)
Fossils: (conodonts, det. by KEGLER)

Gf_{14}, top of the outcrop, DK1996: ds 16.5 — 18.0 (+ reworked DK1996: ds 8.1 — 13.9)

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Polygnathus nodocostatus s. str. BRANSON & MEHL 1934	[Early *crepida* — Latest *marginifera*]
Pseudopolygnathus brevipennatus ZIEGLER 1962	[Early — in Late *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

Gf_{13}, DK1996: ds 16.5 — 18.0 (+ reworked DK1996: ds 8.1 — 13.9)

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Polygnathus communis BRANSON & MEHL 1934	[Early *postera* — ?Middle *praesulcata*]
Polygnathus nodocostatus s. str. BRANSON & MEHL 1934	[Early *crepida* — Latest *marginifera*]
Pseudopolygnathus brevipennatus ZIEGLER 1962	[Early — in Late *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

Gf_{12}, DK1996: ds 17.2 — 18.0

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Pseudopolygnathus brevipennatus ZIEGLER 1962	[Early — in Late *expansa*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus (costatus) ultimus (BISCHOFF 1957) [= *Bispathodus ultimus* (BISCHOFF 1957)]	[near base mid. *expansa* — near top mid. *praesulcata*]
Spathognathodus jugosus (BRANSON & MEHL 1934) [= *Bispathodus jugosus* (BRANSON & MEHL 1934)]	[in Early — (?in) Late *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]

Gf_{11}, base of the outcrop, DK1996: ds 15.2 (14.6 — 15.9)

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis (deflectens) [*gracilis*] *sigmoidalis* (ZIEGLER 1962)	[in Late *trachytera* — in *sulcata*]
Palmatolepis [*perlobata*] *helmsi* (ZIEGLER 1962)	[Early *trachytera* — in Middle *expansa*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Palmatolepis (rugosa) [*perlobata*] *postera* (ZIEGLER 1960)	[Early *postera* — ? in Late *expansa*]
Palmatolepis rugosa trachytera ZIEGLER 1960	[Early — Late *trachytera*]
Spathognathodus inornatus (BRANSON & MEHL 1934) [= *Branmehla inornata* (BRANSON & MEHL 1934)]	[in Late *marginifera* — in Middle *expansa*]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus strigosus (BRANSON & MEHL 1934) [= *Mehlina strigosa* (BRANSON & MEHL 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]

Remarks: revised stratigraphic range: late Famennian; late Hembergian to Dasbergian/Wocklumian-boundary (Early ***postera*** — in Late ***expansa***-zone). DK1996: ds: 15.2 — 18.0 (? in parts with reworked faunas from DK1996: ds 8.1 — 13.9; middle Nehdenian — lowermost Hembergian). No sure concordant lithologic succession (= faulted and folded).
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt (reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (nodular limestones). Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity (compare loc. K 27).

Sample: K 29 (Gf$_{15}$) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 9"
Gauss-Kruger-coordinates: ^{34}34380 - ^{55}83885
Location: near the street Limburg — Eschhofen, beer-cellar directly behind the railway-bridge (geological map 1:25000, 5614 Limburg).
Lithology: red slates with big red limestone nodules, below a diabas (basalt).
Stratigraphic correlation: lower to VI (middle *costatus*-zone)
Fossils: (conodonts, det. by KEGLER)

Palmatolepis deflectens deflectens MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis (deflectens) [*gracilis*] *sigmoidalis* (ZIEGLER 1962)	[in Late *trachytera* — in *sulcata*]
Palmatolepis [*gracilis*] *gonioclymeniae* (MÜLLER 1956)	[Late *expansa* — in Middle *praesulcata*]
Polygnathus communis BRANSON & MEHL 1934	[Early *postera* — ?Middle *praesulcata*]
Spathognathodus aculeatus (BRANSON & MEHL 1934) [= *Bispathodus aculeatus* (BRANSON & MEHL 1934)]	[Middle *expansa* — in Early *crenulata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus costatus spinulicostatus (BRANSON 1934) [= *Bispathodus costatus spinulicostatus* (BRANSON 1934)]	[in Middle *expansa* — Lower Carboniferous]
Spathognathodus stabilis (BRANSON & MEHL 1934) [= *Bispathodus stabilis* (BRANSON & MEHL 1934)]	[Late *marginifera* — ?in *texanus*]
Spathognathodus strigosus (BRANSON & MEHL 1934) [= *Mehlina strigosa* (BRANSON & MEHL 1934)]	[Early *marginifera* — ? in Middle *praesulcata*]
Spathognathodus supremus (ZIEGLER 1962) [= *Branmehla suprema* (ZIEGLER 1962)]	[near base Late *expansa* — near top Middle *praesulcata*]

Remarks: revised stratigraphic range: late Famennian; late Dasbergian to middle Wocklumian (near base Late ***expansa*** — in Middle ***praesulcata***-zone). DK1996: ds: 17.8 — 19.3.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt (reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (nodular limestones). Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity (compare loc. K 27).

Sample: K 30 (Gf$_{16}$) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 9"
Gauss-Kruger-coordinates: ^{34}33930 - ^{55}83710
Location: track between "valley (Tal) Josaphat" and waterhouse, in Limburg (geological map 1:25000, 5614 Limburg).
Lithology: greenish slates with limestone nodules.
Stratigraphic correlation: to IIβ / IIIα (*quadrantinodosus*-zone)
Fossils: (conodonts, det. by KEGLER)

Palmatolepis glabra elongata HOLMES 1928	[Early *marginifera* — ? in Late *trachytera*]
Palmatolepis glabra pectinata ZIEGLER 1960	[Latest *crepida* — Late *marginifera*]
Palmatolepis (quadrantinodosa) marginifera (ZIEGLER 1960)	[Early *marginifera* — in Early *trachytera*]

Remarks: revised stratigraphic range: middle Famennian; late Nehdenian (Early ***marginifera*** — Late ***marginifera***-zone). DK1996: ds: 11.9 — 13.3.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt (reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (nodular limestones). Greenish colours due to prevailing reducing conditions at the time of deposition. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity (compare loc. K 27).

Sample: K 31 (Gf$_{17}$) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 9"
Gauss-Kruger-coordinates: ^{34}33960 - ^{55}83710
Location: track between "valley (Tal) Josaphat" and waterhouse, in Limburg (geological map 1:25000, 5614 Limburg).
Lithology: greenish slates with limestone nodules.
Stratigraphic correlation: to IIIα (upper *quadrantinodosus*-zone)
Fossils: (conodonts, det. by KEGLER)

Palmatolepis [*glabra*] *distorta* (BRANSON & MEHL 1934)	[Early *marginifera* — in Early *trachytera*]
Palmatolepis glabra glabra ULRICH & BASSLER 1926	[Early *rhomboidea* — Early *marginifera*]
Palmatolepis glabra pectinata ZIEGLER 1960	[Latest *crepida* — Late *marginifera*]
Palmatolepis minuta minuta BRANSON & MEHL 1934	[Late *triangularis* — Latest *marginifera*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]

Polygnathus glabra bilobata ZIEGLER 1962 [Late *marginifera* — in Early *trachytera*]
Polygnathus nodoundatus HELMS 1961 ["middle *Prolobites* substage, middle toIII", Late *trachytera*, only preliminary stratigraphic data from HELMS 1961 were available]
Remarks: revised stratigraphic range: middle Famennian; late Nehdenian (Early/Late ***marginifera***-boundary). DK1996: ds: 12.6 (11.9 — 13.3).
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt (reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (nodular limestones). Greenish colours due to prevailing reducing conditions at the time of deposition. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity (compare loc. K 27).

Sample: K 32 (Gf_{18}) **Quotation:** KEGLER 1967a, appendix: "Faunenliste 9"
Gauss-Kruger-coordinates: ^{34}34020 - ^{55}83690
Location: track between "valley (Tal) Josaphat" and waterhouse, in Limburg (geological map 1:25000, 5614 Limburg).
Lithology: red slates with limestone nodules.
Stratigraphic correlation: Nehdenian/Hembergian
Fossils: (conodonts, det. by KEGLER)
Palmatolepis glabra ssp. indet. [? Late *crepida* — ? in Late *trachytera*]
Remarks: revised stratigraphic range: middle Famennian; middle Nehdenian to middle Hembergian (?Late ***crepida*** — ? in Late ***trachytera***-zone). DK1996: ds: (9.4 — 15.2).
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt (reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (nodular limestones). Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, due to episodic submarine volcanic activity (compare loc. K 27).

F 1.8 KREBS 1971

Sample: KRE 1 **Quotation:** KREBS 1971, p. 55 bottom, 58 middle
Gauss-Kruger-coordinates: ^{34}43730 - ^{55}93080
Location: former limestone-quarry northeast of Gaudernbach (geological map 1:25000, 5515 Weilburg).
Lithology: limestone-succession of: a) grey coloured fore-reef limestones (southeastern part of the quarry), b) pink grey to violet grey reef to fore-reef limestones (influenced by time-equivalent neighbouring submarine volcanism: tuffs, hematitic internal sediments, reddish colour), c) grey coloured fore-reef limestones (northwestern part of the quarry), d) repeated formation of sedimentary dikes parallel to bedding with subsequent sedimentation, plastic deformation and intensive brecciation.
Stratigraphic correlation: reef-limestones: early Upper Devonian; sedimentary dikes: early Famennian (upper *triangularis*-zone) and Lower Carboniferous (Dinantian II, Erdbach Limestone, *anchoralis-latus*-zone)
Fossils: (det. by KREBS, from the sedimentary dikes)
conodonts (no conodonts listed, announcement of the publication of detailed results from KREBS & RIETSCHEL which never happened to occur).
Remarks: proposed stratigraphic range for the development of the reef-limestones: earliest Frasnian (?***falsiovalis***-zone, DK1996: ds (?0.0 — ?1.1)); proposed stratigraphic range for the development of the sedimentary dikes: a) early Nehdenian (Late ***triangularis***-zone, DK1996: ds (7.5 — 8.1)); b) uppermost Tournaisian (cu II β ; base to near the top of ***anchoralis-latus***-zone, LCC2003: ci: (11.7 — 12.5)).
Presumable sedimentary environment: carbonate complex erected on submarine volcanic rise (diabases and diabas tuffs as well as keratophyrs). The reefs form atolls or table-reef like bodies in the earliest Frasnian. Repeated reopening of older breccia-zones (sedimentary dikes) from the Famennian to the Lower Carboniferous due to extension tectonics.

F 1.9 KREKELER 1928

Sample: KR 1 (= Fundpunkt 4) **Quotation:** KREKELER 1928, p. 83 bottom
Gauss-Kruger-coordinates: [presumably ^{34}42540 - ^{55}90640 or ^{34}42830 - ^{55}90830]
Location: side valley, which conjuncts southeast with the Kerkerbach valley (topogr. map Weilburg).
Lithology: bright coloured, fine-grained, greywacke-like rock, with considerable amount of mica and cherty matrix.
Stratigraphic correlation: lower upper Koblenzian (*Spirifer* ***paradoxus***-zone)
Fossils: (det. by Dr. DAHMER)
Atrypa reticularis (LINNÉ)
Atrypa var. *squamosa*
[= *Squamatrypa* var. *squamosa*]
Spirifer paradoxus (SCHLOTHEIM 1813) [lower Upper Emsian, lower Lahnsteinian]
[= *Euryspirifer paradoxus* (SCHLOTHEIM 1813)]
Spirifer sp.
Orthis striatula (SCHLOTHEIM)
[= *Schizophoria striatula* (SCHLOTHEIM)]
Orthis sp.
Orthis hysterita (GMELIN)
Chonetes dilatata (v. ROEMER) DE KONINCK
[= *Loreleiella dilatata* (DE KONINCK)
= *Eodevonaria dilatata* DE KONINCK]
Chonetes plebejus (SCHNUR 1853) [Emsian]
[= *Plebejochonetes plebejus* (SCHNUR 1853)]
Anoplotheca venusta (SCHNUR 1853) [Emsian (Ulmenian — Upper Emsian; frequent: Laubachian)]
Anoplia nucleata (HALL 1857) [Lower Devonian]
Pleurodictyum problematicum (GOLDFUSS)
Stropheodonta teniolata (SANDBERGER)
[= *Protodouvillina teniolata* (SANDBERGER)]
Zaphrentis sp.
Meristella follmanni (DAHMER)
Crinoid stems
Remarks: stratigraphic range revised to lower Upper Emsian (lower Lahnsteinian, ca. Early ***inversus*** -zone). DK1996: di: ca. 14.3 — 15.4. DILLMANN (1952) relates his locality ^{34}4283 - ^{55}9083 (D4) to locality "Fundpunkt (FP) 4" [= KR 1] of KREKELER. Succession of grey to greygreen sandy micaceous flaser bedded slates and laminated (platy) slates, punctuated by sudden incursions of silt-medium sand layers and pseudonodules. No greywacke.
Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. Dominating bedding features are graded bedding and laminated sand/silt. Wave energy and mud supply control mud abundance. During heavy storms brachiopod shells together with trochites and *P. problematicum* were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds.

Sample: KR 2 **Quotation:** KREKELER 1928, p. 107 bottom
Gauss-Kruger-coordinates: [presumably ^{34}40570 - ^{55}87650 = location M 5]
Location: in the eastern Kerkerbach valley near Hofen [topogr. map Hadamar].
Lithology: dark slates with intercalations of calcareous layers or nodules.
Stratigraphic correlation: lower Middle Devonian
Fossils: (det. by WEDEKIND)
Anarcestes subnautilinus (SANDBERGER) [Gen. *Anarcestes*: Upper Emsian — lowermost Eifelian (lower Lauchian)]
Aviculida sp.
Orthoceras sp.
Puella sp.
Murchisonia sp.
Remarks: stratigraphic range revised to Upper Emsian — lowermost Eifelian (ca. Late ***inversus*** — ***partitus*** -zone). DK1996: di: ca. 15.1 — dm: 0.6.
KREKELER relates his locality (in the Kerkerbach valley) to the Upper Devonian locality mentioned by AHLBURG (in KEGEL 1922: 39). AHLBURG found "at the eastern slope of the Kerkerbach valley near Hofen" 2 ammonoids: *Sporadoceras bronni* (MÜNSTER) and *Prolobites delphinus* (SANDBERGER) [which correlates probably to middle Hembergian, toIIIβ, **Late** *Palmatolepis rugosa* ***trachytera*** -zone, DK1996: ds: 14.5 — 14.9.]. Since KREKELER found a contradictory fauna, he therefore assumes that AHLBURG's fossil determinations were wrong. This is an improper assumption and neglects the following facts which should have been obtainable by KREKELER with proper literature research:

a) AHLBURG (1918:44) gives a more detailed description of the locality. "[...] Clymenienkalke [*Clymenia* limestones, tocl] have been found at the borderline between Cypridinenschiefer [*Cypridina* slates] and the "Gaudernbacher Schichten" (tot) [...] in the outermost southwest of the map area [geol. map Weilburg] at the eastern slope of the Kerkerbach valley [...]". The location is not <u>in</u> the valley - as quoted by KREKELER - but ca. 200 m uphill the eastern slope (coordinates presumably: ^{34}40830 - ^{55}87240).

b) MICHELS (1926: 239 = sample M 5) described a badly preserved fauna with ?*Anarcestes* from limestone nodules to layers within dark slates in the Kerkerbach valley near Hofen. The outcrop is easily detectable since it is directly at the former track of the Kerkerbach-railway. To me it seems most likely that KREKELER mistakenly mixed up the different localities.

KREKELER (1928:107) also quotes AHLBURG as to have attributed this fauna to the "Gaudernbacher Schichten". This is a wrong quotation. In AHLBURG's opinion the sedimentation of the "Gaudernbacher Schichten" (as a marginal facies) started <u>above</u> the lithologies which contain the described ammonites (AHLBURG 1918: 44; A. in KEGEL 1922: 39). Therefore the Clymenienkalke [*Clymenia* limestones] were attributed by him as intercalations to the "Cypridinen-Schiefer" (the "normal" Upper Devonian facies in his eyes).

Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge.

F 1.10 MICHELS 1926

Sample: M 1 **Quotation:** MICHELS 1926, p. 238 top
Gauss-Kruger-coordinates: [^{34}39850 - ^{55}86710]
Location: C. 500 m northwest of the northwestern exit of Schadeck.
Lithology: More or less micaceous, partly rough, partly mild greywackes or slates of dark, bluegrey colours. Sand content is greater towards the base than towards the top. Often a considerable content of limestone- and iron-carbonate is remarkable, which is always observable in these lithologies everywhere in the Lahn syncline. In the course of weathering brittle brightbrown rocks develop and often accumulations of iron hydroxide, which may in addition under favourable circumstances lead to the build-up of "Krusteneisenstein" (crust iron stone).
Stratigraphic correlation: Upper Koblenzian
Fossils: (det. by MICHELS with maintainance of FUCHS)

Spirifer paradoxus (SCHLOTHEIM 1813) [= *Euryspirifer paradoxus* (SCHLOTHEIM 1813)]	[lower Upper Emsian, lower Lahnsteinian]
Spirifer arduennensis (SCHNUR 1853) [= *Arduspirifer arduennensis* (SCHNUR 1853) = *Acrospirifer arduennensis* (SCHNUR 1853)]	[upper Lower — middle Upper Emsian]
Spirifer subcuspidata (SCHNUR 1854) [= *Subcuspidella subcuspidata* (SCHNUR 1854) MITTMEYER 1972]	
Spirifer curvatus v. SCHLOTHEIM	
Spirifer cf. *incertus* FUCHS	
Spirifer cf. *mediorhenanus* (FUCHS) [= *Alatiformia* cf. *mediorhenana* (FUCHS)]	
Uncinulus pila SCHNUR	
Rhynchonella hexatoma (SCHNUR) [= *Oligoptycherus hexatoma* (SCHNUR)]	
Orthis gervillei DEFRANCE	
Orthis triangularis SANDBERGER	
Orthis cf. *dorsoplana* FRECH	
Anoplotheca venusta SCHNUR 1853	[Emsian (Ulmenian — Upper Emsian; frequent: Laubachian)]
Orthotetes umbraculum SCHLOTHEIM	
Stropheodonta explanata (SOWERBY) [= *Leptostrophia explanata* (SOWERBY)]	
Leptagonia rhomboidalis (WAHLENBERG) [= *Leptaena rhomboidalis* (WAHLENBERG, WILCKENS)]	
Megantheris media MAURER	
Chonetes dilatata (v. ROEMER) DE KONINCK [= *Loreleiella dilatata* (DE KONINCK) = *Eodevonaria dilatata* DE KONINCK]	
Chonetes plebejus (SCHNUR 1853) [= *Plebejochonetes plebejus* (SCHNUR 1853)]	[Emsian]
Chonetes cf. *millestria* FUCHS	
Nucleospira cf. *lens* SCHNUR	

Cypricardinia crenistria SANDBERGER
Gosseletia sp. (DE KONINCK 1883) [Middle Ordovician — Triassic]
Gryphaeus sp.
Fenestella sp.
Crinoid stems
Remarks: stratigraphic range revised to lower Upper Emsian (lower Lahnsteinian, ca. Early ***inversus*** -zone). DK1996: di: ca. 14.2 — 15.4. No greywackes or limestone nodules are observable. Location identical to that of sample S 1 (SOLLE 1942 (vol. 467), p. 170).
Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. Dominating bedding features are graded bedding and laminated sand/silt. Wave energy and mud supply control mud abundance. During heavy storms brachiopod shells together with trochites and other above mentioned fossils were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds.

Sample: M 2 **Quotation:** MICHELS 1926, p. 238 mid
Gauss-Kruger-coordinates: [^{34}37830 - ^{55}85950]
Location: left steep bank of the river Lahn, 100 m uphill opposite the mouth of the Kerkerbach (geological map 1:25000, 5514 Hadamar).
Lithology: More or less micaceous, partly rough, partly mild greywackes or slates of dark, bluegrey colours. Sand content is greater towards the base than towards the top. Remarkable is often a considerable content of limestone- and iron-carbonate, which is always observable in these lithologies everywhere in the Lahn syncline. In the course of weathering develop brittle brightbrown rocks and besides of that often accumulations of iron hydroxide, which may, under favourable circumstances, lead to the build-up of "Krusteneisenstein" (crust iron stone).
Stratigraphic correlation: Upper Koblenzian
Fossils: (det. by MICHELS with confirmation from FUCHS)
Spirifer arduennensis (SCHNUR 1853) [upper Lower — middle Upper Emsian]
[= *Arduspirifer arduennensis* (SCHNUR 1853)
= *Acrospirifer arduennensis* (SCHNUR 1853)]
Spirifer subcuspidata (SCHNUR 1854)
[= *Subcuspidella subcuspidata* (SCHNUR 1854) MITTMEYER 1972]
Anoplotheca venusta SCHNUR 1853 [Emsian (Ulmenian — Upper Emsian; frequent: Laubachian)]
Phacops sp.
numerous "brood" of small brachiopods
Remarks: stratigraphic range revised to Lower Emsian — middle Upper Emsian (Ulmenian — Laubachian, ca. ***excavatus*** — Early ***serotinus*** -zone, DK1996: di: ca. 11.5 — 17.1.). No further temporal subdivision is possible. No greywackes or limestone nodules are observable.
Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. Dominating bedding features are graded bedding and laminated sand/silt. Wave energy and mud supply control mud abundance. During heavy storms brachiopod shells together with other above mentioned fossils were brought in from shallower (max. 75-150m water depth (*Phacops*!)) or epitopographical marine regions and became partly deposited as shell beds.

Sample: M 3 **Quotation:** MICHELS 1926, p. 238 mid
Gauss-Kruger-coordinates: [^{34}39070 - ^{55}86740 (or ^{34}39080 - ^{55}86860, or both?)]
Location: right bank of the Kerkerbach westsouthwest of the track Schadeck—Steeden (geological map 1:25000, 5514 Hadamar).
Lithology: More or less micaceous, partly rough, partly mild greywackes or slates of dark, bluegrey colours. Sand content is greater towards the base than towards the top. Remarkable is often a considerable content of limestone- and iron-carbonate, which is always observable in these lithologies everywhere in the Lahn syncline. In the course of weathering develop brittle brightbrown rocks and besides of that often accumulations of iron hydroxide, which may under favourable circumstances lead to the build-up of "Krusteneisenstein" (crust iron stone).
Stratigraphic correlation: Upper Koblenzian

Fossils: (det. by MICHELS with confirmation from FUCHS; fossils badly preserved).

Spirifer arduennensis (SCHNUR 1853) [= *Arduspirifer arduennensis* (SCHNUR 1853) = *Acrospirifer arduennensis* (SCHNUR 1853)]	[upper Lower — lower Upper Emsian]
Anoplotheca venusta SCHNUR 1853	[Emsian (Ulmenian — Upper Emsian; frequent: Laubachian)]
Spirifer cf. *cultrijugatus* (F. ROEMER 1844) [= *Paraspirifer* cf. *cultrijugatus* SOLLE 1971]	[Late Upper Emsian (middle Kondel-group) — lowermost Lower Eifelian (Lauchian), DK1996: di: 18.0 — dm: 1.2]

Further determinable fossils were found.
Remarks: stratigraphic range revised to Lower Emsian — middle Upper Emsian (Ulmenian — Laubachian, ca. ***excavatus*** — Early ***serotinus*** -zone, DK1996: di: ca. 11.5 — 17.1.). No further temporal subdivision is possible. No greywackes or limestone nodules are observable. *A. arduennensis* and *P. cultrijugatus* never have been observed together. Therefore the determination of *P.* cf. (!) *cultrijugatus* is probably wrong. Maybe *Paraspirifer sandbergeri* SOLLE 1971 was erroneously determined as *P.* cf. *cultrijugatus*.
Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. Dominating bedding features are graded bedding and laminated sand/silt. Wave energy and mud supply control mud abundance. During heavy storms brachiopod shells together with other fossils mentioned above were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds.

Sample: M 4 **Quotation:** MICHELS 1926, p. 239 mid
Gauss-Kruger-coordinates: [^{34}40760 - ^{55}87500]
Location: At the eastern margin of the geological map 1:25000, 5514 Hadamar, southeast of Hofen. See appendix F 2.1, fig. F 2.3.
Lithology: Mostly blueblack, often roofing-slate like, partly sandy, slates with calcareous nodules. Sometimes occurring rough appearance due to higher content of micas. The calcareous intercalations are partly developed as calcareous nodules or partly as layers. Within the slates also small intercalations of eruptiva occur, which developed from a keratophyric magma.
Stratigraphic correlation: Lower Middle Devonian
Fossils: (det. by MICHELS with confirmation from FUCHS).

Mimoceras [HYATT 1884] *gracilis* BRONN 1835 [= *Gyroceratites gracilis* BRONN 1835]	[Upper Emsian; frequent: lowermost Upper Emsian]
Orthoceras sp.	
Crinoid stems	

Remarks: stratigraphic range revised to Upper Emsian (ca. ***inversus*** — ***patulus*** -zone, DK1996: di: ca. 14.3 — (15.1) — 20.0). The calcareous parts at the western termination of the profile had been determined by VOGT to be of ? Middle Devonian age (samples AV 255 and AV 295). Therefore the above mentioned slates represent maybe a Upper Emsian succession. Location almost identical to that of sample S 2 (SOLLE 1942 (vol. 467), p. 173 bottom).
The described intercalations of "keratophyric (silica enriched, quartz-porphyric, basaltic) magma" are misinterpreted by MICHELS due to their "irregular" appearance. HENTSCHEL recognises the magma as spilitic (1979:67-69) and gives a more detailed description (1979: 69): "At last it has to be mentioned as a mineralogically-petrographically rarity, that a small spilitic succession contains breccia-like broken parts, in which with irregular shape black-gleaming anthracite, formerly described as schungite, occurs. The quartzose cement and the next-neighbour spilitic rock are also penetrated by sufficient amounts of epidote. This spilite lies parallel to bedding in Lower Middle Devonian slates [...] (ca. at r ^{34}4062, h ^{55}8764)." HENTSCHEL (1979:67) defines the spilites in this area of the Lahn-syncline as "effusive rocks, which main mineral components are: albitic plagioclase + chlorite". The metamorphic mineral chlorite is treated as mappable index mineral in order to distinguish the spilites from diabases with the main mineral constituents: pyroxene + plagioclase.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge. Episodic volcanic activity lead to submarine basaltic magma outflow.

Sample: M 5 **Quotation:** MICHELS 1926, p. 239 mid
Gauss-Kruger-coordinates: [^{34}40570 - ^{55}87650]
Location: At the eastern margin of the geological map 1:25000, 5514 Hadamar, southeast of Hofen. See appendix F 2.1, fig. F 2.3.
Lithology: Mostly blueblack, often roofing-slate like, partly sandy, slates with calcareous nodules. Sometimes occurring rough appearance due to higher content of micas. The calcareous intercalations are partly developed as calcareous nodules or partly as layers. Within the slates also small intercalations of eruptiva occur, which developed from a keratophyric magma.
Stratigraphic correlation: ? lower Middle Devonian (Wissenbacher Schiefer)

Fossils: (det. by MICHELS with confirmation from FUCHS; in the calcareous nodules, badly preserved).

Anarcestes ? [Gen. *Anarcestes*: Upper Emsian — lowermost Eifelian (lower Lauchian)]

Zaphrentis sp.

Phacopids (small, very numerous)

Remarks: revised stratigraphic range assumed as Upper Emsian — lowermost Eifelian (ca. Late ***inversus* — *partitus*** -zone). DK1996: di: ca. 15.1 — dm: 0.6. Sample taken ca. 200 m westwards (along forest road) from location M 4 (^{34}40760 - ^{55}87500). Location almost identical to that of sample S 2 (SOLLE 1942 (vol. 467), p. 173 bottom), samples AV 255 and AV 295 and probably KR 2 of KREKELER (1928). The described "keratophyric magma" occurs more eastward in the succession (compare location M 4).

Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge.

F 1.11 MUNK 1981

Sample: MU 1 (Co1-o3) **Quotation:** MUNK 1981, p. 57 top-middle + 59 (Profil 1)

Gauss-Kruger-coordinates: ^{34}46160 - ^{55}91220

Location: within an old surficial prospection pit at the forest track from Grube (mine) Georg-Joseph to the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).

Lithology: "Dillenburger Schichten": 1.95m succession of (from bottom to top): a) min. 0.15m reworked tuff, bedded, fine-grained, yellowish; b) 0.03m limestone, slaty, yellowish, weathered; c) 0.06m slates, reddish; d) 0.63m pyroclastic deposit, bedded, coarse- to fine-grained, olive brown (+ between 0.53-0.55m iron ore layer); e) 0.15m limestone, darkred to grey; f) 0.12m tuff-bearing pyroclastic deposit, bedded, fine-grained, olive brown; g) 0.06m limestone, grey; h) min. 0.75m pyroclastic deposit, coarse- to fine-grained, olive brown.

Stratigraphic correlation: Givetian, upper *hermanni-cristatus*-zone

Fossils: (det. by MUNK, with maintenance by BENDER, from the limestones b (Co3), e (Co1), g (Co2))

Co2, 1.20m from bottom, DK1996: dm 18.3 — ds 1.4

Polygnathus decorosus STAUFFER [1938] [?upper *hermanni-cristatus* (?18.3) — ?in *crepida*]

Polygnathus dengleri BISCHOFF & ZIEGLER [1958] [upper *hermanni-cristatus* (18.3) — in *transitans* (ds1.4)]

Co1, 0.95m from bottom, DK1996: dm 18.3 — ds 1.4

Spathognathodus sannemanni sannemanni (BISCHOFF & ZIEGLER) [= *Ozarkodina sannemanni sannemanni* (BISCHOFF & ZIEGLER 1957)] [upper *varcus* (17.0) — near top of *punctata* (ds2.2)]

Polygnathus cristatus HINDE [1879] [upper *hermanni-cristatus* (18.3) — *punctata* (2.3)]

Polygnathus decorosus STAUFFER [1938] [?upper *hermanni-cristatus* (?18.3) — ?in *crepida*]

Co3, 0.17m from bottom, DK1996: (dm 18.7 — ds 1.4)

Palmatolepis (?) cf. *disparalvea* ORR & KLAPPER [lower *disparilis* (dm 18.7) — in *transitans* (ds1.4)]

Remarks: revised stratigraphic range: late Givetian to earliest Frasnian (upper *hermanni-cristatus* — in *transitans*-zone). DK1996: dm 18.3 — ds 1.4.

Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Succession of a) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris (and maybe of finesand) from higher parts of a submarine ridge; b) (turbiditic?) deposition of reworked fine-grained pyroclastic deposits, punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous debris. Episodic submarine volcanic activity lead to deposition of tuff layers.

Sample: MU 2 (Co4) **Quotation:** MUNK 1981, p. 57 middle-bottom + 68 (Profil 2)

Gauss-Kruger-coordinates: ^{34}46140 - ^{55}91250

Location: ca. 30m northwards of MU 1, northwards of the forest track from Grube (mine) Georg-Joseph to the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).

Lithology: "Adorf-Plattenkalke (-platy limestones)": 2.45m succession of (from bottom to top): a) min. 0.88m limestone, thick bedded, partly laterally inconsistent, partly platy, splitting, with pelitic intercalations, black-blackgrey; b) 0.09m slates, brown; c) 0.37m = lithology a) ; d) 0.08m slate, yellowbrown; e) 1.03m = lithology a)

Stratigraphic correlation: Adorfian, middle *asymmetricus*-zone

Fossils: (det. by MUNK, with maintenance by BENDER, from the limestones a (0.1m), c (1.3m), e (1.8m))

Co4, 1.8m from bottom, DK1996: ds 1.7 — 2.0

Ancyrodella gigas [YOUNGQUIST 1947] [*punctata* — Early *rhenana*]
Ancyrodella lobata BRANSON & MEHL [1934] [*punctata* — in Late *rhenana*]
Polygnathus ancyrognathoideus [near base Early *falsiovalis* — *jamiae*]
[= *Ancyrognathus ancyrognathoideus* (ZIEGLER 1958)]
Polygnathus pennatus HINDE [1879] [within *kockelianus* (ca. 6.4) — in *punctata* (ds2.0)]
Palmatolepis punctata [ZIEGLER 1965 (p.663 bottom)] [*punctata* (1.7)— Early *rhenana* (4.9)]
[= *Polygnathus punctata* HINDE 1879
= *Palmatolepis martenbergensis* MÜLLER 1956, nom. nud.]
Palmatolepis transitans MÜLLER [1956] [*transitans* (1.1) — near top Late *hassi* (3.5)]
Palmatolepis proversa ZIEGLER [*punctata* — near top Early *rhenana*]

Co4, 1.3m from bottom, DK1996: ds 1.7 — 2.0 (? + reworked DK1996: dm 18.3 — 1.1)

Ancyrodella gigas [YOUNGQUIST 1947] [*punctata* — Early *rhenana*]
Polygnathus ancyrognathoideus [near base Early *falsiovalis* — *jamiae*]
[= *Ancyrognathus ancyrognathoideus* (ZIEGLER 1958)]
Palmatolepis proversa ZIEGLER [*punctata* — near top Early *rhenana*]
Palmatolepis punctata [ZIEGLER 1965 (p.663 bottom)] [*punctata* (1.7)— Early *rhenana* (4.9)]
[= *Polygnathus punctata* HINDE 1879
= *Palmatolepis martenbergensis* MÜLLER 1956, nom. nud.]
Polygnathus dubius HINDE [1879 (nom. dub.)] [upper *hermanni-cristatus* — ?Late *falsiovalis*]
Polygnathus pennatus HINDE [1879] [within *kockelianus* (ca. 6.4) — in *punctata* (ds2.0)]

Co4, 0.1m from bottom, DK1996: ds 1.7 — 2.0

Ancyrodella lobata BRANSON & MEHL [1934] [*punctata* — in Late *rhenana*]
Polygnathus asymmetricus asymmetricus (BISCHOFF & ZIEGLER 1957) [Late *falsiovalis* (0.5) — near top Early *hassi* (2.8)]
[= *Mesotaxis asymmetricus asymmetricus* SANDBERG, ZIEGLER & BULTYNCK 1989]
Palmatolepis proversa ZIEGLER [*punctata* — near top Early *rhenana*]
Palmatolepis transitans MÜLLER [1956] [*transitans* (1.1) — near top Late *hassi* (3.5)]
Polygnathus pennatus HINDE [1879] [within *kockelianus* (ca. 6.4) — in *punctata* (ds2.0)]

Remarks: revised stratigraphic range: early Frasnian (Early — within ***punctata***-zone). DK1996: ds 1.7 — 2.0 (? + reworked DK1996: dm 18.3 — 1.1 (upper *hermanni-cristatus* — ?Late *falsiovalis*-zone) in parts).

Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Depocentre near the top of the ridge is indicated by the relative thick succession of calcareous debris. Main constituent of the sedimentary facies is clay-finesilt with episodic intercalations of calcareous debris from higher parts of the submarine ridge. Speculation: relative near-shore polygnathid-ancyrodellid biofacies conodonts reworked (during heavy storms?) and transported downslope into an environment of polygnathid-palmatolepid biofacies.

Sample: MU 3 (Co5) **Quotation:** MUNK 1981, p. 65 middle + 63 bottom
Gauss-Kruger-coordinates: around [^{34}46140 - ^{55}91250]
Location: at the same location as MU 2, ca. 30m northwards of the forest track from Grube (mine) Georg-Joseph to the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: "Adorf-Plattenkalke (-platy limestones)": min. ca. 3m succession of a) platy limestones, mm-dm (40cm) bedded (normal ca. 10-20cm); b) thin, mm-cm bedded brownish slates to marly slates.
Stratigraphic correlation: Adorfian, middle *asymmetricus*-zone
Fossils: (det. by MUNK, with maintenance by BENDER, from the limestones)

Ancyrodella gigas [YOUNGQUIST 1947] [*punctata* — Early *rhenana*]
Ancyrodella lobata BRANSON & MEHL [1934] [*punctata* — in Late *rhenana*]
Polygnathus ancyrognathoideus [near base Early *falsiovalis* — *jamiae*]
[= *Ancyrognathus ancyrognathoideus* (ZIEGLER 1958)]
Polygnathus (asymmetricus) ovalis ZIEGLER & KLAPPER [1964] [Early *falsiovalis* (dm 19.7) — in Late *hassi* (ds3.3)]
[= *Klapperina ovalis* SANDBERG, ZIEGLER & BULTYNCK 1989]
Polygnathus asymmetricus asymmetricus (BISCHOFF & ZIEGLER 1957) [Late *falsiovalis* (0.5) — near top Early *hassi* (2.8)]
[= *Mesotaxis asymmetricus asymmetricus* SANDBERG, ZIEGLER & BULTYNCK 1989]
Palmatolepis punctata [ZIEGLER 1965 (p.663 bottom)] [*punctata* (1.7)— Early *rhenana* (4.9)]
[= *Polygnathus punctata* HINDE 1879
= *Palmatolepis martenbergensis* MÜLLER 1956, nom. nud.]
Palmatolepis proversa ZIEGLER [*punctata* — near top Early *rhenana*]
Palmatolepis transitans MÜLLER [1956] [*transitans* (1.1) — near top Late *hassi* (3.5)]

Polygnathus dubius HINDE [1879 (nom. dub.)]	[upper *hermanni-cristatus* — ?Late *falsiovalis*]
Polygnathus pennatus HINDE [1879]	[within *kockelianus* (ca. dm6.4) — in *punctata* (ds2.0)]
Schmidtognathus pietzneri ZIEGLER [1965]	[upper *hermanni-cristatus* (dm18.3) — in Late *falsiovalis* (ds0.7)]

Remarks: revised stratigraphic range: early Frasnian (Early — within ***punctata***-zone). DK1996: ds 1.7 — 2.0 (+ reworked DK1996: dm 18.3 — 0.7 (upper *hermanni-cristatus* — "Middle" *falsiovalis*-zone)).
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Depocentre near the top of the ridge is indicated by the relative thick succession of calcareous debris. Main constituent of the sedimentary facies is clay-finesilt with episodic intercalations of calcareous debris from higher parts of the submarine ridge. Speculation: relative near-shore polygnathid-ancyrodellid biofacies conodonts reworked (during heavy storms?) and transported downslope into an environment of polygnathid-palmatolepid biofacies.

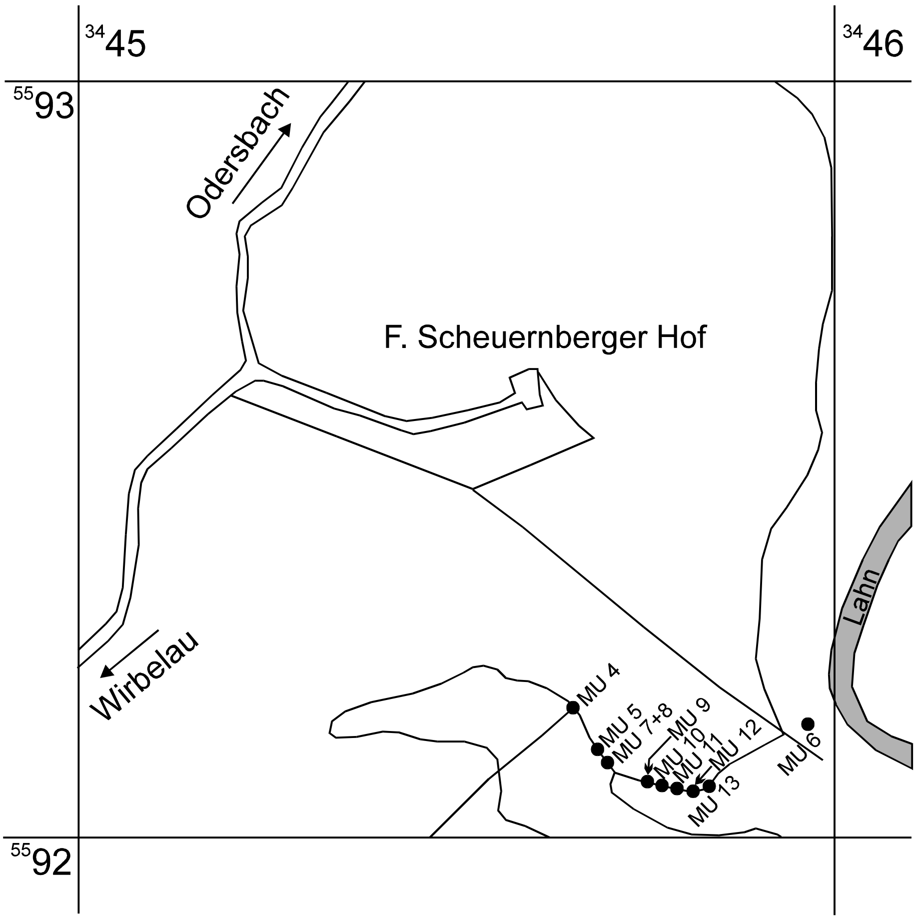


Fig. F 1.3: Sketch map showing the reconstructed locations for the samples MU 4-13 (MUNK 1981).

Sample: MU 4 (P12E1) **Quotation:** MUNK 1981, p. 76 middle + 80a (columnar section)
Gauss-Kruger-coordinates: ^{34}45650 - ^{55}92170
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) greenish to greygreen slates and marly slates; intercalated by b) thin, black and reddish slates and c) grey calcareous layers (partly in 10-15 cm bedded rhythmical succession). In parts also silica-enriched dark slaty nodules occur.
Stratigraphic correlation: Adorfian, upper *triangularis*-zone and Hembergian, middle to upper *velifer*-zone
Fossils: (det. by MUNK, with maintenance by BENDER, from the limestones)

Ancyrodella ioides ZIEGLER [1958]	[*jamiae* — in Late *rhenana*]
Ancyrodella nodosa ULRICH & BASSLER [1926]	[Late *hassi* — in Late *rhenana*]

Ancyrognathus triangularis Youngquist [1947]	[Late *hassi* — in Late *rhenana*]
Palmatolepis perlobata schindewolfi Müller [1956]	[Latest *crepida* — Late *expansa*]
Palmatolepis rugosa trachytera Ziegler [1960]	[Early — Late *trachytera*]
Palmatolepis subrecta Miller & Youngquist [1947]	[Late *rhenana* (4.9) — in *linguiformis* (5.8)]
Scaphignathus velifer Ziegler [= *Scaphignathus velifer velifer* Ziegler 1960]	[Latest *marginifera* — Late *trachytera*]

Remarks: revised stratigraphic range: middle Famennian, middle Hembergian (Early — Late ***trachytera***-zone). DK1996: ds 13.2 — 15.2 (+ reworked DK1996: ds 4.9 — 5.2 (late Adorfian; base Late — within Late *rhenana*-zone)). Munk denies the occurrence of reworked late Adorfian conodonts; he rather declares that at the sample location a not clearly visible fault must have taken place, at which he must have taken calcareous samples from below and above the fault.
Presumable sedimentary environment: Deposition of mud from suspension within an iron-enriched water column at the slope of a submarine ridge, punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous debris (and maybe of silt) from higher parts of the submarine ridge. Colour changes from red to green to black indicate varying redox conditions and iron-content (due to submarine release of hydrothermal waters nearby?).The small nodules which show a cherty character are probably thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: MU 5 (P11E1) **Quotation:** Munk 1981, p. 86 middle + 80a (columnar section)
Gauss-Kruger-coordinates: ^{34}45690 - ^{55}92120
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: Nehden-Rotschiefer (Nehdenian red slates): red, mostly carbonate-free, slates with distinct intercalations of layers of calcareous nodules, which become more frequent towards the top of the ca. 50m thick succession.
Stratigraphic correlation: Nehdenian, lower *marginifera*-zone
Fossils: (det. by Munk, with maintenance by Bender, from the limestones)

Palmatolepis quadrantinodosa inflexoidea Ziegler [1962]	[Late *rhomboidea* — Early *marginifera*]
Palmatolepis glabra lepta Ziegler & Huddle	[Early *marginifera* — in Late *trachytera*]
Palmatolepis glabra prima Ziegler & Huddle	[Late *crepida* — Late *marginifera*]
Palmatolepis perlobata schindewolfi Müller [1956]	[Latest *crepida* — Late *expansa*]
Palmatolepis (quadrantinodosa) marginifera marginifera Helms [1961] [= *Palmatolepis quadrantinodosa marginifera* Ziegler 1960]	[Early *marginifera* — in Early *trachytera*]

Remarks: confirmed stratigraphic range: middle Famennian, late Nehdenian (Early ***marginifera***-zone). DK1996: ds 11.9 — 12.6.
Presumable sedimentary environment: Deposition of mud from suspension near the base of the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge. Increasing carbonate-content towards the top of the succession maybe due to slight sea-level fall with increased carbonate production or erosion.

Sample: MU 6 (Po1) **Quotation:** Munk 1981, p. 86 bottom + 80a (columnar section)
Gauss-Kruger-coordinates: ^{34}45960 - ^{55}92150
Location: outcrop ca. 30m below a forest track near the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: Nehden-Rotschiefer (Nehdenian red slates): red, mostly carbonate-free, slates with distinct intercalations of layers of calcareous nodules, which become more frequent towards the top of the ca. 50m thick succession.
Stratigraphic correlation: Nehdenian, lower part of lower *marginifera*-zone
Fossils: (det. by Munk, with maintenance by Bender, from the limestones)

Palmatolepis glabra pectinata Ziegler [1960]	[Latest *crepida* — Late *marginifera*]
Palmatolepis glabra prima Ziegler & Huddle	[Late *crepida* — Late *marginifera*]
Palmatolepis minuta minuta Branson & Mehl [1934]	[Late *triangularis* — Latest *marginifera*]
Palmatolepis perlobata schindewolfi Müller [1956]	[Latest *crepida* — Late *expansa*]
Palmatolepis quadrantinodosa quadrantinodosa Branson & Mehl	[Early *marginifera*]
Palmatolepis rhomboidea Sannemann [1955]	[Early *rhomboidea* — in Early *marginifera*]

Remarks: confirmed stratigraphic range: middle Famennian, late Nehdenian (base Early — in Early ***marginifera***-zone). DK1996: ds 11.9 — 12.3.
Presumable sedimentary environment: Deposition of mud from suspension near the base of the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge. Increasing carbonate-content towards the top of the succession maybe due to slight sea-level fall with increased carbonate production or erosion.

Sample: MU 7 (P10E5) **Quotation:** MUNK 1981, p. 87 top + 80a (columnar section)
Gauss-Kruger-coordinates: $^{34}45700$ - $^{55}92110$
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: Nehden/Hemberg-Rotschiefer (Nehdenian/Hembergian red slates): red slates with distinct intercalations of layers of calcareous nodules.
Stratigraphic correlation: Nehdenian/Hembergian, lower/upper *marginifera*-zone
Fossils: (det. by MUNK, with maintenance by BENDER, from the limestones)

Palmatolepis minuta minuta BRANSON & MEHL [1934]	[Late *triangularis* — Latest *marginifera*]
Palmatolepis perlobata schindewolfi MÜLLER [1956]	[Latest *crepida* — Late *expansa*]
Palmatolepis quadrantinodosa inflexa MÜLLER [1956]	[Early *rhomboidea* — Early *marginifera*]
Palmatolepis glabra lepta ZIEGLER & HUDDLE	[Early *marginifera* — in Late *trachytera*]
Palmatolepis marginifera marginifera HELMS 1961	[Early *marginifera* — in Early *trachytera*]
[= *Palmatolepis quadrantinodosa marginifera* ZIEGLER 1960]	
Palmatolepis rugosa cf. *ampla* MÜLLER [1956]	[in Early *postera* — in Late *expansa*]
Palmatolepis perlobata sigmoidea ZIEGLER [1962]	[Early *marginifera* — in Late *postera*]
Palmatolepis glabra distorta (BRANSON & MEHL [1934])	[Early *marginifera* — in Early *trachytera*]
Palmatolepis minuta schleizia HELMS [1961]	[Late *rhomboidea* — Late *postera*]
Polygnathus bicavatus ZIEGLER [1962]	[Early — Latest *marginifera*]
Polylophodonta linguiformis BRANSON & MEHL [1934]	[?Early *rhomboidea* — ?Late *trachytera*]

Remarks: confirmed stratigraphic range: middle Famennian, late Nehdenian to lower Hembergian (Early — Latest ***marginifera***-zone). DK1996: ds 11.9 — 13.9. *P. r.* cf. *ampla* may indicate an younger depositional age (= Hembergian/Dasbergian), but lacks as "cf.-form" significant evidence. Compare sample MU 8, taken in immediate vicinity.
Presumable sedimentary environment: Deposition of mud from suspension near the base of the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge.

Sample: MU 8 (P10E3) **Quotation:** MUNK 1981, p. 94 middle + 80a (columnar section)
Gauss-Kruger-coordinates: $^{34}45701$ - $^{55}92110$
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg). Sample taken in immediate vicinity of sample MU 7.
Lithology: succession of a) red slates with layers of calcareous nodules and intercalations of b) cm to dm thick beds of greenish, calcareous (20-30%), graded bedded sandstones, which may develop a total thickness of up to 15m.
Stratigraphic correlation: Hembergian, middle *velifer*-zone
Fossils: (det. by MUNK, with maintainance by BENDER, from the calcareous nodules of lithology a)

Palmatolepis glabra distorta (BRANSON & MEHL [1934])	[Early *marginifera* — in Early *trachytera*]
Palmatolepis minuta minuta BRANSON & MEHL [1934]	[Late *triangularis* — Latest *marginifera*]
Palmatolepis minuta schleizia HELMS [1961]	[Late *rhomboidea* — Late *postera*]
Palmatolepis perlobata schindewolfi MÜLLER [1956]	[Latest *crepida* — Late *expansa*]
Palmatolepis rugosa trachytera ZIEGLER [1960]	[Early — Late *trachytera*]

Remarks: revised stratigraphic range: middle Famennian, middle Hembergian (Early — in Early ***trachytera***-zone). DK1996: ds 13.9 — 14.3. The "sandstones" consist mainly of reworked pyroclastic deposits.
Presumable sedimentary environment: Deposition of mud from suspension within an iron-enriched water column near the base of the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge. Deposition of reworked pyroclastic deposits probably due to explosive submarine magma release with subsequent deposition and turbiditic redeposition of sand-sized volcanic particles.

Sample: MU 9 (P13: 340m) **Quotation:** MUNK 1981, p. 94 bottom + 80a (columnar section)
Gauss-Kruger-coordinates: $^{34}45750$ - $^{55}92090$
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) red slates with layers of calcareous nodules and intercalations of b) cm to dm thick beds of greenish, calcareous (20-30%), graded bedded sandstones, which may develop a total thickness of up to 15m.
Stratigraphic correlation: Hembergian, lower to upper *velifer*-zone
Fossils: (det. by MUNK, with maintenance by BENDER, from the calcareous nodules of lithology a)

Palmatolepis glabra lepta ZIEGLER & HUDDLE	[Early *marginifera* — in Late *trachytera*]
Palmatolepis gracilis gracilis BRANSON & MEHL [1934]	[Late *rhomboidea* — in *sulcata*]
Palmatolepis minuta schleizia HELMS [1961]	[Late *rhomboidea* — Late *postera*]
Palmatolepis perlobata schindewolfi MÜLLER [1956]	[Latest *crepida* — Late *expansa*]

Palmatolepis rugosa trachytera ZIEGLER [1960] [Early — Late *trachytera*]
Scaphignathus velifer ZIEGLER [Latest *marginifera* — Late *trachytera*]
[= *Scaphignathus velifer velifer* ZIEGLER 1960]
Remarks: revised stratigraphic range: middle Famennian (Early — in Late ***trachytera***-zone). DK1996: ds 13.9 — 14.9. The "sandstones" consist mainly of reworked pyroclastic deposits.
Presumable sedimentary environment: Deposition of mud from suspension within an iron-enriched water column near the base of the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge. Deposition of reworked pyroclastic deposits probably due to explosive submarine magma release with subsequent deposition and turbiditic redeposition of sand-sized volcanic particles.

Sample: MU 10 (P8E1) **Quotation:** MUNK 1981, p. 98 middle + 80a (columnar section)
Gauss-Kruger-coordinates: ^{34}45770 - ^{55}92070
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) redbrown, partly greygreen, slates with rare layers of calcareous nodules and b) cm-dm thick graded beds of greenish, calcareous sandstones, which show a total thickness of ca. 12m.
Stratigraphic correlation: Dasbergian, upper *styriacus*-zone
Fossils: (det. by MUNK, with maintenance by BENDER, from the calcareous nodules of lithology a)
Spathognathodus bohlenanus (HELMS) [in Latest *marginifera* — in Early *expansa*]
[= *Branmehla bohlenana* (HELMS 1961)]
Palmatolepis gracilis gracilis BRANSON & MEHL [1934] [Late *rhomboidea* — in *sulcata*]
Palmatolepis gracilis sigmoidalis ZIEGLER [1962] [Late *trachytera* — Late *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER [1956] [Latest *crepida* — Late *expansa*]
Polygnathus styriacus ZIEGLER [1957] [Early *postera* — Early *expansa*]
Remarks: revised stratigraphic range: late Famennian, late Hembergian to earliest Dasbergian (Early *postera* — in Early *expansa*-zone). DK1996: ds 15.2 — 16.8. The "sandstones" consist mainly of reworked pyroclastic deposits.
Presumable sedimentary environment: Deposition of mud from suspension within an iron-enriched water column near the base of the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge. Deposition of reworked pyroclastic deposits probably due to explosive submarine magma release with subsequent deposition and turbiditic redeposition of sand-sized volcanic particles.

Sample: MU 11 (P8E2 + P10E1) **Quotation:** MUNK 1981, p. 158 bottom + 80a (columnar section)
Gauss-Kruger-coordinates: ^{34}45790 - ^{55}92080
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) void-rich spilites, partly as near-surface intrusions into former soft sediments (calcareous debris); b) tuff; c) pillow diabas with inclusions of calcareous layers and nodules.
Stratigraphic correlation: Hembergian, lower to middle part of upper *velifer*-zone
Fossils: (det. by MUNK, with maintenance by BENDER, from the limestones of lithology a)

<u>P10E1, western part of the outcrop, DK1996: ds 13.9 — 15.2</u>
Palmatolepis perlobata schindewolfi MÜLLER [1956] [Latest *crepida* — Late *expansa*]
Palmatolepis rugosa trachytera ZIEGLER [1960] [Early — Late *trachytera*]
Scaphignathus velifer ZIEGLER [Latest *marginifera* — Late *trachytera*]
[= *Scaphignathus velifer velifer* ZIEGLER 1960]

<u>P8E2, eastern part of the outcrop, DK1996: ds 13.9 — 15.2</u>
Palmatolepis minuta schleizia HELMS [1961] [Late *rhomboidea* — Late *postera*]
Palmatolepis perlobata [*rugosa*] *grossi* (ZIEGLER [1960]) [in Late *marginifera* — Late *trachytera*]
Palmatolepis perlobata schindewolfi MÜLLER [1956] [Latest *crepida* — Late *expansa*]
Palmatolepis rugosa trachytera ZIEGLER [1960] [Early — Late *trachytera*]

Remarks: revised stratigraphic range: middle/late Famennian, middle Hembergian (Early — Late ***trachytera***-zone). DK1996: ds 13.9 — 15.2. Compare MU 13.
Presumable sedimentary environment: submarine basic volcanic activity at the slope of a submarine ridge: a) submarine basaltic magma outflow on and in unlithified siliceous and calcareous sediments; b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris from higher parts of the submarine ridge; c) development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments.

Sample: MU 12 (P5E3) **Quotation:** MUNK 1981, p. 98 bottom + 80a (columnar section)
Gauss-Kruger-coordinates: $^{34}45810$ - $^{55}92070$
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) redbrown, partly greygreen, slates with rare layers of calcareous nodules and b) cm-dm thick graded beds of greenish, calcareous sandstones, which show a total thickness of ca. 12m.
Stratigraphic correlation: Dasbergian, lower *costatus*-zone
Fossils: (det. by MUNK, with maintenance by BENDER, from the limestones)

Dasbergina ziegleri (HELMS) [= *Bispathodus ziegleri* (HELMS 1961)]	[Late *expansa* — in Middle *praesulcata*]
Spathognathodus jugosus (BRANSON & MEHL 1934) [= *Bispathodus jugosus* (BRANSON & MEHL 1934)]	[in Early — (?in) Late *expansa*]
Palmatolepis gracilis gracilis BRANSON & MEHL [1934]	[Late *rhomboidea* — in *sulcata*]
Polygnathus extralobatus SCHÄFER	[in Early — in Late *expansa*]
Pseudopolygnathus micropunctatus BISCHOFF & ZIEGLER [1956]	[?within Early *expansa*]

Remarks: revised stratigraphic range: late Famennian, latest Dasbergian to earliest Wocklumian (base Late — in Late ***expansa***-zone). DK1996: ds 17.7 — 18.1. The "sandstones" consist mainly of reworked pyroclastic deposits.
Presumable sedimentary environment: Deposition of mud from suspension within an iron-enriched water column near the base of the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge. Deposition of reworked pyroclastic deposits probably due to explosive submarine magma release with subsequent deposition and turbiditic redeposition of sand-sized volcanic particles.

Sample: MU 13 (P4E1 + P1,2) **Quotation:** MUNK 1981, p. 159 top + 80a (columnar section)
Gauss-Kruger-coordinates: $^{34}45830$ - $^{55}92070$
Location: outcrop at a forest track at the slope uphill the west bank of the river Lahn (geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) void-rich spilites, partly as near-surface intrusions into former soft sediments (calcareous debris); b) tuff; c) pillow diabas with inclusions of calcareous layers and nodules.
Stratigraphic correlation: Hembergian, *velifer*- — lower *styriacus*-zone
Fossils: (det. by MUNK, with maintenance by BENDER, from the limestones of lithology c)

Palmatolepis perlobata schindewolfi MÜLLER [1956]	[Latest *crepida* — Late *expansa*]
Scaphignathus velifer ZIEGLER [= *Scaphignathus velifer velifer* ZIEGLER 1960]	[Latest *marginifera* — Late *trachytera*]

Remarks: revised stratigraphic range: middle Famennian, lower to middle Hembergian (Latest *marginifera* — Late *trachytera*-zone). DK1996: ds 13.3 — 15.2. Compare MU 11.
Presumable sedimentary environment: submarine basic volcanic activity at the slope of a submarine ridge: a) submarine basaltic magma outflow on and in unlithified siliceous and calcareous sediments; b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris from higher parts of the submarine ridge; c) development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments.

F 1.12 OETKEN 1997
(detailed fossil lists in this actual publication)

Sample: O 1 (S 4) **Quotation:** OETKEN 1997, p. 11 bottom, 13 top, 19 top
Gauss-Kruger-coordinates: $^{34}41650$ - $^{55}92280$
Location: former Terazzo-quarry in the Kerkerbach valley, 1.5km northeast of Schupbach (geological map 1:25000, 5515 Weilburg).
Lithology: up to ca. 85m limestone succession of a) lapilli-reworked tuff with reworked reef-organisms and reef derived lithoclasts; b) floatstone/bindstone with (mudstone-) wackestone matrix and *Syringopora* as sediment-binder; c) wackestones (/packstones) with brachiopods; d) rudstones (/grainstones), with stromatopores and tabulate corals; e) grainstones (/packstones) with bioturbation and peloids; f) floatstones with wackestone matrix, bearing *Amphipora* and *Stachyodes*.
Stratigraphic correlation: middle Givetian, Middle *varcus*-subzone
Fossils: (det. by OETKEN)
conodonts, benthic shallow-water ostracods, bryozoan remnants

Remarks: confirmed stratigraphic range: late Givetian; (Middle ***varcus*** -zone). DK1996: dm 14.1 — 17.0. BUGGISCH & FLÜGEL (1992: 82-84, 86) described conodont faunas from this location which also account for an age correlation with the Middle *varcus*-zone. Their results are discussed and incorporated in OETKEN (1997) and therefore not separately listed above.
Presumable sedimentary environment: massive clastic limestones, deposited within a fore-reef region proximal to the reef. The layers represent probably an ecological succession from the first settlement of reef organisms towards a fully developed reef. Belodellid biofacies.

Sample: O 2 (S 1) **Quotation:** OETKEN 1997, p. 21 bottom, 26 middle, 28
Gauss-Kruger-coordinates: ^{34}41870 - ^{55}91500
Location: abandoned limestone quarry, 500m northeast of Schupbach (geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) ca. 7m reef-limestones of biostromal character; b) ca. 15m, dm-m thick bedded, grey to darkgrey debritic limestones with increasing clay-content and occurrence of flaser bedding and thin tuff-layers towards the top. Roughly from bottom to top the following facies types are observable: 1) floatstones with *Stachyodes* + *Thamnopora* and grainstone/packstone- or wackestone/packstone matrix, 2) floatstones with stromatopores and packstone/grainstone-matrix, 3) rudstones with *Stachyodes* + *"Thamnopora"*, 4) bindstones with stromatopores and tabulate corals (*Alveolites*), 5) floatstones with stromatopores and mudstone/packstone-matrix, 6) wackestones/packstones with bioturbation, 7) mudstones/wackestones with gastropods, crinoids, calcispheres and peloids.
Stratigraphic correlation: Lowermost Frasnian, Late *falsiovalis*-subzone
Fossils: (det. by OETKEN)
conodonts, ostracods, crinoids, brachiopods, stromatopores, corals, gastropods, calcispheres, foraminifers
Remarks: confirmed stratigraphic range: lowermost Frasnian; (Late ***falsiovalis***-zone). DK1996: ds 0.5 — 1.1.
Presumable sedimentary environment: Deposition of biostromal reef-limestones on top of a submarine ridge, succeeded by deposition of clay with intercalations of detrital limestones due to increasing rise of the sea-water level. Episodic deposition of tuff layers due to short-termed explosive volcanic activity. Polygnathid-Icriodontid biofacies.

Sample: O 3 (S 3) **Quotation:** OETKEN 1997, p. 36, 39 middle
Gauss-Kruger-coordinates: ^{34}41770 - ^{55}92040
Location: abandoned quarry "Rosario", 750m northeast of Schupbach (geological map 1:25000, 5515 Weilburg).
Lithology: limestone-succession of: a) floatstones with stromatopores and tabulate corals, b) floatstones with brachiopods and "*thamnopora*", c) wackestones/packstones/grainstones (partly grapestones) with calcareous algae, d) mudstones with calcispheres. Sedimentary (neptunian) dykes with plastic deformation and brecciation of the infilled sediments common.
Stratigraphic correlation: Givetian, lower *varcus*-subzone to *hermanni-cristatus*-zone
Fossils: (det. by OETKEN)
conodonts, calcareous algae, calcispheres, brachiopods, stromatopores, ostracods, foraminifers
Remarks: confirmed stratigraphic range: Givetian; (lower ***varcus***-subzone to ***hermanni-cristatus***-zone). DK1996: dm 12.8 — 18.7. The sedimentary material of neptunian dykes from outcrops near Gaudernbach show fossil evidence for a generation from Famennian to Lower Carboniferous time (KREBS 1971: 58).
Presumable sedimentary environment: Partly protected, near- to central reef environment with short-distance lateral changes of different facies types. Sediments partly synsedimentary reworked and brecciated. "Belodellid" biofacies.

Sample: O 4 (S 8) **Quotation:** OETKEN 1997, p. 40, 43
Gauss-Kruger-coordinates: ^{34}42220 - ^{55}91650
Location: abandoned quarry "Goldader", 1.0km northeast of Schupbach (geological map 1:25000, 5515 Weilburg).
Lithology: min. 9m limestone succession of: a) floatstones with stromatopores and grainstone matrix, b) mudstones/wackestones with bioturbation, foraminifers, calcispheres, peloids.
Stratigraphic correlation: Earliest Frasnian, upper part of Early *falsiovalis*- — within Late *falsiovalis*-zone
Fossils: (det. by OETKEN)
conodonts, foraminifers (e. g. *Nanicella* sp.), calcispheres, stromatopores, echinoderms, gastropods, trilobites, very rare: spiculae of sponges
Remarks: confirmed stratigraphic range: earliest Frasnian; (in Early ***falsiovalis***- — Late ***falsiovalis***-zone). DK1996: ds 0.2 — 1.1.
Presumable sedimentary environment: limestones of an open marine shallow water environment. OETKEN (1997: 43): "Therefore a development of the depositional environment from [a:] a perhaps open-lagoonal milieu with connection to the offshore-sea or [b:] a fore-reef position with steady influence of currents or waves - via a milieu of more reduced energetic influence - towards a region of enhanced biotic production within a shallower, higher energetic milieu is derivable. Frequent intraclasts point to enhanced water energy and reworking of sediments. [...] This development is explainable by varying sea-water levels." Polygnathid-icriodontid biofacies.

Sample: O 5 (S 7) **Quotation:** OETKEN 1997, p. 48
Gauss-Kruger-coordinates: ^{34}41920 - ^{55}92530
Location: abandoned limestone-quarry in the Kerkerbach valley, 1.2km northeast of Schupbach, "in the densely overgrown left-sided slope of the valley" (geological map 1:25000, 5515 Weilburg).
Lithology: darkgrey to black, massive limestones: fine-grained bioclastic wackestones to packstones, partly with bioturbation.
Stratigraphic correlation: Givetian, *varcus* — *hermanni-cristatus*-zone
Fossils: (det. by OETKEN)
conodonts (rare), fish remnants, crinoid remnants, foraminifers, tabulate and rugose corals, gastropods, brachiopods, ostracods, trilobites, ? stromatopores, ? bryozoans
Remarks: confirmed stratigraphic range: Givetian; (***varcus* — *hermanni-cristatus***-zone). DK1996: dm 12.8 — 18.7.
Presumable sedimentary environment: sediments with characteristics of the shallow, open "shelf" (deposition within a lagoon between two neighbouring submarine ridges?). Sedimentation took place in a quiet milieu below the wave base. "Panderodid" biofacies.

Sample: O 6 (Ga 1) **Quotation:** OETKEN 1997, p. 49, 51 top
Gauss-Kruger-coordinates: ^{34}43090 - ^{55}93240
Location: abandoned limestone-quarry, 1.0km north of Gaudernbach (geological map 1:25000, 5515 Weilburg).
Lithology: ca. 5m succession of a) thin red pelite layers which become thinner and less frequent towards the top, within b) redgrey to grey bedded limestones (partly with graded bedding).
Stratigraphic correlation: Givetian, from upper *varcus*-subzone onwards.
Fossils: (det. by OETKEN)
only: *Ozarkodina semialternans* (WIRTH 1967) [upper *varcus* — ? *disparilis*]
stromatopores ("*Stachyodes*"), tabulata ("*Thamnopora*" and "*Scoliopora*"), crinoids, brachiopod remnants, broken rugose corals, echinids and rare calcareous algae (*Solenopora* sp.) and amphipores.
Remarks: confirmed stratigraphic range: late Givetian; (upper ***varcus*** — ? ***disparilis***-zone). DK1996: dm 17.0 — ? 19.7.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Downslope transport of limestone detritus (which was firstly deposited as bioclastic debris at a position proximal to the reef) into a low energy environment with prevailing deposition of clay to silt.

Sample: O 7 (Ga 4) **Quotation:** OETKEN 1997, p. 54, 56 middle
Gauss-Kruger-coordinates: ^{34}42390 - ^{55}92120
Location: outcrop along a (sunken) forest track, at the eastern slope of the Kerkerbach valley, 1.2km northeast of Schupbach (geological map 1:25000, 5515 Weilburg).
Lithology: min. 3.2m lightgrey to grey, indistinctly dm-bedded limestones, developed as stromatopora-floatstone/rudstone with a) peloid-bearing grainstone matrix or b) packstone matrix.
Stratigraphic correlation: younger than uppermost Middle Devonian; upper *falsiovalis*-zone to Late *marginifera*-zone
Fossils: (det. by OETKEN)
only: *Polygnathus* cf. *webbi* STAUFFER 1938 [in Early *falsiovalis* — Late *marginifera*]
(free blade and anterior part not preserved)
stromatopores (*Stachyodes*)
echinoids, crinoids
? cyanophyceans
Remarks: confirmed stratigraphic range: Frasnian to Lower Famennian (Nehdenian); (in Early ***falsiovalis*** — Late ***marginifera***-zone). DK1996: ds 0.5 — 13.3. Probably earliest Frasnian (DK1996: ds 0.5 — 1.1, *falsiovalis*-zone).
Presumable sedimentary environment: Deposition of the sediments at a backward position of the reef-region under influence of middle - sometimes enhanced - water energy, in a restricted milieu.

Sample: O 8 (Wi 1) **Quotation:** OETKEN 1997, p. 65-67, 77-79, 131-132 (pl. 3)
Gauss-Kruger-coordinates: ^{34}44160 - ^{55}90820
Location: abandoned limestone-quarry "Jörrissen", 800m northeast of Wirbelau (geological map 1:25000, 5515 Weilburg).
Lithology: ca. 12m succession of a) crinoid-dominated coarse-sandy to gravely detrital limestones and b) very coarse detrital limestone layers, partly with larger components of tabulate corals and stromatopores. The lithologic change a-b occurs 12 times along the northern quarry wall. Palaeoslope-inclination: ca. 30-35°.
Stratigraphic correlation: latest Givetian/earliest Frasnian; (Early — Late *falsiovalis*-zone)

Fossils: (det. by OETKEN)
Alveolithes, crinoid remnants, stromatopores ("mamelon"-type), tabulate corals

Wi1 - 2m above base (4.8 kg limestone dissolved)
316 determinable conodont remnants (53.5% *Polygnathus*, 8% coniform elements (*Belodella* etc.), 7% *Ozarkodina*, 5% *Mesotaxis*, 0.5% *Pelekysgnathus*, 26% ramiform elements): lower — upper *falsiovalis*-zone. Conodont-biofacies (OETKEN 1997:126): polygnathid.
Wi1 - 3m above base (5.7 kg limestone dissolved)
858 determinable conodont remnants (61% *Polygnathus*, 22% "*Mesotaxis/Klapperina*", 4% coniform elements (*Belodella* etc.), 13% ramiform elements): Late *falsiovalis*-zone. Conodont-biofacies (OETKEN 1997:126): polygnathid-mesotaxid.
Wi1 - 2m below top (1.2 kg limestone dissolved)
8 determinable conodont remnants (38% *Polygnathus*, 38% coniform elements (*Belodella* etc.), 12% *Ozarkodina*, 12% *Mesotaxis*): *disparilis* — Late *falsiovalis*-zone. Conodont-biofacies (OETKEN 1997:126): "belodellid".
Wi1 - top (7.5 kg limestone dissolved)
42 determinable conodont remnants (45% *Polygnathus*, 17% coniform elements (*Belodella* etc.), 7% *Ozarkodina*, 11% ramiform elements, 2% "others"): Early — Late *falsiovalis*-zone. Conodont-biofacies (OETKEN 1997:126): "belodellid"-polygnathid.
Wi1 - 40 eastern quarry wall (2.72 kg limestone dissolved)
4 determinable conodont remnants (25% *Polygnathus*, 25% *Ozarkodina*, 50% ramiform elements).
Wi1 - 41 eastern quarry wall (2.72 kg limestone dissolved)
355 determinable conodont remnants (33% coniform elements (*Belodella* etc.), 18% *Polygnathus*, 13.5% *Mesotaxis*, 5% *Ozarkodina*, 0.5% "*Pedavis*"?, 30% ramiform elements and broken remnants). Conodont-biofacies (OETKEN 1997:126): "belodellid"-polygnathid-mesotaxid.
Wi1 - 43 eastern quarry wall (2.72 kg limestone dissolved)
33 determinable conodont remnants (46% *Polygnathus*, 18% coniform elements (*Belodella* etc.), 3% *Mesotaxis*, 11% ramiform elements and broken remnants): Early — Late *falsiovalis*-zone. Conodont-biofacies (OETKEN 1997:126): polygnathid-"belodellid".
Wi1 - 44 eastern quarry wall (2.04 kg limestone dissolved)
65 determinable conodont remnants (40% *Polygnathus*, 5% coniform elements (*Belodella* etc.), 3% *Ozarkodina*, 52% ramiform elements and broken remnants): Late *falsiovalis*-zone. Conodont-biofacies (OETKEN 1997:126): polygnathid.
Remarks: confirmed stratigraphic range: latest Givetian/earliest Frasnian; (Early — Late ***falsiovalis***-zone). DK1996: dm 19.7 — ds 1.1. BISCHOFF (1956) as well as BISCHOFF & ZIEGLER (1957) described conodont faunas from this location. Their results are discussed and incorporated in OETKEN (1997) and therefore not separately listed above.
Presumable sedimentary environment (OETKEN 1997, p. 71-72, 81): "KREBS (1972) interprets the limestones of Wirbelau as reef-derived carbonates of the final cap-phase of the reef development. [...] A back-reef with sediments typical for a low-energy and restricted milieu is absent in this interpretation. [...However,] The limestones of Wirbelau are mainly coarse debritic limestones of the distal fore-reef. Only the outcrops in the north of the quarries show evidence for facies types which would allow for a correlation with a more protected back-reef or within-reef environment. [...] The sediments [in the Wirbelau limestone quarries] give evidence for a depositional environment at a shelf-slope area with free exposition to the open sea."

Sample: O 9 (Wi 3) **Quotation:** OETKEN 1997, p. 68
Gauss-Kruger-coordinates: ^{34}44050 - ^{55}91160
Location: abandoned limestone-quarry, ca. 800m northeast of Wirbelau (geological map 1:25000, 5515 Weilburg).
Lithology: massive limestones: grainstones/rudstones.
Stratigraphic correlation: Uppermost Middle Devonian, *disparilis*-zone
Fossils: (det. by OETKEN)
conodonts
crinoids, tabulate corals (*Thamnopora, Scoliopora*), stromatopores, brachiopods, calcareous sponges, remnants of bryozoans.
Remarks: confirmed stratigraphic range: latest Givetian; (***disparilis***-zone). DK1996: dm 18.7 — 19.7.
Presumable sedimentary environment: Deposition of sediments on top of a submarine ridge. "The depositional environment of the sediments was characterised by a steady acting high water energy. Therefore the sedimentation of micritic material was impossible. The enrichment of the sediment in washed-out crinoid- and coral-detritus point to a depositional environment in shallow to medium-deep water. The frequent occurrence of branching tabulate corals may indicate the neighbourhood to a "*Thamnopora*-lawn". The depositional environment was situated at the edge of the reef /reef-slope or in a shallow, plain, fore-reef shelf region."

Sample: O 10 (Georg 3) **Quotation:** OETKEN 1997, p. 82-90, 133-134
Gauss-Kruger-coordinates: ^{34}45950 - ^{55}91040
Location: borehole location of drill site "Georg 3", ca. 1.1 km northeast of Wirbelau (geological map 1:25000, 5515 Weilburg).
Lithology: ca. 25 m succession of allodapic limestones (dip: ca: 30°, therefore dip-corrected "true" thickness ca. 21.7m). The succession contains the following facies-types: a) darkgrey to black laminated mudstones (foraminifers-mudstone/wackestone; mm-cm bedding; partly distal turbidites), b) wackestones (tentaculites-wackestone; cm-dm bedding), c) packstones/grainstones (tentaculites-packstones/grainstones; cm-dm bedding), d) black to greybrown laminated pelites (mm-cm bedding). Within the uppermost 8m of the core (*rhenana*-zone) the content of pelites decreases in favour of increasing bed thicknesses of the carbonates which at last become massive, lightgrey, strongly flasered limestones.
Stratigraphic correlation: Early to middle Frasnian (Late *falsiovalis*- — Early *rhenana*-zone)
Fossils: (conodonts det. by OETKEN 1997 and BISCHOFF & ZIEGLER 1957). Numeric stratigraphic data determined and added by VOGT.
Tentaculites, single- and multi-chambered foraminifers, radiolarians, shell remnants, filaments, rare echinoderm remnants.
<u>Core samples, from top to bottom:</u>
133.2 - 133.49 m (500g, min. 548 individual conodonts, palmatolepid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 4.5 — 4.8 (within Early *rhenana*-zone)
138.32 - 138.38 m (179g, min. 554 individual conodonts, palmatolepid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 3.9 — 4.8 (in *jamieae* — within Early *rhenana*-zone)
---------- 139.6 m: gap ? (OETKEN 1997:84)
140.04 - 140.11 m (180g, min. 394 individual conodonts, palmatolepid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 4.2 — 4.8 (within Early *rhenana*-zone)
140.45 - 140.51 m (180g, min. 233 individual conodonts, palmatolepid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 2.3 — 4.8 (*hassi* — within Early *rhenana*-zone)
141.23 - 141.4 m (400g, min. 76 individual conodonts, polygnathid-mesotaxid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 0.5 — 2.8 (in "Middle" *falsiovalis* — within Early *hassi*-zone) + reworked DK1996: dm 19.5 — ds 0.5 (in upper *disparilis*— in "Middle" *falsiovalis*-zone) [? and DK1996: dm 13.8 — 15.6 (in lower — in Middle *varcus*-zone)]
141.80 m, "Georg 3", OETKEN 1997, spore-sample (processed with 73% HF; processing and analysis by VOGT): kerogen-flakes, partly oxidised phytoclasts, indet. palynoclasts (partly pyritised), frequent framboidal pyrite.
143.06 - 143.13 m (200g, min. 64 individual conodonts, polygnathid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 0.2 — 5.5 (in Early *falsiovalis* — *rhenana*-zone) + reworked DK1996: dm 19.5 — ds ?0.5 (in upper *disparilis*— in "Middle" *falsiovalis*-zone)
143.4 m, "Georg 3", BISCHOFF & ZIEGLER 1957, DK1996: ds 3.0 — 5.2 (Late *hassi* — in Late *rhenana*-zone) + reworked DK1996: ds 0.8 — 2.6 (in Late *falsiovalis*— in Early *hassi*-zone)
---------- 145.5 m: gap ? (OETKEN 1997:84)
147.34 - 147.55 m (700g, min. 559 individual conodonts, polygnathid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 1.1 — 1.4 (base — within *transitans*-zone)
148.3 m, "Georg 3", BISCHOFF & ZIEGLER 1957, DK1996: ds 0.8 — 2.3 (in Late *falsiovalis* — *punctata*-zone)
149.0 m, "Georg 3", BISCHOFF & ZIEGLER 1957, DK1996: ds 0.8 — 2.3 (in Late *falsiovalis* — *punctata*-zone)
---------- 149.7 m: gap ? (OETKEN 1997:84)
151.50 m, "Georg 3", OETKEN 1997, spore-sample (processed with 73% HF; processing and analysis by VOGT): kerogen-flakes, partly oxidised phytoclasts, indet. palynoclasts (partly pyritised), frequent framboidal pyrite.
154.7 - 154.85 m (410g, min. 193 individual conodonts, polygnathid-mesotaxid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 0.5 — 1.4 (in "Middle" *falsiovalis* — in *transitans*-zone)
---------- 155.1 m: gap ? (OETKEN 1997:84)
156.0 - 156.13 m, "Georg 3", OETKEN 1997, DK1996: ds 0.5 — 1.1 (in "Middle" — Late *falsiovalis*-zone)
157.51 - 157.58 m (160g, min. 22 individual conodonts, polygnathid-mesotaxid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 0.5 — 1.4 (in "Middle" *falsiovalis* — in *transitans*-zone)

157.58 - 157.7 m, "Georg 3", OETKEN 1997, DK1996: ds 0.5 — 1.4 (in "Middle" *falsiovalis* — in *transitans*-zone) + reworked DK1996: dm 5.5 — 14.1 (within *kockelianus* — lower *varcus*-zone)

157.7 - 157.75 m, "Georg 3", OETKEN 1997, DK1996: ds 0.5 — 1.4 (in "Middle" *falsiovalis* — in *transitans*-zone) + reworked DK1996: dm 5.5 — 14.1 (within *kockelianus* — lower *varcus*-zone)

157.86 - 157.95 m, "Georg 3", OETKEN 1997, DK1996: ds 0.5 — 2.0 (in "Middle" *falsiovalis* — in *punctata*-zone) + reworked DK1996: dm 5.5 — 14.1 (within *kockelianus* — lower *varcus*-zone)

158.1 m (230g, min. 68 individual conodonts, polygnathid-mesotaxid conodont-biofacies), "Georg 3", OETKEN 1997, DK1996: ds 0.5 — 2.3 (in "Middle" *falsiovalis* — *punctata*-zone) [? + reworked DK1996: dm 12.8 — ? (lower *varcus*-zone — ?)

Remarks: confirmed stratigraphic range: early to middle Frasnian; (in "Middle" ***falsiovalis*** — near top of Early ***rhenana***-zone). DK1996: ds 0.5 — 4.8 (with reworked faunas: a) DK1996: dm 12.8 — 15.6 (lower *varcus* — in Middle *varcus*-zone), b) DK1996: dm 19.5 — 0.5 (in upper *disparilis* — in "Middle" *falsiovalis*-zone) and c) DK1996: ds 0.8 — 2.6 (in Late *falsiovalis*— in Early *hassi*-zone)). BISCHOFF & ZIEGLER (1957) described conodont faunas from this location. Their results are discussed and incorporated in OETKEN (1997). A similar lithologic succession can be observed in an outcrop described by KEGLER 1967a (= sample K 26).

OETKEN 1997 interprets the whole succession as concordant bedded, with presumed "gaps" due to bad core storage in-between. However, the above listing indicates a concordant succession only from 158.1 to 145.5m ("Middle" *falsiovalis* — *transitans*-zone). The "gap" at 145.5m is therefore interpreted as fault. Above the fault the succession starts with the Late *hassi*-zone at 143.4m and becomes successively older up to core-depth 141.23m (*falsiovalis*-zone). The lifetime ranges of the described conodont-assemblages clearly do not show sufficient evidence for this interpretation. But the change from offshore ?palmatolepid biofacies (143.4m) via nearshore polygnathid biofacies (143.13m) towards an offshore mesotaxid-polygnathid biofacies (141.23m) - in addition - maintains this view. From 140.45m onwards a *Palmatolepis*-dominated biofacies dominates (*hassi* — Early *rhenana*-zone). Between 141.23m and 140.51m only 72cm are left to cover the whole *transitans*—*punctata*-time. This is not in accordance with the data obtained at greater depth, where the *transitans*-time covers at least ca. 3m. Hence, between 141.23m and 140.51m a further fault should be expected. By summarising all these assumptions we can conclude the following: a) ca. 10m allodapic limestone/pelite succession represents the Middle and late parts of the *falsiovalis*-zone, with a mesotaxid-polygnathid conodont-biofacies (offshore); b) min. 3m allodapic limestone/pelite succession represents parts of the *transitans*-zone, with a polygnathid conodont-biofacies (rel. nearshore); c) no sufficient data are available in order to give evidence for deposits of the *punctata*-time; d) ca. 8m allodapic limestone/pelite succession represents parts of the *hassi* — Early *rhenana*-zone, with a palmatolepid conodont-biofacies (offshore).

Presumable sedimentary environment: Basinal facies; deposition at the slope of a submarine ridge (former reef). Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge. The sedimentary inventory points to an offshore shelf with low energy environment, wherein repeatedly restricted conditions with presumably low oxygen supply and varying pH, Eh (?and salinity) prevailed. Repeated (discyclic?) influx of fine-grained sediment, perhaps in the form of distal turbidites, is reflected by frequent concentration of fossils on the bedding planes, which are separated by mm to cm thick layers of limestone.

Due to OETKEN (1997:82) "deep-water limestones".

F 1.13 PETER 1994

Sample: P 1 **Quotation:** PETER 1994, p. 80 middle

Gauss-Kruger-coordinates: ^{34}40850 - ^{55}88290

Location: northeast of Hofen, eastern slope of the Kerkerbach-valley, in the forest, ca. 160m west of the Kerkerbach (geological map 1:25000, 5515 Weilburg).

Lithology: > 1.5m succession of a) 5-15 cm thick beds of darkgrey very fine-grained crinoid-limestone, intercalated by b) up to a few mm-cm thick dark slates.

Stratigraphic correlation: Lower Carboniferous

Fossils: (det. by BENDER, from lithology a)

Gnathodus sp. indet. [?*isosticha* / upper *crenulata* — early Namurian B ?]

crinoid remnants

Remarks: revised stratigraphic range: Lower Carboniferous; the conodont-genus *Gnathodus* has its first occurrence in the middle Tournaisian (late *Pericyclus* IIα; ? *isosticha* / upper *crenulata*-zone — early Namurian B?). LCC2003: ci (8.3 — > 20.0).

Presumable sedimentary environment: Deposition near the base of a basinal slope. Main constituent of the sedimentary facies is dark, oxygen-depleted, clay-silt with episodic (seismically induced?) intercalations of (turbiditic) calcareous debris from higher parts of the submarine ridge.

Sample: P 2 **Quotation:** PETER 1994, p. 77 bottom
Gauss-Kruger-coordinates: ^{34}41100 - ^{55}88350 (compare also ^{34}41150 - ^{55}88365)
Location: at the forest track between Hofen and Eschenau, western slope of the Kerkerbach-valley, in the forest (geological map 1:25000, 5515 Weilburg).
Lithology: > 1.5m succession of a) ca. 2-15 cm thick beds of reddish flinty slates, intercalated by b) up to ca. 30 cm thick beds of lightgrey, coarse-grained crinoid-limestone.
Stratigraphic correlation: Lower Carboniferous
Fossils: (det. by BENDER, from lithology b)

Paragnathodus commutatus [= *Paragnathodus (Gnathodus) commutatus* (BRANSON & MEHL 1941) HIGGINS 1975]	[in *texanus* — in *bilineatus*]
crinoid remnants	

Remarks: revised stratigraphic range: Lower Carboniferous; early to middle Viséan (in *texanus* — in *bilineatus*-zone). LCC2003: ci 14.1 — 17.5.
Presumable sedimentary environment: Deposition near the base of a basinal slope within an iron-enriched water column. Main constituent of the sedimentary facies is clay (-finesilt?) with episodic (seismically induced?) intercalations of (turbiditic) calcareous debris from higher parts of the submarine ridge. The flinty slates as well as the cherty nodules are probably products of deposition of primary siliceous oozes which became partly separated during diagenesis and compaction. An alternative origin by deposition of thin finesilt intercalations seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are mostly not observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: P 3 **Quotation:** PETER 1994, p. 45 bottom + 56 top
Gauss-Kruger-coordinates: ^{34}41075 - ^{55}88470
Location: at the slope directly below the forest track between Hofen and Eschenau, western slope of the Kerkerbach-valley, in the forest (geological map 1:25000, 5515 Weilburg).
Lithology: Meta-basalt, void-rich, with interstitials of lightgrey-lightred limestone- nodules and irregular shaped limestone-compartments. The limestone inhabits a micritic matrix (mudstone).
Stratigraphic correlation: Hemberg-stage (Late *trachytera*-zone)
Fossils: (det. by BENDER, from the limestones)

Palmatolepis glabra lepta	[Early *marginifera* — in Late *trachytera*]
Palmatolepis gracilis sigmoidalis [ZIEGLER 1962]	[Late *trachytera* — Late *praesulcata*]
Palmatolepis perlobata schindewolfi [MÜLLER 1956]	[Latest *crepida* — Late *expansa*]
Palmatolepis perlobata sigmoidea [ZIEGLER 1962]	[Early *marginata* — in Late *postera*]
Palmatolepis rugosa trachytera [ZIEGLER 1960]	[Early — Late *trachytera*]
Scaphignathus subserratus	[?]

Remarks: revised stratigraphic range: middle Famennian; Hembergian (Late *trachytera* — in Late *trachytera*-zone). DK1996: ds 14.6 — 14.9. Fossil evidence from the calcareous nodules maybe does not reflect the true time of submarine magma outflow (which happened during the Lower Carboniferous ?; compare e.g. P 6, but also MU 11).
Presumable sedimentary environment: submarine basic volcanic activity, development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments. Basinal marine environment. Succession of a) submarine basaltic magma outflow; b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris from higher parts of a submarine ridge.

Sample: P 5 (P 4: no determ. fauna) **Quotation:** PETER 1994, p. 46 middle + 56 middle
Gauss-Kruger-coordinates: ^{34}41200 - ^{55}88560
Location: outcrop at the slope directly above the forest track between Hofen and Eschenau, western slope of the Kerkerbach-valley, in the forest (geological map 1:25000, 5515 Weilburg).
Lithology: micro-porphyritic metabasalt; a) at the southern flank of the outcrop the basalt shows "bread-crust" like surfaces and contains sometimes coarse-grained crinoid-limestones and only a few small calcareous nodules; b) at the northern flank of the outcrop a lot of (sometimes big) fine-grained, reddish to lightgrey calcareous nodules are enclosed.
Stratigraphic correlation: Hemberg-stage (Late *trachytera*-zone)
Fossils: (det. by BENDER, from the limestones of lithology b)

Palmatolepis glabra lepta	[Early *marginifera* — in Late *trachytera*]
Palmatolepis gracilis sigmoidalis [ZIEGLER 1962]	[Late *trachytera* — Late *praesulcata*]
Palmatolepis minuta schleizia	[Late *rhomboidea* — Late *postera*]
Palmatolepis perlobata schindewolfi [MÜLLER 1956]	[Latest *crepida* — Late *expansa*]
Palmatolepis rugosa trachytera [ZIEGLER 1960]	[Early — Late *trachytera*]
cephalopod remnants, indet.	

echinoderm remnants, indet.
Remarks: revised stratigraphic range: middle Famennian; Hembergian (Late *trachytera* — in Late *trachytera*-zone). DK1996: ds 14.6 — 14.9. Fossil evidence from the calcareous nodules maybe does not reflect the true time of submarine magma outflow (which happened during the Lower Carboniferous ?; compare e.g. P 6, but also MU 11).
Presumable sedimentary environment: submarine basic volcanic activity, development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments. Basinal marine environment. Succession of a) submarine basaltic magma outflow; b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris from higher parts of a submarine ridge.

Sample: P 6 **Quotation:** PETER 1994, p. 46 bottom + 56 bottom
Gauss-Kruger-coordinates: ^{34}41175 - ^{55}88610
Location: ca. 100m uphill of the main forest track between Hofen and Eschenau, western slope of the Kerkerbach-valley, in the forest (geological map 1:25000, 5515 Weilburg).
Lithology: micro-porphyric metabasalt with numerous calcareous enclosures: ca. 2-30 cm thick subsphaerical limestone- nodules, elongated limestone- nodules, flattened limestone-layers and up to 1m thick limestone beds. The fine-grained limestones (filament-limestones, biomicrites, shell-wackestones to shell packstones) are lightred or lightgrey and contain numerous fossils.
Stratigraphic correlation: Lower Carboniferous, cd II, upper part of *anchoralis-latus*-zone.
Fossils: (det. by BENDER, from the limestones)

Gnathodus cuneiformis MEHL & THOMAS 1947	[? lower *typicus* — ? *anchoralis-latus*]
Gnathodus pseudosemiglaber THOMPSON & FELLOWS 1970	[in *anchoralis-latus* — in *bilineatus*]
Gnathodus cf. *texanus* ROUNDY 1926	[*texanus* — in *bilineatus*]
Hindeodella segaformis (BISCHOFF 1957)	[base to near the top of *anchoralis-latus* zone]
Polygnathus bischoffi RHODES, AUSTIN & DRUCE 1969	[*anchoralis-latus* — in *texanus*]
Scaliognathus anchoralis BRANSON & MEHL 1941	[base to near the top of *anchoralis-latus*]

echinoderm remnants, mostly crinoid-detritus, indet.
trilobites
ostracods (rare)
cephalopod-embryos (Goniatites ?; frequent)
gastropods (rare)
shells of molluscs (frequent)
Remarks: preliminary stratigraphic range: Lower Carboniferous; late Tournaisian (in *anchoralis-latus* — near the top of *anchoralis-latus*-zone). LCC2003: ci 12.5 — 13.2. HENNINGSEN (1965, samples H 23 + 24) presented two fossil lists for Lower Carboniferous limestones (from outcrops near the village Steeden) which indicate a depositional age of **LCC2003: ci: 13.3 — 17.5** (cu II γ, "Erdbacher Kalk III") - with a rich reworked fauna of *anchoralis-latus* age. If *G.* cf. *texanus* represents the nominal species, the age of the limestones from this locality would also point into the lower Viséan. Compare also equivalent lithologic settings and faunal compositions at localities K 7 and K 8 (KEGLER 1967), W 2 and W 3 (WALLISER 1960).
Presumable sedimentary environment: submarine basic volcanic activity, development of pillow-basalts with inclusions of syngenetic soft and lithified older sediments. Basinal marine environment. Succession of a) submarine basaltic magma outflow; b) long-term clay-silt deposition with punctual (maybe storm-induced) intercalations of fossiliferous calcareous debris from higher parts of a submarine ridge.

Sample: P 7 **Quotation:** PETER 1994, p. 77 bottom + 56 bottom
Gauss-Kruger-coordinates: ^{34}41300 - ^{55}88825
Location: 3 small abandoned limestone quarries, ca. 130m uphill of the main forest track between Hofen and Eschenau, western slope of the Kerkerbach-valley, in the forest (geological map 1:25000, 5515 Weilburg).
Lithology: > 1.5m lightgrey coarse-grained crinoid-limestone (Erdbacher Kalk); cm-dm thick bedded.
Stratigraphic correlation: Lower Carboniferous.
Fossils: (det. by BENDER, from the limestones)

Paragnathodus commutatus [= *Paragnathodus (Gnathodus) commutatus* (BRANSON & MEHL 1941) HIGGINS 1975]	[in *texanus* — in *bilineatus*]

? tabulate corals
crinoid remnants
shells of molluscs
? foraminifers
Remarks: revised stratigraphic range: Lower Carboniferous; early to middle Viséan; Erdbacher Kalk III (in *texanus* — in *bilineatus*-zone). LCC2003: ci 14.1 — 17.5.

Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Depocentre near the top of the ridge is indicated by the relative thick succession of calcareous debris. Main constituent of the sedimentary facies is clay-finesilt with episodic intercalations of calcareous debris from higher parts of the submarine ridge.

Sample: P 8 **Quotation:** PETER 1994, p. 77 bottom + 56 bottom
Gauss-Kruger-coordinates: ^{34}41425 - ^{55}88990
Location: ca. 300m south of Eschenau at the main forest track between Hofen and Eschenau, western slope of the Kerkerbach-valley, in the forest (geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) > 1.0m lightgrey coarse-grained crinoid-limestone (Erdbacher Kalk), ca. 5-15 cm thick bedded; above b) strongly folded darkgrey, fine-grained crinoid-limestone with c) thin (mm-cm) intercalations of greenish slates.
Stratigraphic correlation: Lower Carboniferous.
Fossils: (det. by BENDER, from the limestones)
Gnathodus sp. [?*isosticha* / upper *crenulata* — early Namurian B ?]
crinoid remnants
shells of molluscs
Remarks: revised stratigraphic range: Lower Carboniferous; the conodont-genus *Gnathodus* has its first occurrence in the middle Tournaisian (late *Pericyclus* IIα; ? *isosticha* / upper *crenulata*-zone — early Namurian B?). LCC2003: ci (8.3 — > 20.0).
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Depocentre near the top of the ridge is indicated by the relative thick succession of calcareous debris. Main constituent of the sedimentary facies is clay-finesilt with episodic intercalations of calcareous debris from higher parts of the submarine ridge.

Sample: P 9 **Quotation:** PETER 1994, p. 29 bottom
Gauss-Kruger-coordinates: ^{34}41145 - ^{55}87800
Location: ca. 420m eastsoutheast of the Oberhofer Mühle (O. mill) near a forest track, eastern slope of the Kerkerbach-valley, in the forest (geological map 1:25000, 5515 Weilburg).
Lithology: Kalkknotenschiefer (Kramenzelkalk): greenish slates with cm-dm thick bedded intercalations of lightred or lightgrey calcareous layers or nodules.
Stratigraphic correlation: Upper Hemberg- to Dasberg-stage (Early to Late *postera*-zone)
Fossils: (det. by BENDER, from the calcareous layers)
Palmatolepis gracilis sigmoidalis [ZIEGLER 1962] [Late *trachytera* — Late *praesulcata*]
Palmatolepis minuta schleizia [Late *rhomboidea* — Late *postera*]
Palmatolepis perlobata schindewolfi [MÜLLER 1956] [Latest *crepida* — Late *expansa*]
Polygnathus styriacus [ZIEGLER 1957] [Early *postera* — Early *expansa*]
esp. in the reddish limestones:
echinoderm remnants
trilobite remnants
cephalopod remnants, indet.
bivalves, indet. (also opaque minerals: ? pyrite)
Remarks: revised stratigraphic range: middle Famennian; late Hembergian (Early — Late *postera*-zone). DK1996: ds 15.2 — 16.5.
Presumable sedimentary environment: Deposition of mud from suspension at the slope of a submarine ridge in an iron-enriched water column, under reducing conditions. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris from higher parts of the submarine ridge.

Sample: P 10 **Quotation:** PETER 1994, p. 74 bottom
Gauss-Kruger-coordinates: ^{34}41150 - ^{55}88365 (compare also ^{34}41100 - ^{55}88350)
Location: at the forest track between Hofen and Eschenau, western slope of the Kerkerbach-valley, in the forest (geological map 1:25000, 5515 Weilburg).
Lithology: > 1.0m succession of a) ca. 2-15 cm thick beds of reddish flinty slates, intercalated by b) up to ca. 40 cm thick beds of lightgrey, coarse-grained crinoid-limestone.
Stratigraphic correlation: Lower Carboniferous
Fossils: (det. by BENDER, from lithology b)
Paragnathodus commutatus [in *texanus* — in *bilineatus*]
[= *Paragnathodus (Gnathodus) commutatus* (BRANSON & MEHL 1941) HIGGINS 1975]
Remarks: revised stratigraphic range: Lower Carboniferous; Early to middle Viséan (in *texanus* — in *bilineatus*-zone). LCC2003: ci 14.1 — 17.5.
Presumable sedimentary environment: Deposition near the base of a basinal slope within an iron-enriched water column. Main constituent of the sedimentary facies is clay (-finesilt?) with episodic (seismically induced?) intercalations of (turbiditic) calcareous debris from higher parts of the submarine ridge. The flinty slates as well as the

cherty nodules are probably products of deposition of primary siliceous oozes which became partly separated during diagenesis and compaction. An alternative origin by deposition of thin finesilt intercalations seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are mostly not observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

F 1.14 SOLLE 1942

Sample: S 1 (= Liste 180) **Quotation:** SOLLE 1942 (vol. 467), p. 170
Gauss-Kruger-coordinates: [^{34}39850 - ^{55}86710]
Location: ca. 500 m northwest of the northwestern exit of Schadeck.
Lithology: Platy, seldom thin-bedded, grey to brownish sandstones, which appear often quartzose, are intercalated with slates, which are often of grey to blackgrey colour, split up like leaves and into leave-shaped chips. The slates become often more competent, with undulate surface, rough, brown and quite sandy.
Stratigraphic correlation: late Laubachian, near the turning point Laubach-/Kondel-group (Early to middle Upper Emsian)
Fossils: (det. by SOLLE)

Trilobita indet.	
Gastropoda indet.	
Cypricardinia crenistria (SANDBERGER)	
Schizophoria striatula (SCHLOTHEIM)	
Dalmanella cf. *fascicularis* (D´ORBIGNY)	
Dalmanella subelegantula (MAURER)	
Dalmanella sp.	
Stropheodonta explanata (SOWERBY) [= *Leptostrophia explanata* (SOWERBY)]	
Stropheodonta sp.	
Leptagonia rhomboidalis (WAHLENBERG) [= *Leptaena rhomboidalis* (WAHLENBERG, WILCKENS)]	
Orthothetina (Schellwienella) hipponyx (SCHNUR) [= *Irichistrophia hipponyx* (SCHNUR)]	
Chonetes dilatata (v. ROEMER) DE KONINCK (++) [= *Loreleiella dilatata* (DE KONINCK) = *Eodevonaria dilatata* DE KONINCK]	
Chonetes plebejus (SCHNUR 1853) [= *Plebejochonetes plebejus* (SCHNUR 1853)]	[Emsian]
Camarotoechia hexatoma (SCHNUR 1853) [= *Oligtypcherhynchus hexatoma* (SCHNUR 1853)]	[Lower — Middle Devonian]
Uncinulus pila (SCHNUR) (+++)	[Lower — Middle Devonian]
Atrypa reticularis (LINNÉ) ?	[Silurian — Emsian]
Spirifer paradoxus (SCHLOTHEIM 1813) [= *Euryspirifer paradoxus* (SCHLOTHEIM 1813)]	[lower Upper Emsian (lower Lahnsteinian)]
Spirifer arduennensis (SCHNUR 1853) (+++) [= *Arduspirifer arduennensis* (SCHNUR 1853) = *Acrospirifer arduennensis* (SCHNUR 1853)]	[upper Lower — lower Upper Emsian]
Spirifer [= *Arduspirifer*] aff. *arduennensis* (SCHNUR), transition to *Spirifer intermedius maturus* SPRIESTERBACH 1935 (+)	
Spirifer sp. aff. *subcuspidata* (SCHNUR 1854) [= *Subcuspidella* sp. aff. *subcuspidata* (SCHNUR 1854) MITTMEYER 1972]	
Spirifer sp.aff. *mediorhenanus* (FUCHS) ? [= *Alatiformia* sp. aff. *mediorhenana* (FUCHS) ?]	
Spirifer sp. sp.	
Meganteris ovata MAURER	[Lower Devonian]
Anoplotheca venusta SCHNUR 1853 (+)	[Emsian (frequent: Laubachian)]
Fenestella sp.	
Crinoida indet.	
Olkenbachia [= *Clionolithes* CLARKE 1908] *hirsuta* (SOLLE 1938) (+)	

The transitional forms from *Arduspirifer* (*Spirifer) arduennensis* to *(Spirifer) intermedius maturus* are all still closer to *arduennensis*; forms which are closer to *intermedius maturus* are rare.

Abbreviations: (+) = numerous, (++) = quite numerous, (+++) = very numerous - The other fossils of this location are single or rare forms.
Remarks: stratigraphic range revised to lower (— ? middle) Upper Emsian (ca. ***inversus*** (—? Early ***serotinus***)-zone). DK1996: di: ca. 14.2 — 15.4 (— 17.1). In SOLLE (1953) *(Spirifer) intermedius maturus* is revised to *Hysterolites* (*Acrospirifer*) *mosellanus* n. sp. - which is now *Arduspirifer* (*Hysterolites* (*Acrospirifer*)) *mosellanus* (SOLLE 1953), a zone-fossil for the late Upper Emsian (DK1996: di: 17.1 — 20.0). Location identical to that of sample M 1 (MICHELS 1926, p. 238).
Presumable sedimentary environment: Marine (inner/outer) shelf. Deposition of mud from suspension below wave base or along protected, low-energy coasts, punctuated by sudden (?turbiditic) incursions of rapidly deposited silt to finesand. Dominating bedding features are graded bedding and laminated sand/silt. Wave energy and mud supply control mud abundance. During heavy storms brachiopod shells together with trochites and other above mentioned fossils were brought in from shallower or epitopographical marine regions and became partly deposited as shell beds.

Sample: S 2 **Quotation:** SOLLE 1942 (vol. 467), p. 173 bottom
Gauss-Kruger-coordinates: [between ^{34}40570 - ^{55}87650 and ^{34}40760 - ^{55}87500]. See appendix F 2.1, fig. F 2.3.
Location: At the eastern margin of the geological map 1:25000, 5514 Hadamar, southeast of Hofen.
Lithology: mostly blueblack, often roofing-slate like slates with calcareous nodules.
Stratigraphic correlation: ? lower Middle Devonian (Wissenbacher Schiefer; Eifelian)
Fossils: (completion of the fossil material found by MICHELS 1926)
Orthoceras sp. (several indet. species)
Asteropyge sp.
? *Sowerbyella minor* [Lower — Middle Devonian]
Remarks: revised stratigraphic range, due to evident fossil determinations by MICHELS 1926, assumed as Upper Emsian — lowermost Eifelian (ca. Late ***inversus*** — ***partitus*** -zone, DK1996: di: ca. 15.1 — dm: 0.6). Location almost identical to that of samples M 4 and M 5 (MICHELS 1926, p. 239 mid).
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt with intercalations of calcareous debris (and maybe of finesand) from higher parts of the submarine ridge.

F 1.15 TRAUTWEIN & WITTEKINDT 1960
(data-set is only used in parts in this study (samples: 1+2, 16+20, 23+24, 25), esp. the sets concerning the proposed "Gaudernbacher Schichten")

Sample: TW 1 (samples 1+2) **Quotation:** TRAUTWEIN & WITTEKINDT 1960: 474-476
Gauss-Kruger-coordinates: [ca. ^{34}46450 - ^{55}92910]
Location: section (between ^{34}46450 - ^{55}92900 and ^{34}46400 - ^{55}92600) at the railway track between Kirschhofen-tunnel and Michelsberg-tunnel south of Kirschhofen (at railway-km 26.390 - ca. 10m northwards of the tunnel-entrance; geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) min. 1.6m dark sandy slates with dark crystalline limestones-nodules and -beds, which become more frequent towards the top and subsequently build up b) a nodular limestone (0.8m); c) min. 0.4m platy limestone beds.
Stratigraphic correlation: Eifelian. Sample 1: "Günterode limestone"; sample 2: "Zwischenschichten (intermediate layers) between Günterode limestone and Ballersbach limestone".
Fossils: (conodonts, det. by TRAUTWEIN & WITTEKINDT; from lithologies b: sample 1 and c: sample 2)

(2): DK1996: dm: 6.4 (just before lower Kacak-event)

Polygnathus angustipennatus BISCHOFF & ZIEGLER 1957	[in *australis* (4.0) — n. top low. *kockelianus* (6.4)]
Polygnathus [*linguiformis*] *linguiformis* HINDE 1879	[in *costatus* (2.0) — *punctata* (ds2.3)]
Polygnathus xylus STAUFFER 1940 [= *Polygnathus xylus* ?*ensensis* s.l. ZIEGLER, KLAPPER & JOHNSON 1976]	[*ensensis* (6.4) — in *transitans* (ds 1.4)]

(1): DK1996: dm: 5.0 — 6.4 (before lower Kacak-event)

Polygnathus [*linguiformis*] *linguiformis* HINDE 1879	[in *costatus* (2.0) — *punctata* (ds2.3)]
Polygnathus angustipennatus BISCHOFF & ZIEGLER 1957	[in *australis* (4.0) — near top of lower *kockelianus* (6.4)]
Polygnathus eiflius BISCHOFF & ZIEGLER 1957	[near base *kockelianus* (5.0) — within *hemiansatus* (9.4)]
Polygnathus kockelianus BISCHOFF & ZIEGLER 1957 [= *Tortodus kockelianus* (s. l.) WEDDIGE 1977]	[*kockelianus* (dm 4.8 — 6.8)]
Polygnathus webbi STAUFFER 1938	[Lower Devonian — Late *marginifera* (ds13.3)]

Remarks: revised stratigraphic range: late Eifelian (near base ***kockelianus*** — in ***kockelianus***-zone). DK1996: dm: 5.0 — 6.4.
Presumable sedimentary environment: Deposition near the base of a rising submarine ridge. Debritic carbonate input increases towards the top of the succession, indicating the generation of succeedingly favourable conditions for the carbonate-production at the top of the ridge - due to sea-level fall and/or tectonically induced rise of the ridge.

Sample: TW 2 (samples 16+20) **Quotation:** TRAUTWEIN & WITTEKINDT 1960: 474-476
Gauss-Kruger-coordinates: [ca. ^{34}46400 - ^{55}92600]
Location: section (between ^{34}46450 - ^{55}92900 and ^{34}46400 - ^{55}92600) at the railway track between Kirschhofen-tunnel and Michelsberg-tunnel south of Kirschhofen (at railway-km 26.705 - directly above the tunnel-entrance; geological map 1:25000, 5515 Weilburg).
Lithology: succession of a) 11.2m intrusive-diabas, [contact zone], b) 1.0m darkgrey, laterally inconsistent, slates with a 15cm thick lightgrey limestone bed, c) 1.2m coarse-grained, strongly cleaved intrusive diabas, [contact-metamorphosed zone], d) 0.6m greenish sandy slates, e) 1.0m lightgrey, partly reddish limestones-beds and - nodules; within the limestones lies a 15cm thick concordant-bedded massive diabas, f) min. 3.2m pillow-basalt and massive diabas.
Stratigraphic correlation: Sample 16: late Famennian (Dasbergian, toV). Sample 20: middle to higher *Gattendorfia*-stage (cu I).
Fossils: (conodonts, det. by TRAUTWEIN & WITTEKINDT; from lithologies b (sample 16) and e (sample 20))

(20): LCC2003: ci: 5.8 —6.7 (? + reworked DK1996: ds 15.2 — 17.1)

Polygnathus [*communis*] *communis* BRANSON & MEHL 1934	[Early *postera* — ? in *texanus*]
Polygnathus cf. *flabellus* BRANSON & MEHL 1934	[in Early *crenulata*— in *anchoralis-latus*]
Polygnathus inornatus BRANSON 1934	[in Early *expansa*— *anchoralis-latus*]
Polygnathus purus purus VOGES 1959	[in *sulcata*— *sandbergi*]
Polygnathus purus subplanus VOGES 1959	[in Late *praesulcata*— in upper *duplicata*]
Polygnathus cf. *styriacus* ZIEGLER 1957	[Early *postera* — Early *expansa*]
Protognathodus (Gnathodus) kockeli BISCHOFF 1956	[Late *praesulcata* — in lower *crenulata*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Pseudopolygnathus triangulus inaequalis VOGES 1959	[in lower *duplicata* — in *sandbergi*]
Pseudopolygnathus triangulus triangulus VOGES 1959	[in *sandbergi* — lower *crenulata*]
Siphonodella duplicata (BRANSON & MEHL 1934)	[*duplicata* — in Early *crenulata*]
Siphonodella lobata (BRANSON & MEHL 1934)	[in *sandbergi* — in *isosticha* / upper *crenulata*]
Siphonodella obsoleta HASS	[in upper *duplicata* — ?in *isosticha* / upper *crenulata*]

---------- biostratigraphic "gap". However, if we compare the thickness of the successive deposits between samples 16 and 20 (1.2 m diabas + 0.6m slate) with that described by HENNINGSEN 1965 between samples H 20 and H 21 (0.05m slate) from a position near a ridge-top, the assumption of a concordant bedded succession seems convincing.

(16): DK1996: ds 18.0 — 18.9 (+ reworked DK1996: ds 13.9 — 16.5)

Spathognathodus costatus spinulicostatus (BRANSON 1934) [= *Bispathodus costatus spinulicostatus* (BRANSON 1934)]	[in Middle *expansa* — Lower Carboniferous]
Spathognathodus inornatus (BRANSON & MEHL 1934) [= *Branmehla inornata* (BRANSON & MEHL 1934)]	[in Late *marginifera* — in Middle *expansa*]
Palmatolepis [(*basilica*) *deflectens*] *deflectens* MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Polygnathus nodomarginatus BRANSON 1934	[in Late *expansa* — in Middle *praesulcata*]
Polygnathus subserratus BRANSON & MEHL 1934	[Early *trachytera* — Late *postera*]
Pseudopolygnathus marburgensis BISCHOFF & ZIEGLER 1956	[Early *expansa* — Early *praesulcata*]

Remarks: revised stratigraphic range: A) sample 20: Lower Tournaisian; in *sandbergi*- — top *sandbergi*-zone; LCC2003: ci: 5.8 — 6.7 (? + reworked DK1996: ds 15.2 — 17.1; Early *postera* — Early *expansa*-zone); B) sample 16: Wocklumian; in Late *expansa* — Early *praesulcata*-zone; DK1996: ds 18.0 — 18.9 (+ reworked DK1996: ds 13.9 — 16.5; Early *trachytera* — Late *postera*-zone). The profile at the railway track south of Kirschhofen had also been described by RIETSCHEL (1961, 1966: 26-27, 30-37), however without delivering details which had not been presented by TRAUTWEIN&WITTEKINDT before.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies within the late Famennian is clay-silt (greenish and reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (marls, limestones, calcareous nodules). Episodic submarine volcanic activity lead to submarine magma outflow (pillow-basalt) or subsurface intrusions. Short-termed rapid sea-level fall during Middle *praesulcata* zone, followed by (?sudden) influx of anoxic bottom waters (Hangenberg event). Continuous sea-level rise during the lower Lower Carboniferous within a starved basin. Due to submarine volcanic activity reactivation of old submarine ridges as environment of carbonate production, evidenced by repeated influx of calcareous debris throughout the lower Tournaisian in this region.

Sample: TW 3 (samples 23+24) **Quotation:** TRAUTWEIN & WITTEKINDT 1960: 474-476
Gauss-Kruger-coordinates: [ca. ^{34}46450 - ^{55}92860]
Location: section (between ^{34}46450 - ^{55}92900 and ^{34}46400 - ^{55}92600) at the railway track between Kirschhofen-tunnel and Michelsberg-tunnel south of Kirschhofen (at railway-km 26.445 - ca. 50m southwards the tunnel entrance; geological map 1:25000, 5515 Weilburg).
Lithology: concordant succession of a) 4m (?intrusive) diabas, b) 1m dark slates, c) 0.8m limestone, d) 3.2m pillow basalt with calcareous layers and nodules in between.
Stratigraphic correlation: *Gattendorfia*-stage (cu I)
Fossils: (conodonts, det. by TRAUTWEIN & WITTEKINDT; from lithologies c (sample 23) and d (sample 24))

(24): LCC2003: ci: 5.8 (5.0 — 6.7) (? + reworked DK1996: ds 19.8 — LCC2003: ci: 5.0)

Polygnathus inornatus BRANSON 1934	[in Early *expansa*— *anchoralis-latus*]
Polygnathus purus purus VOGES 1959	[in *sulcata*— *sandbergi*]
Polygnathus purus subplanus VOGES 1959	[in Late *praesulcata*— in upper *duplicata*]
Protognathodus (Gnathodus) kockeli BISCHOFF 1956	[Late *praesulcata* — in lower *crenulata*]
Pseudopolygnathus cf. *fusiformis* BRANSON & MEHL 1934	[? lower *crenulata* ?]
Pseudopolygnathus triangulus inaequalis VOGES 1959	[in lower *duplicata* — in *sandbergi*]
Pseudopolygnathus triangulus triangulus VOGES 1959	[in *sandbergi* — lower *crenulata*]
Siphonodella duplicata (BRANSON & MEHL 1934)	[*duplicata* — in Early *crenulata*]
Siphonodella lobata (BRANSON & MEHL 1934)	[in *sandbergi* — in *isosticha* / upper *crenulata*]
Siphonodella obsoleta HASS	[in upper *duplicata* — ?in *isosticha* / upper *crenulata*]

(23): LCC2003: ci: 5.8 (5.0 — 6.7) (+ reworked DK1996: ds 16.5 — 17.4)

Spathognathodus costatus cf. *costatus* (BRANSON 1934) [= *Bispathodus costatus* cf. *costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Polygnathus cf. *flabellus* BRANSON & MEHL 1934	[in Early *crenulata*— in *anchoralis-latus*]
Polygnathus cf. *styriacus* ZIEGLER 1957	[Early *postera* — Early *expansa*]
Polygnathus inornatus BRANSON 1934	[in Early *expansa*— *anchoralis-latus*]
Polygnathus purus purus VOGES 1959	[in *sulcata*— *sandbergi*]
Polygnathus [*purus*] *radinus* COOPER 1939	[?]
Polygnathus purus subplanus VOGES 1959	[in Late *praesulcata*— in upper *duplicata*]
Protognathodus (Gnathodus) kockeli BISCHOFF 1956	[Late *praesulcata* — in lower *crenulata*]
Pseudopolygnathus dentilineatus BRANSON 1934	[Early *expansa* — *sandbergi*]
Pseudopolygnathus triangulus inaequalis VOGES 1959	[in lower *duplicata* — in *sandbergi*]
Pseudopolygnathus triangulus triangulus VOGES 1959	[in *sandbergi* — lower *crenulata*]
Siphonodella duplicata (BRANSON & MEHL 1934)	[*duplicata* — in Early *crenulata*]
Siphonodella lobata (BRANSON & MEHL 1934)	[in *sandbergi* — in *isosticha* / upper *crenulata*]
Siphonodella obsoleta HASS	[in upper *duplicata* — ?in *isosticha* / upper *crenulata*]

Remarks: revised stratigraphic range: lower Tournaisian (in ***sandbergi***-zone). LCC2003: ci: 5.8 (with reworked faunas a) from DK1996: ds 19.8 — LCC2003: ci: 5.0; in Late *praesulcata*— in upper *duplicata*-zone; b) DK1996: ds 16.5 — 17.4; Early — in Middle *expansa*-zone). The profile at the railway track south of Kirschhofen had also been described by RIETSCHEL (1961, 1966: 26-27, 30-37), however without delivering details which had not been presented by TRAUTWEIN & WITTEKINDT before.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Episodic submarine volcanic activity lead to submarine magma outflow (pillow-basalt) or subsurface intrusions. Short-termed rapid sea-level fall during Middle *praesulcata* zone, followed by (?sudden) influx of anoxic bottom waters (Hangenberg event). Continuous sea-level rise during the lower Lower Carboniferous within a starved basin. Due to submarine volcanic activity reactivation of old submarine ridges as environment of carbonate production, evidenced by repeated influx of calcareous debris throughout the lower Tournaisian in this region.

Sample: TW 4 (sample 25) **Quotation:** TRAUTWEIN & WITTEKINDT 1960: 473 middle
Gauss-Kruger-coordinates: [ca. ^{34}46450 - ^{55}92900]
Location: section (between ^{34}46450 - ^{55}92900 and ^{34}46400 - ^{55}92600) at the railway track between Kirschhofen-tunnel and Michelsberg-tunnel south of Kirschhofen (at railway-km 26.4 - directly at and above the tunnel-entrance; geological map 1:25000, 5515 Weilburg).
Lithology: concordant succession of a) 6.4m pillow basalt, b) 4.8 m dark partly cherty slates with small phosphatic concretions (Liegende Alaunschiefer), c) 3-5m (inferred: 9.6m) dark flinty slates (Kieselschiefer).
Stratigraphic correlation: lower *Pericyclus*-stage (cu II)

Fossils: (conodonts, det. by TRAUTWEIN & WITTEKINDT; from phosphatic concretions at the top of lithology b)

Doliognathus sp.	[?in lower *typicus* — near top of *anchoralis-latus*?]
Hindeodella cf. *undata* BRANSON & MEHL 1941	[?]
Hindeodella deflecta HIBBARD 1927	[?]
Hindeodella similis ULRICH & BASLER 1926	[?]
Lonchodina projecta ULRICH & BASLER 1926	[?]
Polygnathus inornatus BRANSON 1934	[in Early *expansa*— *anchoralis-latus*]
Prioniodina cassilaris BRANSON & MEHL 1941	[?]
Pseudopolygnathus triangulus [s.l.]VOGES 1959	[in lower *duplicata* — lower *crenulata*]
Siphonodella crenulata COOPER 1939	[lower *crenulata* — in *isosticha* / upper *crenulata*]
Siphonodella duplicata (BRANSON & MEHL 1934)	[*duplicata* — in lower *crenulata*]
Solenodella ? sp.	[?]
Spathognathodus crassidentatus (BRANSON & MEHL 1934)	[?]

Remarks: revised stratigraphic range: late Tournaisian (cu II β; in Early ***typicus***- — near the top of ***anchoralis-latus***-zone). LCC2003: ci: 10.3 — 13.1 (with reworked fauna from LCC2003: ci: 6.7 — 7.5; Early — in Early *crenulata*-zone). Lithologies b and c are, due to AHLBURG (1918: 44 middle) part of the then assumed uppermost Upper Devonian "Gaudernbacher Schichten". The profile at the railway track south of Kirschhofen had also been described by RIETSCHEL (1961, 1966: 26-27, 30-37), however without delivering details which had not been presented by TRAUTWEIN & WITTEKINDT before.
Presumable sedimentary environment: Deposition within a basin. Episodic submarine volcanic activity lead to submarine magma outflow (pillow-basalt). Continuous rising of the sea-level during the lower Lower Carboniferous within a starved basin. Successively less input of silt-sized clastics, eventually lead to "pure" deposition of primary siliceous oozes (Kieselschiefer), partly intercalated by tuff layers.

F 1.16 WALLISER 1960

Sample: W 1 (Eschenau 1) **Quotation:** WALLISER 1960, p. 232 mid
Gauss-Kruger-coordinates: [34]40870 - [55]88710
Location: at the forest-margin, directly above the forest track, 100m westwards the junction with the street Eschenau — Hofen. Ca. 200 m westwards of Kerkerbach between Hofen and Eschenau (geological map 1:25000, 5515 Weilburg). Equivalent to sample-locality K 7.
Lithology: limestone nodules in "Bomben-Schalstein" (pyroclastic deposits with bomb-shaped, void-bearing basaltic ejecta). KEGLER (1967; compare also K 7) also found Lower Carboniferous (and lowermost Nehdenian) conodont faunas at this location in Deckdiabas breccias.
Stratigraphic correlation: Gonioclymenia- to Wocklumeria-stage.
Fossils: (conodonts, det. by WALLISER, from the limestone- nodules)

Palmatolepis [*gracilis*] *gonioclymeniae* (MÜLLER 1956)	[Late *expansa* — in Middle *praesulcata*]
Spathognathodus costatus costatus (BRANSON 1934) [= *Bispathodus costatus costatus* (BRANSON 1934)]	[in Middle *expansa* — in Middle *praesulcata*]
Spathognathodus spinulicostatus spinulicostatus (BRANSON 1934) [= *Bispathodus costatus spinulicostatus* (BRANSON 1934)]	[in Middle *expansa* — Lower Carboniferous]
Spathognathodus tridentatus (BRANSON 1934) [= ?*Bispathodus tridentatus* (BRANSON 1934)]	[?]

Remarks: revised stratigraphic range: late Famennian; uppermost Dasbergian — middle Wocklumian (in Middle ***expansa*** — in Middle ***praesulcata***-zone). DK1996: ds: 17.4 — 19.3. Although KEGLER (1967) and WALLISER (1960) tell us the same coordinates for this location they sampled two different lithologies, which in parts - esp. when they are tuff-bearing - are hardly to distinguish.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Submarine basic volcanic activity lead to release of pyroclastic deposits in the Late Famennian (and magma in the Lower Carboniferous). Reworked and downslope transported material prevails. Intercalations of calcareous debris from higher parts of the submarine ridge (limestones) and as inclusions in submarine released magma.

Sample: W 2 (Eschenau 2) **Quotation:** WALLISER 1960, p. 232 bottom
Gauss-Kruger-coordinates: [34]41020 - [55]88740
Location: Near location W 1 (Eschenau 1). Ca. 100 m westwards of the Kerkerbach, at the street between Eschenau and Hofen (geological map 1:25000, 5515 Weilburg). Equivalent to sample-locality K 2.
Lithology: limestone fragment in pillow-diabas.
Stratigraphic correlation: *anchoralis-bilineatus*- interregnum

Fossils: (conodonts, det. by WALLISER, from the limestone fragments)

Gnathodus [*commutatus*] *homopunctatus* (ZIEGLER)	[in *anchoralis-latus* — in *bilineatus*]
Gnathodus delicatus BRANSON & MEHL 1938	[*isosticha* / upper *crenulata* — ?in *anchoralis-latus*]
Gnathodus punctatus (COOPER 1939)	[*isosticha* / upper *crenulata* — in lower *typicus*]
Gnathodus semiglaber (BISCHOFF 1957)	[in *isosticha* / upper *crenulata* — in *bilineatus*]
Gnathodus texanus ROUNDY 1926	[*texanus* — in *bilineatus*]
Hindeodella undata BRANSON & MEHL	[?]
Gnathodus commutatus commutatus (BRANSON & MEHL 1941)	[in *texanus* — in *bilineatus*]
[= *Paragnathodus commutatus commutatus* HIGGINS 1975]	

Remarks: revised stratigraphic range: lower Viséan (cu II γ -— cu III α; Chadian — Asbian; in *Gnathodus texanus* -zone — in *Gnathodus bilineatus* -zone). LCC2003: ci: 14.1 — 17.5 (with reworked faunas from LCC2003: ci: 9.1 — 10.3; in *isosticha* / upper *crenulata* — in lower *typicus*-zone).
Presumable sedimentary environment: submarine basic volcanic activity, development of pillow basalts with inclusions of syngenetic soft sediments.

Sample: W 3 (Eschenau 3) **Quotation:** WALLISER 1960, p. 233 top
Gauss-Kruger-coordinates: ^{34}41110 - ^{55}88610
Location: Ca. 100 m southeast of location W 2 (Eschenau 2) the Kerkerbach flows around a morphological ridge, which consists mainly of "Bomben-Schalstein" (pyroclastic deposits with bomb-shaped ejecta). Within the Bomben-Schalstein small nodules of (?syngenetically depositied) limestone with late Famennian fauna occur. Also ca. 13m of a red, bedded, partly cherty pelite is observable. At the forest track between Eschenau and Hofen (geological map 1:25000, 5515 Weilburg). Equivalent to sample-locality K 11.
Lithology: a) "Bomben-Schalstein" (pyroclastic deposits with bomb-shaped ejecta) with intercalations of small nodules of (?syngenetically deposited) limestone; b) ca. 13 m red, thick bedded, partly flinty-slates with thin layers of red slates; intercalated by up to 30 cm thick coarse-grained limestone beds, which are mainly build-up by crinoid-detritus.
Stratigraphic correlation: fauna a) uppermost Upper Devonian IV-V; fauna b) *anchoralis-bilineatus*- interregnum
Fossils: (conodonts, det. by WALLISER, from the limestones)

<u>fauna a)</u>

Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Polygnathus styriacus ZIEGLER 1957	[Early *postera* — Early *expansa*]

also: conodonts from the lower Upper Devonian

<u>fauna b)</u>

Gnathodus [*commutatus*] *homopunctatus* (ZIEGLER)	[in *anchoralis-latus* — in *bilineatus*]
Gnathodus delicatus BRANSON & MEHL 1938	[*isosticha* / upper *crenulata* — ?in *anchoralis-latus*]
Gnathodus semiglaber (BISCHOFF 1957)	[in *isosticha* / upper *crenulata* — in *bilineatus*]
Hindeodella undata BRANSON & MEHL	[?]
Prioniodina alatoidea (COOPER)	[?]
Gnathodus commutatus commutatus (BRANSON & MEHL 1941)	[in *texanus* — in *bilineatus*]
[= *Paragnathodus commutatus commutatus* HIGGINS 1975]	

Remarks: revised stratigraphic range: <u>fauna a)</u> late Famennian, upper Hembergian to lower Dasbergian (Early ***postera*** — Early ***expansa***-zone). DK1996: ds 15.2 — 17.1 (in parts with reworked faunas from the lower Upper Devonian); <u>fauna b)</u> lower Viséan (cu II γ -— cu III α; Chadian — Asbian; in ***texanus*** -zone — in ***bilineatus*** -zone). LCC2003: ci: 14.1 — 17.5 (? with reworked fauna from LCC2003: ci: 8.3 — 12.5; *isosticha* / upper *crenulata* — ? in *anchoralis-latus*-zone).
Presumable sedimentary environment: a) late Famennian: Deposition at the slope of a submarine ridge. Submarine basic volcanic activity lead to release of pyroclastic deposits. Reworked and downslope transported material prevails. Intercalations of calcareous debris from higher parts of the submarine ridge (limestones) and as inclusions in submarine released magma. b) Early Viséan: Deposition within a starved basin. Low-energy environment prevails. Siliciclastic input partly that low, that siliceous ooze could not be thinned out by coarser grained sediment particles; therefore deposition of cherty slates and flinty slates (with radiolarians) partly prevailed. Main constituent of the sedimentary facies is clay-silt (reddish slates) with turbiditic intercalations of calcareous debris from higher parts of a submarine ridge (bedded, graded limestones). Due to episodic submarine volcanic activity "pure" pyroclastic deposits were deposited. Also pyroclastic deposits which were firstly deposited at/near the top of the ridge are observable in the form of subsequently reworked and downslope transported sediments.

Sample: W 4 (Limburg E) **Quotation:** WALLISER 1960, p. 233 bottom
Gauss-Kruger-coordinates: ^{34}34220 - ^{55}83900
Location: south of the railway-track Limburg — Wetzlar, directly west of the railway-bridge at the street Limburg — Eschhofen (geological map 1:25000, 5614 Limburg).
Lithology: lithologic succession of a) "Schalstein", original and reworked pyroclastic deposits, b) reddish slates, partly intercalated with calcareous nodules.
Stratigraphic correlation: uppermost Upper Devonian IV-V
Fossils: (conodonts, det. by WALLISER, from the calcareous nodules)

Palmatolepis (basilica) [*deflectens*] *deflectens* MÜLLER 1956	[in *rhomboidea* — ? in *praesulcata*]
Palmatolepis perlobata schindewolfi MÜLLER 1956	[Latest *crepida* — Late *expansa*]
Palmatolepis basilica n. subsp.	[?, nomen nudum]
Polygnathus styriacus ZIEGLER 1957	[Early *postera* — Early *expansa*]

Remarks: revised stratigraphic range: late Famennian; upper Hembergian to lower Dasbergian (Early ***postera*** — Early ***expansa*** -zone). DK1996: ds 15.2 — 17.1.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge. Main constituent of the sedimentary facies is clay-silt (reddish slates) with intercalations of calcareous debris from higher parts of the submarine ridge (flaser-limestones). Due to episodic submarine volcanic activity "pure" pyroclastic deposits were deposited. Also pyroclastic deposits which were firstly deposited at/near the top of the ridge are observable in the form of subsequently reworked and downslope transported sediments.

F 1.17 WIERICH & VOGT 1997

Sample: WV 1 (AV 147) **Quotation:** WIERICH & VOGT 1997, p. 106 bottom, 107 mid
Gauss-Kruger-coordinates: ^{34}35071.54 - ^{55}84363.16
Location: drill site BK 3004/5 (depth: 26.8m) of the Deutsche Bahn AG, ca. 800m south of Dietkirchen (directly north of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: lithologic succession of a) 21.1m grey to (weathered:) lightgrey/whitish, graded bedded sandstones, with max. ca. 3m thick intercalations of b) black to darkgrey slates. Since the layers dip with ca. 70-80° within the whole core, only 3-4m concordant sandstone/slate succession is directly provable. The ratio between sandstone and slate is ca. 2:1.
Stratigraphic correlation: presumably lower Viséan, with reworked flora from the Tournaisian
Fossils: (spores, det. by WIERICH & VOGT, from lithology b) at 22.3m depth)

Convolutispora vermiformis HUGHES & PLAYFORD 1961	[late Upper Devonian — CM]
Corbulispora cancellata (WALTZ) BHARADWAJ & VENKATACHALA 1961	[late Upper Devonian — ME]
Densosporites aculeatus PLAYFORD 1962	[PU — NC (— ?lower Namurian)]
Densosporites subcrenatus (WALTZ) POTONIE & KREMP 1955	[PU — NC (— ?lower Namurian)]
Densosporites sp.	
Knoxisporites hederatus (ISHCHENKO) PLAYFORD 1962	[late Upper Devonian — TS]
Lycospora pusilla (IBRAHIM) SOMERS 1972	[PU — Upper Carboniferous]
Monoletes indet.	

Remarks: revised stratigraphic range: Viséan; (ca. ***texanus*** — lower part of ***multinodosus***-zone). LCC2003: ci: 13.3 — > 20.0 (with reworked flora from DK1996: ds 18.9 — LCC2003: ci: 13.3 (CM); ca. Middle *praesulcata* — *anchoralis-latus*-zone).
Presumable sedimentary environment: Deposition of mud from suspension, puntuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles. The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

Sample: WV 2 (AV 25) **Quotation:** WIERICH & VOGT 1997, p. 106 bottom, 107 mid
Gauss-Kruger-coordinates: ^{34}35250 - ^{55}84620
Location: abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen (directly north of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Bruchberg-sandstone formation: lithologic succession of a) 25 -30m grey to (weathered:) lightgrey/whitish, graded bedded sandstones, with max. ca. 0.1m thick intercalations of b) laterally inconsistent black to darkgrey slates. Since repetitions of the lithologic succession occur due to faulting and folding, only 6.5m concordant sandstone succession is directly provable.
Stratigraphic correlation: presumably lower Viséan, with reworked flora from the Tournaisian

Fossils: (spores, det. by WIERICH & VOGT, from lithology b)

Acanthotriletes sp.	
Densosporites brevispinosus HOFFMEISTER, STAPLIN & MALLOY 1955	[PU — NC (— ?lower Namurian)]
Densosporites sp.	
Knoxisporites sp.	
Lycospora pusilla (IBRAHIM) SOMERS 1972	[PU — Upper Carboniferous]
Radiizonates mirabilis PHILLIPS & CLAYTON 1980	[PC — CM]
Retusotriletes sp.	
Spelaeotriletes sp.	
Tumulispora rarituberculata (LUBER) PLAYFORD 1991	[in *pusillites*-*lepidophyta* — CM]

Remarks: revised stratigraphic range: Viséan; (ca. ***texanus*** — lower part of ***multinodosus***-zone). LCC2003: ci: 13.3 — > 20.0 (with reworked flora from LCC2003: ci: 8.5 — 13.3; PC — CM; ca. in *isosticha* / Late *crenulata* — *anchoralis*-*latus*-zone).

Presumable sedimentary environment: Deposition of mud from suspension, puntuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles. The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

F 2

Register of new biostratigraphic results

F 2.1 Listing of data

Sample: AV 1
Gauss-Kruger-coordinates: ^{34}40820 - ^{55}87970
Location: abandoned small quarry at forest track north of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: bedded black flinty slate (Dunkle Lydite).
Stratigraphic correlation: Upper Tournaisian (ca. *Albaillella* ***deflandrei*** — *A.* ***indensis*** - zone). LCC2003: ci: (8.7 — 14.4).
Fossils: (acritarchs, radiolarians, conodonts (indet.); det. by VOGT)

Diexallophasis absonda WICANDER 1974 (AV 1-2, 29.0/99.2; F 2.2, plate F 2-8, fig. 4)	[Tournaisian]
Leiofusa sp. (AV 1-4, 29.0/110.6 (F 2.2, plate F 2-8, fig. 1), 40.2/102.8)	
Veryhachium sp. (AV 1-2, 38.1/106.9)	
Unidentified palynomorph (acritarch?) (AV 1-2, 39.5/98.8; F 2.2, plate F 2-8, fig. 5)	
Unidentified palynomorph (acritarch?) (AV 1-2, 32.7/102.0; F 2.2, plate F 2-8, fig. 6)	
Unidentified acritarch (AV 1-4, 41.2/105.9, pl. F 2-8, fig. 2)	
Unidentified palynomorph (acritarch?) (AV 1-4, 39.8/106.3; F 2.2, plate F 2-8, fig. 7)	
Thorn in *knorria*-preservation (AV 1-4, 41.6/102.8 (F 2.2, plate F 2-8, fig. 3), 41.8/98.6)	
? Radiolarian (cf. *Entactinosphaera palimbola* FOREMAN 1963) (AV 1-1, 42.3/103.5, organic preservation)	[(Lower Famennian — Upper Tournaisian (*A. paradoxa*-zone))]
Palaeoscenidium cladophorum DEFLANDRÉ 1953 (Franke-cell AV 1)	[Frasnian — Tournaisian]
cf. *Entactinia tortispina* (ORMISTON & LANE 1976) BRAUN 1990 (Franke-cell AV 1)	[*A. deflandrei* — *Latentifistula concentrica*-zone]
Cubaxonium ? *octaedrospongiosum* WON 1983 (Franke-cell AV 1)	[Upper part of Pericyclus II β-zone — "*Pericyclus* γ -zone", since the radiolarian-bearing sample was taken from lithologies which were attributed to this age on the geological map.]
Belowea sp. aff. *Entactinosphaera palimbola* FOREMAN 1963 in WON 1983, pl. 5 (Franke-cell AV 1)	[Famennian — Tournaisian; frequent in the "Liegender Alaunschiefer"]
Conodonta indet. (cf. juvenile *Polygnathus communis communis* BRANSON & MEHL 1934) (Franke-cell AV 1)	

Remarks: The observed palynofacies is dominated by (poorly preserved) acritarchs, which are characteristic for an open marine, but still shelf-influenced off-shore palaeoposition.
Presumable sedimentary environment: Deposition of mud from suspension within a basin. High equatorial radiolarian-productivity in connection with reduced clastic influx from an increasingly arid southern Laurussian continent (with reduced topography) allowed for a sedimentation of radiolarian-rich siliceous oozes. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: AV 2
Gauss-Kruger-coordinates: ^{34}40820 - ^{55}87960
Location: abandoned small quarry at forest track north of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: Dark, partly silty, slate with intercalations of cherty nodules and flinty slates.
Stratigraphic correlation: uppermost Emsian — lowermost Eifelian (*douglastownense* - *eurypterota* — near base *velatus* - *langii* -zone). DK1996: ca. di 19.0 — ca. dm 1.4; with reworked upper Silurian (Pridolian).
Fossils: (spores, acritarchs, ?prasinophycean algae (cysts), chitinozoans; det. by VOGT).

Ancyrospora kedoae (RIEGEL 1973) TURNAU 1974 (AV 2-2, 30.9/97.2)	[uppermost Emsian — lower Eifelian (*douglastownense* - *eurypterota* (ca. di 19.0) — in *velatus* - *langii* (ca. dm 2.5))]
Apiculiretusispora arenorugosa MCGREGOR 1973 (AV 2-2, 34.5/108.0)	[Lower Siegenian — lower Eifelian (near base *polygonalis* - *emsiensis* (ca. di 7.6) — near base *velatus* - *langii* (ca. dm 1.4))]

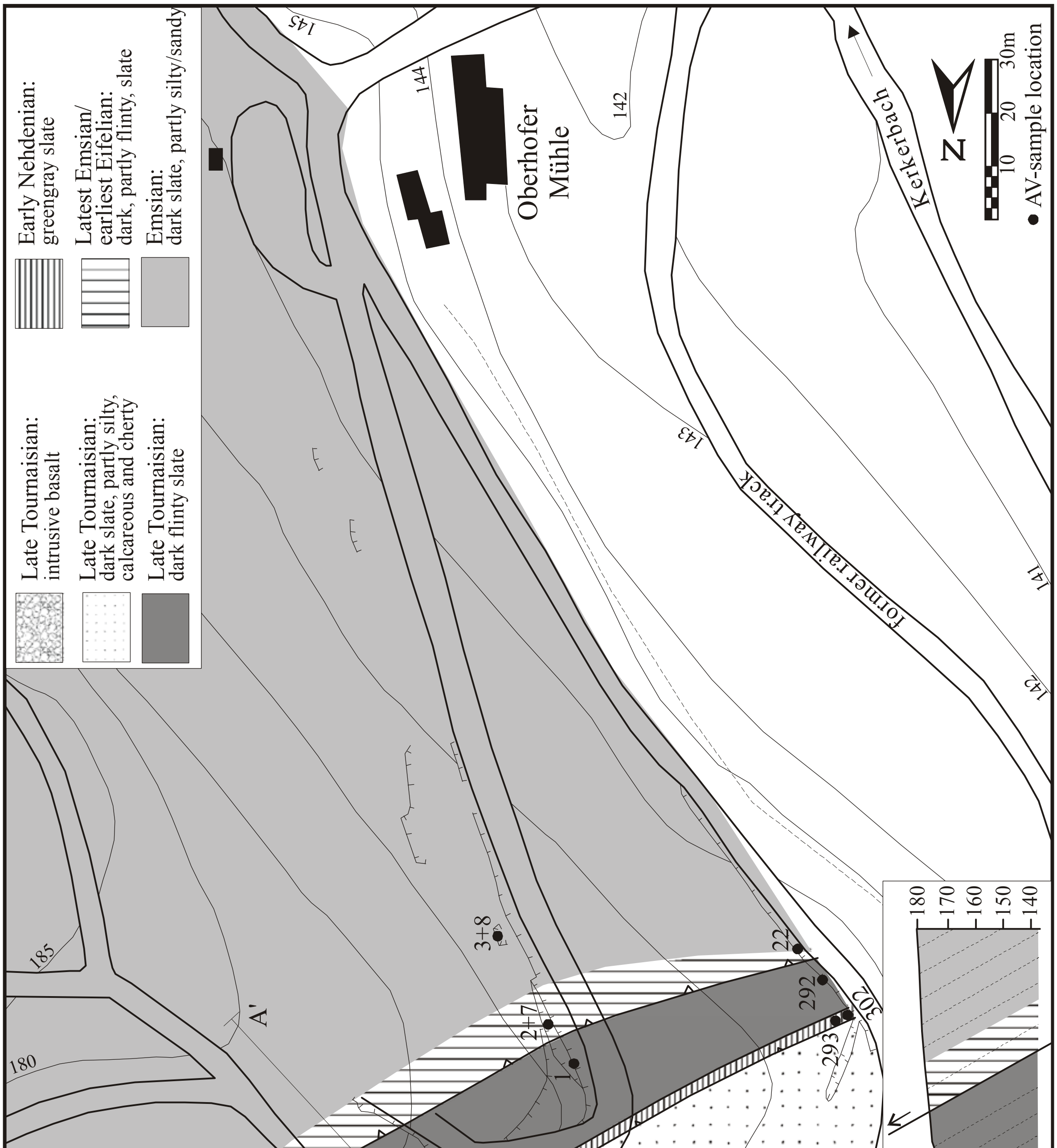


Fig. F 2.1: Geological situation north of the Oberhofer Mühle near Hofen. Detail of the boundary between autochthonous units (Emsian - Eifelian; Nehdenian) and the Giessen nappe (late Tournaisian) with sample locations.

Apiculiretusispora cf. *brandtii* STREEL 1967 in EDWARDS 1968, RICHARDSON & MCGREGOR 1986 (AV 2-2, 29.9/113.2, ? 9.6/111.0)	[Lower Siegenian — lower Eifelian (near base *polygonalis* - *emsiensis* (ca. di 7.6) — in *velatus* - *langii* (ca. dm 2.4))]
Apiculiretusispora plicata (ALLEN 1965) STREEL 1967 (AV 2-2, 20.6/113.1)	[Lower Gedinnian — Lower Eifelian (within *micrornatus* - *newportensis* (ca. di 1.4 — near top *velatus* - *langii* (ca. dm 3.0))]
Archaezonotriletes polymorphus NAUMOVA 1953 (AV 2-2, 23.5/112.7)	[uppermost Emsian — lower Eifelian]
Cymbosporites verrucosus RICHARDSON & LISTER 1969 (AV 2-2, 7.6/113.7)	[Upper Silurian (lowermost Pridolian)]
Dibolisporites eifelensis (LANNINGER 1968) MCGREGOR 1973 (AV 2-2, 27.5/111.0)	[Siegenian — lower Eifelian (*polygonalis* - *emsiensis* (ca. di 6.7) — in *velatus* - *langii* (ca. dm 2.0))]
Dictyotriletes sp. aff. *D. minor* NAUMOVA 1953 in SCHULTZ 1968 (AV 2-2, 26.9/113.0)	[? Emsian — ? Givetian]
Gneudnaspora divellomedium (TCHIBRIKOVA 1962, BALME 1962) BALME 1988 in AVKHIMOVITCH et al. 1993 (AV 2-2, 35.1/113.2, 25.2/105.6)	[uppermost Emsian — lower Eifelian due to AVKHIMOVITCH et al. 1993; Frasnian due to BALME 1988]
Spinozonotriletes sp. aff. *S. arduinnae* RIEGEL 1973 (AV 2-2, 24.0/103.1, 26.6/96.7)	[? uppermost Emsian — ? lower Eifelian (*douglastownense* - *eurypterota* (ca. di 19.0) — in *velatus* - *langii* (ca. dm 2.5))]
cf. *Ambitisporites* sp. B of RICHARDSON & IOANNIDES 1973 in RICHARDSON & MCGREGOR 1986 (AV 2-2, 30.9/99.9)	[Upper Silurian (Pridolian) — lower Siegenian (*tripapillatus* - *spicula* — within *polygonalis* - *emsiensis* (ca. di 8.0))]
cf. *Apiculiretusispora gaspiensis* MCGREGOR 1973 (AV 2-1, 23.6/102.5)	[Upper Emsian — Eifelian (near top *annulatus* - *sextantii* (ca. di 17.7) — in *devonicus* - *naumovii* (ca. dm 7.7)]
cf. *Brochotriletes* sp. A of RICHARDSON & IOANNIDES 1973 in RICHARDSON & MCGREGOR 1986 (AV 2-2, 29.2/113.8)	[Upper Silurian (uppermost Wenlockian — lowermost Pridolian)]
cf. *Calyptosporites biornatus* (LANNINGER 1968) RICHARDSON 1974 (AV 2-2, 24.3/108.2)	[Upper Emsian — lowermost Eifelian (within *annulatus* - *sextantii* (ca. di 15.7) — *douglastownense* - *eurypterota* (ca. dm 1.1))]
Onondagaella deunffi CRAMER 1966 (AV 2-2, 32.9/113.2)	[Silurian (— Lower Devonian)]
Leiofusa cf. *exilata* DORNING 1981	[Upper Silurian]
Veryhachium aff. *trispininflatum* CRAMER 1964 (AV 2-2, 20.5/112.9)	[? middle Siegenian — ? middle Emsian]
Leiofusa sp. (AV 2-2, 23.7/112.8, 31.0/109.2)	[probably reworked Silurian species]
Onondagaella sp. (AV 2-1, 5.4/110.6)	
Veryhachium sp. (AV 2-1, 10.0/102.6)	
Chitinozoa indet. (AV 2-2, 34.5/112.7)	[probably reworked Silurian species]

Remarks: Sample 7 is equal to sample 2, but was taken from a different part of the original sample (ca. 2 kg) collected at the above mentioned site. Since the palynoclasts are indeterminable in sample 7 this shows how surficial weathering and originally varying pyrite and heavy mineral content act as important limitations on the state of preservation and therefore the possibility of palynofacies studies.

Presumable sedimentary environment: Marine shelf, but not too far away from terrestrial areas, since the spore spectrum dominates over the acritarch flora. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited finesilt. Tectonic activity (rifting ?) lead to redeposition of upper Silurian (Pridolian) sediments. Dominating bedding features are lenticular bedding and laminated finesilt or mud. Wave energy and mud supply control mud abundance. The small nodules which show a cherty character are probably thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: AV 3 + 8
Gauss-Kruger-coordinates: ^{34}40830 - ^{55}87940
Location: abandoned small quarry at forest track north of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: Dark slate with minor coarsesilt - finesand intercalations (small pseudonodules).
Stratigraphic correlation: Emsian (late *annulatus* - *sextantii* - zone). DK1996: ca. di 16.7 — 17.4; with reworked upper Silurian (upper Wenlockian — Ludlowian).

Fossils: (spores, acritarchs, prasinophycean algae (cysts), chitinozoans; det. by Vogt)

Acinosporites lindlarensis Riegel 1968 var. *minor* (AV 3-1 (SEM, pict. 17860; F 2.2, plate F 2-3, fig. 3))	[Upper Emsian — middle Givetian (in *annulatus-sextantii* (ca. di 16.7) — in *lemurata-magnificus* (ca. dm 13.6))]
Camptozonotriletes caperatus McGregor 1973 (AV 8-3, 49.3/107.7; F 2.2, plate F 2-1, fig. 3)	[middle Siegenian — lower Eifelian (in *polygonalis - emsiensis* (di 8.1) — in *velatus - langii* (dm 1.6))]
Chelinospora favosa Steemans 1989 [= *Dictyotriletes favosus* McGregor & Camfield 1976] (AV 8-1, 24.5/98.5; F 2.2, plate F 2-1, fig. 1)	[Pragian — Lower Emsian (within *polygonalis - emsiensis* (ca. di 7.5) — within *annulatus - sextantii* (ca. di 12.3))]
Chelinospora ? vermiculata (Chaloner & Streel 1968) McGregor & Camfield 1976 (AV 8-1, 19.2/91.5; F 2.2, plate F 2-2, fig. 5)	[Upper Silurian — Gedinnian]
Convolutispora clivosa Kaiser 1971 (AV 8-3, 21.8/110.1, 20.6/107.9 (F 2.2, plate F 2-1, fig. 10))	[Emsian (di 10.2) — Upper Devonian]
Cymbosporites paulus McGregor & Camfield 1976 (AV 8-1, 34.0/105.0; F 2.2, plate F 2-1, fig. 8)	["Middle" Pragian — Emsian (within *polygonalis - emsiensis* (ca. di 8.2) — *annulatus - sextantii* -zone (ca. di 19.0))]
Dibolisporites abitibiensis McGregor & Camfield 1976 (AV 8-1, 29.5/113.0; F 2.2, plate F 2-1, fig. 7)	[Emsian, ca. *annulatus - sextantii* - zone (di 11.2 - 19.0)]
Dictyotriletes subgranifer McGregor 1973 (AV 8-1, 21.2/97.0; F 2.2, plate F 2-1, fig. 9, reticulate sculpture partly destroyed)	[Emsian (ca. *annulatus -sextantii* -zone)]
Retusotriletes maculatus McGregor & Camfield 1976 (AV 8-2, 25.5/92.1 (F 2.2, plate F 2-2, fig. 4), AV 8-3, 43.0/114.0 (plate F 2-2, fig. 1))	[Gedinnian — Emsian (*micrornatus - newportensis* (di 0.6) — in *annulatus - sextantii* (di 17.4))]
Tholisporites chulus (Cramer) McGregor 1973 var. *nanus* [= *Archaeozonotriletes chulus* var. *nanus* Richardson & Lister 1969] (AV 8-1, 35.0/114.0; F 2.2, plate F 2-2, fig. 6)	[Silurian (upper Llandovery) — within Gedinnian (ca. di 3.0)]
Verrucosisporites polygonalis Lanninger 1968 (AV 8-3, 23.6/91.3)	[Siegenian — Emsian (*polygonalis - emsiensis* (di 6.7) — *annulatus - sextantii* (di 19.0))]
Dictyotriletes cf. *D. emsiensis* (Allen 1965, McGregor 1973) McGregor & Camfield 1976 (AV 8-2, 18.7/92.8 (F 2.2, plate F 2-1, fig. 6), ca. ½ of the specimen preserved)	[Pragian — Eifelian (*polygonalis-emsiensis* (di 6.7) — in *velatus-langii* (ca. dm 2.5))]
Emphanisporites cf. *annulatus* McGregor 1961 (AV 8-3, 31.6/109.0)	[Emsian — Givetian (*annulatus - sextantii* (di 11.2) — near base *optivus - triangulatus* (dm 17.4))]
Retusotriletes cf. *R. dubius* (Eisenack) Richardson 1965, of Richardson & Ioannides 1973 (AV 3-1 (SEM, pict. 17861))	[Emsian (ca. *annulatus-sextantii*-zone (ca. di 11.2 — 19.0)]
cf. *Ambitisporites avitus* Hoffmeister 1959 (AV 8-3, 22.9/107.9, 47.1/106.3)	[Silurian (middle Llandoverian — Ludlowian)]
cf. *Clivosispora verrucata* McGregor var. *verrucata* McGregor 1973 (AV 8-3, 44.0/102.8)	[uppermost Gedinnian — Emsian (in *breconensis - zavallatus* (di 4.4) — near base *douglastownense - eurypterota* (di 19.2))]
cf. *Retusotriletes clandestinus* Chibrikova (AV 3-1 (SEM, pict. 17859; F 2.2, plate F 2-3, fig. 2))	[Emsian (? early *annulatus-sextantii* — late *annulatus-sextantii*-zone, approx. RC-zone of the Eastern European zonation (ca. di ?11.2 — 19.0))]
Camarozonotriletes sp. (AV 8-3, 23.8/113.9, pl. F 2-1, fig. 4)	
Convolutispora sp. (AV 3-1 (SEM, pict. 17857; F 2.2, plate F 2-3, fig. 1))	
Retusotriletes sp. (AV 8-3, 47.6/100.0, AV 8-4, 49.5/99.2)	
Dictyotidium cavernosulum Playford 1977 (AV 8-3, 30.2/110.9; F 2.2, plate F 2-1, fig. 12)	[Emsian]
Leiofusa exilata Dorning 1981 (AV 8-3, 25.2/92.1; F 2.2, plate F 2-2, fig. 8)	[upper Silurian (lower Ludlowian)]
Multiplicisphaeridium ramusculosum (Deflandre 1942) Lister 1970 (AV 8-3, 49.5/99.5; F 2.2, plate F 2-1, fig. 11)	[Upper Ordovician — Middle Devonian]
Micrhystridium cf. *vigintispinum* Staplin 1961 (AV 8-3, 45.0/110.1; F 2.2, plate F 2-1, fig. 5)	[Upper Siegenian — Upper Devonian]
Multiplicisphaeridium cf. *M. eltonensis* Dorning 1981 (AV 8-3, 51.8/97.2; F 2.2, plate F 2-2, fig. 3)	[Upper Silurian (upper Wenlockian — lower Ludlowian)]
Multiplicisphaeridium cf. *M. variabile* (Lister 1970) Dorning 1981 (AV 8-1, 38.8/91.0; F 2.2, plate F 2-2, fig. 2)	[Upper Silurian (Ludlowian)]
Veryhachium cf. *V. trispininflatum* Cramer 1964 (AV 8-3, 31.2/104.5)	[? middle Siegenian — ? middle Emsian]
Leiofusa sp. (AV 8-3, 30.1/105.0)	
Tasmanites sp. (AV 8-3, 29.1/112.5)	
Acritarcha indet. (AV 8-3, 21.8/94.7, plate F 2-2, fig. 9)	[probably reworked Silurian species]

Angochitina ? *thadeui* Paris 1981 (AV 8-3, 43.2/107.3, ; F 2.2, plate F 2-2, fig. 7) [upper Silurian (upper Wenlockian — Ludlowian)]

Remarks: Sample 3 was taken from the same location as sample 8, but more surficially and therefore more weathered. Since the palynoclasts in sample 3 are nearly totally disaggregated and therefore indeterminable this shows how surficial weathering act as important limitation on the state of preservation and therefore the possibility of palynofacies studies.

Presumable sedimentary environment: Marine (inner) shelf, not too far away from terrestrial areas, since the spore spectrum dominates over the acritarch flora. Tectonic activity (rifting ?) lead to redeposition of upper Silurian (upper Wenlockian — Ludlowian) sediments. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt - finesand. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 4

Gauss-Kruger-coordinates: ^{34}44690 - ^{55}93100

Location: Kahlhau (geological map 1:25000, 5515 Weilburg).

Lithology: Breccia of dark flinty slates and pelitic slates (Kieselschieferbrekzie).

Stratigraphic correlation: younger than upper Tournaisian (? Viséan; younger than *Latentifistula concentrica* - zone, since the flinty-slate parts of the breccia, which most probably bear the radiolarians, had been completely lithified before brecciation). LCC2003: younger than ci 16.4 — 17.2; ? with reworked Upper Devonian (Famennian) and Tournaisian: DK1996: ca. ds 6.1 — LCC2003: ca. ci 13.3.

Fossils: (acritarchs, prasinophycean algae (cysts), ? radiolarians; det. by Vogt)

Navifusa bacillum (Deunff 1955) Playford 1977 (AV 4-2, 41.6/100.0, 27.4/95.2)	[late Pragian — Lower Carboniferous (Tournaisian)]
Stellinium cristatum Wicander 1974 (AV 4-3, 15.0/108.4, AV 4-4, 34.9/98.0 (cf.))	[Lower Carboniferous (Tournaisian)]
cf. *Estiastra rugosa* Wicander 1974 (AV 4-2, 36.1/96.9)	[Upper Devonian (Famennian)]
Leiofusa sp. (AV 4-1, 31.8/102.5, 34.5/102.5)	
? Radiolarian (cf. *Albaillella furcata* Won 1983, AV 4-3, 13.6/94.9, organic preservation)	[*Albaillella indensis* — in *Latentifistula concentrica* - zone]
? Radiolarian (*Latentifistula* (Nazarov & Ormiston 1983, *Scharfenbergia* Won 1983) Braun 1990 sp., maybe transition between *L.* (*S.) concentrica* (Rüst 1882, Won 1983) Braun 1990 and *L.* (*S.) plenospongiosa* (Won 1983) Braun 1990, both in Won 1983, AV 4-3, 28.0/93.6, organic preservation)	[*Latentifistula concentrica* - zone]

Remarks: No determinable radiolarians had been detected after treatment with 5%-HF.

Presumable sedimentary environment: Marine. Reworking of lithefied upper Tournaisian-Viséan flinty slates and pelites. The components of the evolved breccia consist of very angular flinty slate and pelite gravel. Reworking possible a) during sea-level fall with exposition of flinty slates sedimented on top of a submarine high or b) during volcanic (Deckdiabas-) activity with sudden destruction of a flinty slate succession at a flank of a submarine high and subsequent gliding of the shattered components towards the foot of the slope. I prefer alternative "b" because of the very angular components of the breccia which show no evidence for intensive (near-shore-) reworking and the spatial vicinity to an ancient submarine high built up by diabas.

Sample: AV 5 + 6

Gauss-Kruger-coordinates: ^{34}37850 - ^{55}87325

Location: Temporary outcrop (excavation for a building) within Steeden (geological map 1:25000, 5514 Hadamar).

Lithology: Blackish - violet slate.

Stratigraphic correlation: Uppermost Viséan (LCC2003: ca. ci 18.8) — Early Namurian.

Fossils: (spores, acritarchs, prasinophycean algae (cysts), radiolarians; det. by Vogt)

Dictyotriletes densoreticulatus Potonie & Kremp 1955 in Smith & Butterworth 1967, p. 196 (AV 6-1, 31.9/99.3)	[? Namurian — Westphalian]
Rotaspora cf. *fracta* (Schemel 1950) Smith & Butterworth 1967 (AV 5-1, 47.8/114.4)	[VF — Namurian]
Florinites sp. (AV 6-1, 30.6/91.8, transparent, oxidised & partly disaggregated, TAI ca. 3, size: ca. 100µm)	[NC — in Upper Carboniferous]
Potoniesporites sp. (AV 6-1, 43.0/92.8, transparent, oxidised & partly disaggregated, TAI ca. 3, size: ca. 75 x 60µm)	[NC — in Upper Carboniferous]
cf. *Schulzospora* sp. (AV 6-1, 47.7/104.7)	[TC — in Upper Carboniferous]
Cymatiosphaera sp. (AV 6-1, 49.7/111.7)	
Veryhachium sp. (AV 6-1, 51.2/110.6)	
cf. *Pterospermella* sp. (AV 6-1, 46.5/98.5, ca. 60µm)	
Saharidia ? sp. (AV 6-1, 42.7/105.6)	
cf. *Albaillella* sp. (? *A. nazarovi* Cheng 1986) (AV 6-1, 46.2/111.8)	[(?*A. nazarovi* - zone — ? Namurian)]

Remarks: HF-processed sample partly contaminated by light-yellowbrown recent palynomorphs - but these are easy to distinguish from the nearly opaque palaeozoic ones. By chance also a few oxidised and partly disaggregated transparent brownish palaeozoic spores are observable (*Potoniesporites*, *Florinites*) which are distinguished from recent species by their partly conserved remnant reflectivity under reflective light microscopy and their generally bad state of preservation.
Presumable sedimentary environment: Open marine, not too far away from terrestrial areas, since the spore spectrum dominates over the acritarch flora. Deposition of mud from suspension below or within wave base. Dominating bedding feature is laminated mud. Wave energy and mud supply control mud abundance.

Sample: AV 9
Gauss-Kruger-coordinates: ^{34}31510 - ^{55}80210
Location: Outcrop opposite of Aardecker Mühle (geological map 1:25000, 5614 Limburg, see ch. C 3, fig. C 3.3).
Lithology: Dark slate (compare chapter C 11, fig. C 11.2 and enclosure 1).
Stratigraphic correlation: Upper Emsian — ? Eifelian (in *annulatus* - *sextantii* - zone — ?). DK1996: ca. di (15.0) — ? > 20.0; with reworked upper Silurian (Ludlowian).
Fossils: (spores, acritarchs, prasinophycean algae (cysts), chitinozoans; det. by VOGT)

Emphanisporites annulatus MCGREGOR 1961 (AV 9-1, 49.5/104.0)	[Emsian — Givetian (*annulatus* - *sextantii* (di 11.2) — near base *optivus* - *triangulatus* (dm 17.4))]
Synorisporites sp. (AV 9-2, 40.8/98.4)	[typical for upper Silurian — lower Gedinnian]
cf. *Tetraletes variabilis* CRAMER 1966 (AV 9-1, 31.6/107.7)	[Upper Silurian (Ludlowian — in Pridolian)]
Dictyotidium variatum PLAYFORD 1977 (AV 9-2, 41.5/112.0)	[at least: late Pragian — Eifelian]
Leiofusa bernesgae CRAMER 1964 (AV 9-1, 27.0/95.7)	[Silurian (upper Llandoverian) — Emsian]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 9-1, 45.0/111.5; AV 9-2, 26.1/105.7, 43.1/101.3)	[late Pragian — Lower Carboniferous (Tournaisian)]
Pterospermella foveolata (LISTER) DORNING 1981 (AV 9-1, 52.3/113.7)	[Upper Silurian (upper Llandoverian — lower Ludlowian)]
Schizmatosphaeridium combazis CRAMER & DIEZ 1976 (AV 9-1, 38.3/93.7)	[late middle Emsian]
Leiofusa cf. *pumilia* DEUNFF 1966 (AV 9-1, 37.1/110.5; AV 9-2, 49.0/104.9, 53.5/104.2)	["Upper Devonian of Tunisia"]
Multiplicisphaeridium cf. *thyrae* (CRAMER 1964) DIEZ & CRAMER 1977 (AV 9-2, 31.4/105.9)	[? Silurian — middle *Platyclymenia*-zone (Upper Devonian, Famennian, upper Hembergian)]
Domasia sp. (AV 9-2, 50.0/100.0, 49.4/109.5)	[Silurian]
Leifusa sp. (AV 9-1, 49.8/112.2)	
Micrhystridium sp. (AV 9-2, 51.5/107.3, 46.1/107.0, 26.8/104.5)	
Tasmanites sp. (AV 9-2, 48.0/109.7, 40.9/102.9)	
Phycomata of ? *Tasmanites* (AV 9-2, 31.9/111.5, 45.9/108.2, 47.0/94.8, 43.7/110.9 (aggregate))	
cf. *Florisphaeridium* sp. (AV 9-2, 23.0/112.5)	
Conochitina sp. (AV 9-1, 46.8/107.6)	
Sphaerochitina sp. (AV 9-2, 44.0/106.4)	
Chitinozoa indet. (AV 9-2, 31.1/109.6)	

Remarks: Poorly preserved flora.
Presumable sedimentary environment: Marine (outer) shelf, maybe at the base of the slope of a submarine high; not too near to terrestrial areas, since the (Devonian) spore and acritarch flora are nearly in equilibrium. Tectonic activity (rifting ?) leads to redeposition of upper Silurian (? Ludlowian) sediments. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited calcareous debris. Dominating bedding feature is laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 10
Gauss-Kruger-coordinates: ^{34}44660 - ^{55}93260
Location: Outcrop directly at the street; Kahlhau (geological map 1:25000, 5515 Weilburg).
Lithology: *Posidonia* - slate: dark, blackblue, bluegrey to grey slate, partly flaser bedding
Stratigraphic correlation: Upper Viséan (min. NM — NC -zone). LCC2003: ca. ci 16.9 — >20.0. If the proposed time correlation for sample D9 (DILLMANN 1952; LCC2003: ca. ci 17.3 — 18.3) proves to be correct, this sample AV 10 must be remarkably younger since it follows ca. 7.5 m above sample location AV 275 (= D 9) within a concordant bedded succession. ? With reworked Upper Devonian (Famennian) and Tournaisian: DK1996: ca. ds 6.1 — LCC2003: ca. ci 13.3.
Fossils: (spores, acritarchs, prasinophycean algae (cysts), det. by VOGT)

Raistrickia nigra LOVE 1960 (AV 10-1, 40.8/114.4)	[NM — NC]
Dictyotriletes (*Reticulatisporites*) cf. *peltatus* PLAYFORD 1962 (AV 10-1, 44.5/112.8, 44.1/110.2)	[NM — Upper Carboniferous]

cf. *Tumulispora rarituberculata* (LUBER in LUBER & WALTZ 1941, TURNAU 1975) PLAYFORD 1990 (AV 10-1, 51.0/90.9 (45µm, tortuous))	[in pusillites-lepidophyta — CM]
Monoletes sp. 3 (AV 10-1, 36.5/109.9 (130x25µm), 45.2/98.5 (130x20µm), 32.2/95.0 (90x20µm); AV 10-2, 30.5/111.4 (130x30µm))	
Diexallophasis absonda WICANDER 1974 (AV 10-2, 50.0/115.4)	[Lower Carboniferous (Tournaisian)]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 10-1, 31.4/112.9 (125x20µm), 25.7/110.5, 41.4/109.3 (100x25µm), 29.8/108.4 (105x20µm), 24.8/94.0 (120x18µm), 40.0/114.3 (65x20µm))	[late Pragian — Lower Carboniferous (Tournaisian)]
Stellinium sp. cf. *S. micropolygonale* (STOCKMANS & WILLIÉRE) PLAYFORD 1977 (AV 10-2, 29.7/98.8 (105µm))	[Upper Emsian — Tournaisian]
Cymatiosphaera sp. aff. *C. brevicrista* WICANDER 1974 (AV 10-1, 55.8/109.7, broken)	[Famennian]
Leiofusa sp. (several species: AV 10-1, 26.1/103.2 (min.80x20µm); AV 10-2, 46.1/113.8 (min.280x25µm, broken), 25.2/112.4 (length: 395µm), 30.5/111.4 (130x30µm), 41.9/92.2 (min.300x25µm))	
Navifusa sp. (AV 10-1, 40.5/112.8 (min.105x30µm), 51.9/108.1 (50x10µm, curved), 26.4/102.5 (min.55x15µm, tortuous))	
Stellinium sp. (AV 10-1, 29.5/101.9, longest diameters: 130x80µm), 49.6/99.4, 56.3/97.8 (broken), 42.7/96.3 (partly transparent), 49.6/96.1 (?))	
Tasmanites sp. (AV 10-1, 30.1/99.1 (75µm), 27.9/91.4 (58µm))	
Veryhachium sp. (AV 10-1, 48.1/113.0)	
cf. *Estiastra* sp. (AV 10-1, 39.5/98.4 (tortuous))	
cf. *Pterospermella* sp. (AV 10-2, 49.1/110.8 (45µm))	
cf. *Villosacapsula* sp. (AV 10-1, 52.2/108.4)	
Phycomata of ? *Tasmanites* (AV 10-1, 30.8/103.6 (25µm), 28.3/96.7 (28µm), 52.3/93.0 (25µm); AV 10-2, 42.4/100.1 (40µm))	
Unidentified acritarchs, probably several new species (AV 10-1, 42.3/114.1, 36.9/109.5, 31.4/109.8 (partly transparent sac with phycomata); AV 10-2, 52.1/112.8 (partly transparent sac with phycomata), 33.0/92.3 (opaque), 50.1/115.0, 34.5/106.8, 23.0/100.0, 28.5/100.4, 26.9/98.7 (105x25µm), 38.8/97.9 (100 x max.25µm), 37.5/95.7 (120x40µm))	
? *Sphaerochitina* sp. (AV 10-2, 38.9/112.8 (140µm))	

Remarks: The palynofacies is dominated by acritarchs of compact appearance (type *Leiofusa*/*Navifusa* etc.). No acritarchs with process-rich and/or branching processes - which would indicate an off-shore open marine environment - are present. Due to the bad preservation it cannot be decided whether the species which terminate within the Tournaisian are longer-lasting or occur as reworked species. The occurrence of the - due to its bad preservation - probably reworked chitinozoan ?*Sphaerochitina* sp. is - at least - interesting.

Presumable sedimentary environment: Marine outer shelf, not too near to terrestrial areas, since the acritarch spectrum dominates over the spore flora. Tectono-seismic activity maybe lead to redeposition Famennian — Tournaisian sediments. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt - finesand and tuff. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 11
Gauss-Kruger-coordinates: ^{34}44660 - ^{55}93260
Location: Outcrop directly at the street; Kahlhau (geological map 1:25000, 5515 Weilburg).
Lithology: *Posidonia* - slate: dark, blackblue, bluegrey to grey slate, partly flaser bedding.
Stratigraphic correlation: Upper Viséan (min. NM — NC -zone). LCC2003: ca. ci 16.9 — >20.0. Slightly younger than AV 10. If the proposed time correlation for sample D9 (DILLMANN 1952; LCC2003: ca. ci 17.3 — 18.3) proves to be correct, this sample AV 11 must be remarkably younger since it follows ca. 11.6 m above sample location AV 275 (= D 9) and ca. 3.9 m above sample AV 10 within a concordant bedded succession. ? With reworked Upper Devonian (Famennian) and Tournaisian: DK1996: ca. ds 6.1 — LCC2003: ca. ci 13.3.
Fossils: (acritarchs, prasinophycean algae (cysts), det. by VOGT)

Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 11-1, 31.3/113.6 (115x25µm), 31.1/103.2 (100x25µm))	[late Pragian — Lower Carboniferous (Tournaisian)]
Stellinium comptum WICANDER & LOEBLICH 1977 (AV 11-1, 38.3/102.3 (65µm); AV 11-2, 29.8/103.0 (55µm))	[Middle Devonian — Tournaisian]
Cymatiosphaera sp. aff. *C. brevicrista* WICANDER 1974 (AV 11-2, 32.9/112.6 (80µm))	[Late Famennian]
Leiofusa sp. (several species: AV 11-1, 38.0/110.4 (75x25µm), 39.8/107.3 (70x25µm); AV 11-2, 34.0/110.4 (55x20µm); AV 11-1, 45.1/110.0 (min.200x40µm, broken - ca. 50% remnant), 43.3/101.4 (130x20µm))	
Navifusa sp. (several species: AV 11-1, 46.4/111.8 (50x25µm), 46.4/107.0 (80x25µm), 39.5/105.3 (60x22µm); AV 11-2, 29.2/99.7 (min.160x20µm, broken - ca. 50% remnant))	
Tasmanites sp. (AV 11-1, 34.4/112.0 (60µm); AV 11-2, 41.7/114.4 (85µm))	
Veryhachium sp. (AV 11-1, 31.0/108.9 (25µm))	
cf. *Cymatiosphaera* sp. (AV 11-2, 21.7/105.7 (45µm))	
cf. *Estiastra* sp. (AV 11-1, 46.8/92.8)	
Phycomata of ? *Tasmanites* (AV 11-1, 46.1/105.2 (30µm); AV 11-2, 30.2/92.5 (25µm))	
Unidentified acritarchs (several species: AV 11-1, 46.8/111.3 (80µm), 44.0/112.1, 32.8/100.5 (50x30µm); AV 11-2, 32.0/104.5 (45x20µm), ? 31.5/109.9 (70x22µm))	

Remarks: The palynofacies is dominated by acritarchs of compact appearance (type *Leiofusa*/*Navifusa* etc.). No acritarchs with process-rich and/or branching processes - which would indicate an off-shore open marine environment - are present. Due to the bad preservation it cannot be decided whether the species which terminate within the Tournaisian are longer-lasting or occur as reworked species.
Presumable sedimentary environment: Marine outer shelf, not too near to terrestrial areas, since the acritarch spectrum dominates over the spore flora. Tectono-seismic activity maybe lead to redeposition Famennian — Tournaisian sediments. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt - finesand and tuff. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 18
Gauss-Kruger-coordinates: ^{34}42390 - ^{55}90860
Location: south of former railway station Schupbach (geological map 1:25000, 5515 Weilburg).
Lithology: Black to darkbluegrey slate, partly with minor intercalations of quartzose (silt-finesand) beds.
Stratigraphic correlation: Lower — "middle" Emsian (*annulatus-sextantii* - zone). DK1996: di ca. 11.2 — ? 17.7; with reworked middle/upper Silurian — ? Gedinnian (m/u Silurian — DK1996: di 3.5). Sample location identical to that of D 1 (DILLMANN 1952) which yielded the following age correlation: upper Lower Emsian (Zlichovian, DK1996: di: ca. 12.8 — 14.3).
Fossils: (spores, acritarchs, prasinophycean algae (cysts), chitinozoans, brachiopods, det. by VOGT)

Apiculiretusispora plicata (ALLEN 1965) STREEL 1967 (AV 18-1, 49.4/108.5)	[Lower Gedinnian — Lower Eifelian (within *micrornatus - newportensis* (ca. di 1.4 — near top *velatus - langii* (ca. dm 3.0))]
Apiculiretusispora cf. *brandtii* STREEL 1967 in EDWARDS 1968, RICHARDSON & MCGREGOR 1986 (AV 18-1, 22.0/113.8, 47.9/112.1, 25.0/105.0, 44.8/101.2)	[Lower Siegenian — lower Eifelian (near base *polygonalis - emsiensis* (ca. di 7.6) — in *velatus - langii* (ca. dm 2.4))]
Dibolisporites wetteldorfensis (LANNINGER 1968) MCGREGOR 1973 (AV 18-1, 50.0/105.4, ? 49.2/91.2)	[Siegenian (near base of *polygonalis-emsiensis*, ca. di 7.6) — Emsian (near base of *douglastownense-eurypterota*, ca. di 19.2)]
Retusotriletes maculatus MCGREGOR & CAMFIELD 1976 (AV 18-1, 49.5/104.4)	[Gedinnian (*micrornatus-newportensis*, ca. di 0.6) — "middle" Emsian (in *annulatus-sextantii*, ca. di 17.7)]

Emphanisporites sp. cf. *E. annulatus* McGregor 1961 (AV 18-1, 25.1-114.0, 23.0/105.1)	[Emsian — Givetian (*annulatus - sextantii* (di 11.2) — near base *optivus - triangulatus* (dm 17.4))]
Verrucosisporites sp. cf. *V. polygonalis* Lanninger 1968 (AV 18-1, 40.2/98.5)	[Siegenian (*polygonalis-emsiensis*, ca. di 6.7) — Emsian (*annulatus-sextantii*, ca. di 19.0)]
cf. *Ambitisporites avitus* Hoffmeister 1959 (AV 18-1, 42.1/104.0)	[Middle — upper Silurian (middle Llandoverian, *avitus-dilutus* — middle Pridolian, in *tripapillatus-spicula*)]
cf. *Apiculiretusispora plicata* (Allen 1965) Streel 1967 (AV 18-1, 49.5/103.0, 51.9/94.0)	[Lower Gedinnian — Lower Eifelian (within *micrornatus - newportensis* (ca. di 1.4 — near top *velatus - langii* (ca. dm 3.0))]
cf. *Perotriletes microbaculatus* Richardson & Lister 1969 (AV 18-1, 25.0/112.7, 36.1/111.3, 30.2/109.9	[Gedinnian (in *micrornatus-newportensis*, ca. di 0.9 — 3.5)]
cf. *Retusotriletes warringtonii* Richardson & Lister 1969 (AV 18-1, 52.1/110.5)	[Middle Silurian (middle Llandoverian (in *avitus-dilutus*) — Gedinnian (in *micrornatus-newportensis*, ca. di 3.0)]
Emphanisporites sp. (AV 18-1, 49.4/101.7)	
Deunffia brevispinosa Downie 1960 (AV 18-1, 42.9/104.0, 25.8/91.5)	[Silurian (lower Wenlockian)]
Tasmanites sp. (AV 18-1, 24.5/105.2, ? 50.5/99.5)	
Chitinozoa indet. (AV 18-1, 5 different types: 49.6/112.3, 28.5/111.1 (broken remnant), 33.5/107.0 (distinct), 45.0/104.1, 32.7/102.7, ? 40.0/99.5)	[probably reworked Silurian forms]

Remarks: I also collected some brachiopods (spiriferids a. o.) at this site and presented them for further determination to the specialist Ulrich Jansen, Forschungsinstitut Senckenberg Frankfurt.

Presumable sedimentary environment: Marine (outer) shelf; but relatively shallow marine or near to small islands, since acritarchs are nearly absent. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt to finesand. Dominating bedding features are lenticular bedding and laminated sand/silt/mud. Wave energy and mud supply control mud abundance.

Sample: AV 21

Gauss-Kruger-coordinates: $^{34}42380$ - $^{55}90880$

Location: ca. 1m north of AV 20; south of former railway station Schupbach (geological map 1:25000, 5515 Weilburg).

Lithology: Dark, partly silty, slate (compare AV 19).

Stratigraphic correlation: upper Lower — lower Upper Emsian (in *annulatus-sextantii* — near base of *douglastownense-eurypterota* -zone). DK1996: ca. di 12.3 — 19.2; ? with reworked chitinozoans of unknown age.

Fossils: (spores, acritarchs, prasinophycean algae (cysts), ? chitinozoans, ? scolecodonts, det. by Vogt)

Apiculiretusispora plicata (Allen 1965) Streel 1967 (AV 21-2, 38.8/111.8 (40x30µm), ? 42.2/100.3 (35x25µm))	[Lower Gedinnian — Lower Eifelian (within *micrornatus - newportensis* (ca. di 1.4 — near top *velatus - langii* (ca. dm 3.0))]
Dibolisporites echinaceus (Eisenack) Richardson 1965 (AV 21-2, 23.6/104.2 (60x50µm))	[Emsian (in *annulatus-sextantii*, ca. di 12.3) — Frasnian (in *ovalis-bulliferus*, ca. ds 4.3)]
Dibolisporites wetteldorfensis (Lanninger 1968) McGregor 1973 (AV 21-2, 53.7/112.3 (40µm), ? 38.3/99.3 (30µm))	[Siegenian (near base of *polygonalis-emsiensis*, ca. di 7.6) — Emsian (near base of *douglastownense-eurypterota*, ca. di 19.2)]
Emphanisporites rotatus McGregor 1961 (AV 21-1, 39.1/112.8 (50x40µm), 41.0/91.1 (50x40µm))	[Devonian — lower Tournaisian]
Emphanisporites sp. cf. *E. annulatus* McGregor 1961 (AV 18-1, 25.1-114.0, 23.0/105.1)	[Emsian — Givetian (*annulatus - sextantii* (di 11.2) — near base *optivus - triangulatus* (dm 17.4))]
Emphanisporites sp. cf. *E. rotatus* McGregor 1961(AV 21-1, 41.0/91.1)	[Devonian — lower Tournaisian]
Punctatisporites sp. (AV 21-1, 27.9/110.8 (70x55µm))	
Baltisphaeridium anfractum Playford 1977 (AV 21-1, 28.0/109.5)	[Emsian (in *polygonalis-emsiensis*, ca. di 10.2) — lower Eifelian (in *velatus-langii*, ca. dm 2.4)]
Tasmanites sp. (AV 21.1, 29.3/100.7 (55x42µm))	
cf. Chitinozoa indet. (AV 21-1, 44.7/107.2, broken, length 100µm)	[probably reworked]

Remarks: Sample taken in near vicinity of a fault/thrust plane.

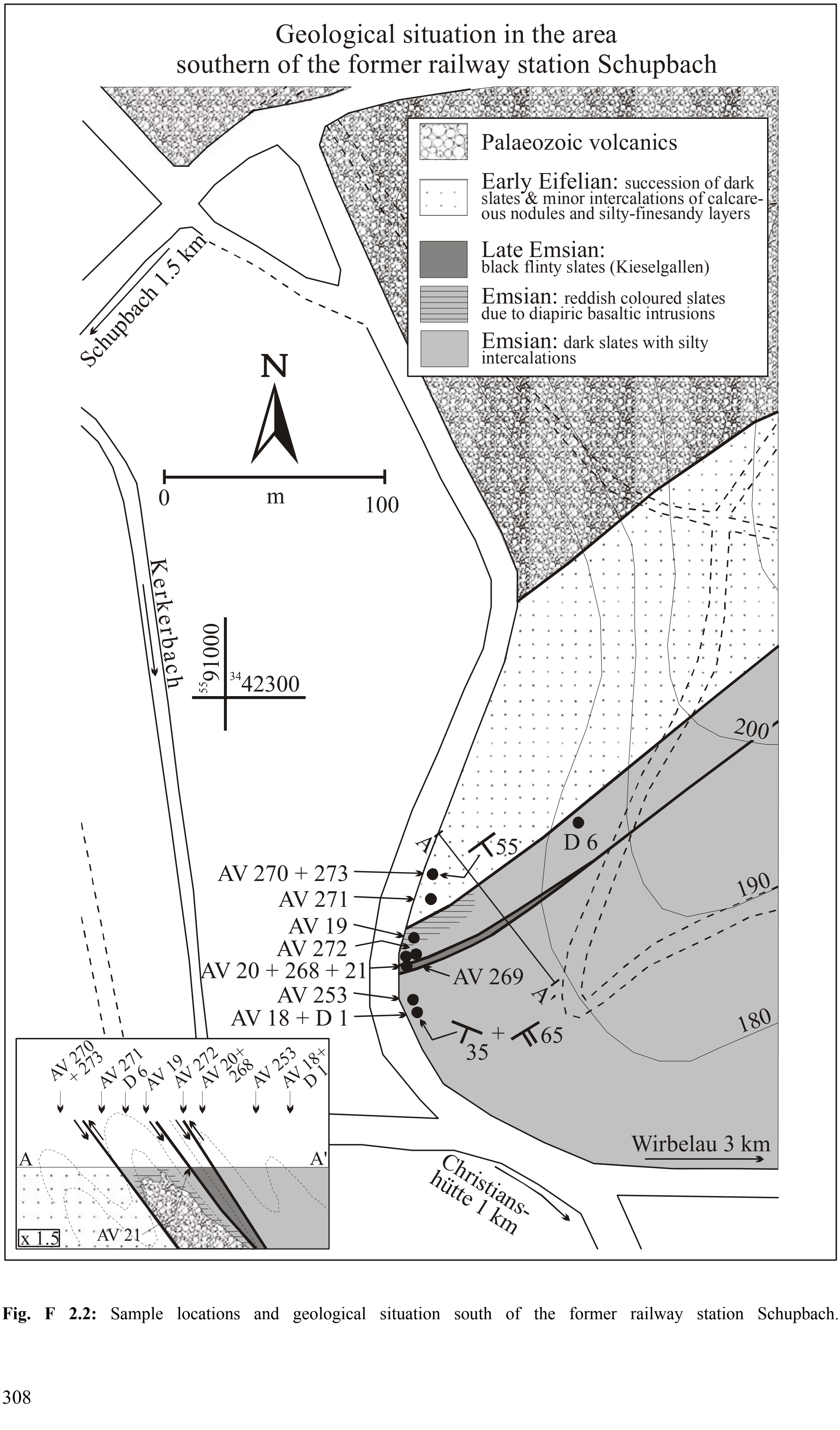


Fig. F 2.2: Sample locations and geological situation south of the former railway station Schupbach.

Presumable sedimentary environment: Marine (outer) shelf; far-shore acritarchs (*Baltisphaeridium anfractum*) are present. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt to finesand. Dominating bedding features are lenticular bedding and laminated sand/silt/mud. Wave energy and mud supply control mud abundance.

Sample: AV 22
Gauss-Kruger-coordinates: ^{34}40700 - ^{55}87950
Location: north of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: Dark slate with silty intercalations.
Stratigraphic correlation: Emsian. Probably of same age as sample AV 3 (late *annulatus* - *sextantii* - zone, DK1996: ca. di 16.7 — 17.4).
Fossils: (brachiopods)
indet. brachiopods
Remarks: Sample taken from near the surface. Fossils weathered and disaggregated; maybe better preservation if samples will be recovered from greater depth.
Presumable sedimentary environment: Marine (inner) shelf. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt - finesand. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 23
Gauss-Kruger-coordinates: ^{34}40690 - ^{55}88030
Location: north of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: Dark slate, partly silty, calcareous and cherty.
Stratigraphic correlation: Lower Carboniferous, maybe "middle" Tournaisian — ? lower Viséan (near the top of VI — ? PU-zone), ? with reworked Famennian. (LCC2003: ? ci 4.0 — ? 14.7, ? with reworked DK 1996: ds ? 6.1 — 20). But probably younger.
Fossils: (spores, acritarchs, ?radiolarians, det. by VOGT)

Knoxisporites literatus (WALTZ in LUBER & WALTZ 1938, PLAYFORD 1963) PLAYFORD 1971 (AV 23-1, 32.8/106.2, 47.8/104.1)	[Upper Devonian (latest Famennian, in *pusillites-lepidophyta* (ca. ds 19.1) — Namurian A (Arnsbergian)]
Spelaeotriletes sp. cf. *S. balteatus* (PLAYFORD) HIGGS 1975 (AV 23-1A, 38.6/100.5, 85x75µm)	["middle" Tournaisian (near the top of VI-zone, ca. ci 4.0) — ? Lower Viséan (? Pu-zone, ? ca. ci 14.7)]
? *Aneurospora greggsi* (MCGREGOR) STREEL 1974 (AV 23-2, 50.3/110.0, 50µm)	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Cymatiosphaera adaiochorata WICANDER 1974 (AV 23-2, 41.9/105.1, 40µm)	[Famennian]
Radiolarian ? (cf. *Albaillella* sp., AV 23-1, 53.0/105.8, organic preservation)	[? Lower Carboniferous (BRAUN 1990: most frequent in the Rheinisches Schiefergebirge from *Pericyclus* (ca. LCC2003: ci 6.7) — *Goniatites* α3 (ca. ci 17.5)]
Worm-like spiral-winding fossil (? foraminifer), attached to a piece of wood (AV 23-1, 51.7/110.8, 60x10µm; see AV 210)	

Remarks: The stratigraphic range of *Cymatiosphaera adaiochorata* WICANDER 1974 was confined to the Famennian by WICANDER 1974; however, e. g., another then established species, *Cymatiosphaera daioariochora* WICANDER 1974 is meanwhile proven to reach well into the Visean (GAO 1986: 20). Due to the bad preservation and the poor flora *C. adaiochorata* WICANDER 1974 is treated as reworked species in this sample, but one has to bear in mind that it may be a Lower Carboniferous acritarch.
Presumable sedimentary environment: Marine outer shelf, not too near to terrestrial areas, since ?radiolarians are present. Tectono-seismic activity maybe lead to redeposition Famennian sediments. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt and calcareous debris. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance. The small nodules which show a cherty character are probably thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable.

Sample: AV 25 (WV 2)
Gauss-Kruger-coordinates: ^{34}35250 - ^{55}84620
Location: abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen (directly north of Limburg; geological map 1:25000, 5614 Limburg). Identical to location WV 2 (WIERICH & VOGT 1997).
Lithology: Bruchberg-sandstone formation: lithologic succession of a) 25 - 30m gray to (weathered:) lightgray/whitish, graded bedded sandstones, with max. ca. 0.1m thick intercalations of b) laterally inconsistent black

to darkgray slates. Since repetitions of the lithologic succession occur due to faulting and folding, only 6.5m concordant sandstone succession is directly provable.

Stratigraphic correlation: The original correlation (see WV 2), which only allowed for a designation into the Viséan (LCC2003: ci: 13.3 — > 20.0 (with reworked flora from LCC2003: ci: 8.5 — 13.3; PC — CM), is herewith further confined to the **late Viséan** (NM — VF-zone): LCC2003: ci 16.9 — 19.2.
Fossils: (initial fossil-list in WIERICH & VOGT 1997 (WV 2). Additions are posted herein: spores, acritarchs, det. by VOGT, from lithology b)

Densosporites brevispinosus HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 25-3, 38.6/103.0, plate F 2-10, fig. 7)	[PU — Upper Carboniferous]
Densosporites spinifer HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 25-3, 43.2/96.4; F 2.2, plate F 2-10, fig. 10)	[PU — Upper Carboniferous]
Densosporites subcrenatus (WALTZ in LUBER & WALTZ 1938) POTONIÉ & KREMP 1955 (AV 25-3, 37.8/101.3; F 2.2, plate F 2-10, fig. 2)	[PU — Upper Carboniferous]
Dictyotriletes trivialis (NAUMOVA 1953) KEDO 1963 (AV 25-3, 35.7/106.0)	[*pusillites-lepidophyta* — ? TS]
Knoxisporites stephanephorus LOVE 1960 (AV 25-3, 36.8/108.1 (F 2.2, plate F 2-10, fig. 6), transparent!)	[TS — Upper Carboniferous]
Knoxisporites triradiatus HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 25-3, 32.0/96.0 (F 2.2, plate F 2-10, fig. 3), equatorial view)	[TS — Upper Carboniferous]
Lycospora pusilla (IBRAHIM) SOMERS 1972 (AV 25-3, 40.0/114.0)	[PU — Upper Carboniferous]
Monilospora mutabilis STAPLIN 1960 (AV 25-4, 26.6/113.8)	[TC — VF]
Radiizonates mirabilis PHILLIPS & CLAYTON 1980 (AV 25.3, 23.4/100.8; F 2.2, plate F 2-10, fig. 5)	[PC — CM]
Diatomozonotriletes cf. *rarus* PLAYFORD 1962/63 (AV 25-4, 40.2/93.2)	[*Diatomozonotriletes* spp.: Viséan — Lower Namurian]
Rotaspora cf. *knoxi* BUTTERWORTH & WILLIAMS 1958 (AV 25-3, 23.6/96.0)	[NM — ? Namurian]
cf. *Dictyotriletes trivialis* (NAUMOVA 1953) KEDO 1963 AV 25-4, 33.5/93.2)	[*pusillites-lepidophyta* — ? TS]
Calamospora sp. (AV 25-4, 29.5/114.3, ? 25.0/103.2)	
Convolutispora sp. (AV 25-4, 32.0/91.5)	
Densosporites sp. (AV 25-3, 52.1/114.5)	
Dictyotriletes sp. (AV 25-3, 43.8/103.4)	
Schulzospora sp. (AV25-3, 30.1/109.1)	[TC — in Upper Carboniferous]
Spelaeotriletes sp. (AV 25-3, 29.8/114.8 (plate F 2-10, fig. 12), 30.0/100.3, 34.9/97.8 (plate F 2-10, fig. 4), frequent)	
Leiofusa sp. (AV 25-3, 29.2/111.8)	
Monoletes indet. (AV 25-3, 29.2/111.8, plate F 2-10, fig. 8)	
Acritarcha indet. (AV 25-3, 26.6/115.0, 51.0/112.3)	
Unidentified palynomorph (AV 25-3, 36.9/111.0; F 2.2, plate F 2-10, fig. 11)	

Remarks: The palynofacies is almost entirely dominated by spores and indicate an originally nearshore, shallow marine, depositional environment (both in late Tournaisian and late Viséan times). Lithofacies and petrographic analyses give evidence for a redeposition of these sediments during the late Viséan.
Presumable sedimentary environment: Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles. The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

Sample: AV 32
Coordinates: E ca. 29°29' - N ca. 52°4'
Location: abandoned slate quarry at the Blue Lake between Gommern and Pretzien, southeast of Magdeburg (geological maps 1:25000, 3936 Schönebeck / 3937 Leitzkau).
Lithology: Bruchberg-sandstone formation: lithologic succession of a) gray to darkgray, graded bedded conglomeratic sandstones (AV 31, compare WIERICH & VOGT 1997), with intercalations of b) black to darkgray slates (AV 32). Sample taken from the collection of the Institut für Geologie & Paläontologie in Marburg.

Stratigraphic correlation: Lower Carboniferous (Bruchberg-sandstone formation). (LCC2003: ca. ci 17.5 — ca. 19.2).
Fossils: (acritarchs, ? radiolarians, from lithology b; det. by Vogt)

Unidentified palynomorph (AV 32-1, 52,3/92.6 (40µm, pyritised), compare AV 227-1, 47.0/114.7, 46.8/101.1, ?42.4/98.6)	[Lower Carboniferous, ? VF — NC ?]

Remarks: Stratigraphic correlation entirely based on petrographic analyses (compare Wierich & Vogt 1997: 110-113).
Presumable sedimentary environment: Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles. The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

Sample: AV 38 (= F 23 in Wierich & Vogt 1997)
Gauss-Kruger-coordinates: ^{34}70650 - ^{56}17580
Location: southwestern slope of the Niedernberge; abandoned small "quartzite-" quarry (ca. 20x20m) in the forest, ca. 1.1 km southwest of Weipoltshausen (geological map 1:25000, 5317 Rodheim-Bieber).
Lithology: Bruchberg-sandstone formation: greenbrown to (weathered:) yellowishgray, sandstones with up to 2cm big dark pelite clasts.
Stratigraphic correlation: The original correlation (see Wierich & Vogt 1997, sample F 23), which only allowed for a designation into the late Upper Devonian to Viséan, is herewith further confined to the **late Viséan** (NM — ? NC-zone): LCC2003: ci 16.9 — > 20.0 (occurrence of reworked late Tournaisian species questionable).
Fossils: (spores, acritarchs, prasinophycean algae (cysts), from the pelite clasts, det. by Vogt)

Knoxisporites cinctus (Waltz in Luber 1938) Butterworth & Williams 1958 in Smith & Butterworth 1967: 219 (AV 38-5, 50.7/91.7; F 2.2, plate F 2-9, fig. 2)	[PU — Namurian A]
Punctatisporites irrasus Hacquebard 1957 (F 23, Wierich & Vogt 1997: pl. 8, fig. 1)	[? Upper Devonian — Lower Carboniferous; frequent: PC-zone]
Knoxisporites sp. cf. *K. literatus* (Waltz in Luber & Waltz 1938, Playford 1963) Playford 1971 (AV 38-6, 36.2/99.7 (55x45µm))	[Upper Devonian (latest Famennian, in *pusillites-lepidophyta* (ca. ds 19.1) — Namurian A (Arnsbergian)]
cf. *Lycospora pusilla* (Ibrahim) Somers 1972 (AV 38-4, 38.8/109.8, 46.5/96.4, both partly transparent)	[PU — Upper Carboniferous]
cf. *Vallatisporites vallatus* Hacquebard 1957 (AV 38-1, 50.2/98.5)	[uppermost Upper Devonian (*lepidophyta* - *nitidus* - zone) — "middle" Viséan]
Densosporites sp. (AV 38-1, 17.3/103.2, AV 38-6, 25.5/104.7)	
Knoxisporites sp. (F 23, Wierich & Vogt 1997)	[late Upper Devonian — ? Namurian]
Lycospora sp. (AV 38-6, 26.1/106.0 (35x22µm), partly transparent)	[PU — Upper Carboniferous]
Punctatisporites sp. (AV 38-6, 31.9/104.8 (60x45µm), 27.4/103.0, ? 38.6/101.6, 34.2/101.7, ? 25.3/97.2, 28.8/92.4 (50µm))	[Devonian — Carboniferous]
Rotaspora sp. (AV 38-6, 39.0/97.5 (40x25µm))	[NM — Namurian]
Navifusa cf. *bacillum* (Deunff 1955) Playford 1977 (AV 38-1, 39.5/104.0, AV 38-6, 33.0/93.8 (75x20µm))	[late Pragian — Lower Carboniferous (Tournaisian)]
Leiofusa sp. (AV 38-1, different species: 38.5/104.5, 45.0/99.6 (105x30µm), 43.6/98.4 (80x25µm))	
cf. *Cymatiosphaera* sp. (AV 38-1, 53.8/111.0)	
Acritarcha indet. (AV 38-1, different species: 36.6/114.5, 32.3/103.3 (65x55µm))	
Wood fragment with thorn in *knorria* preservation (AV 38-4, 40.2/111.9; F 2.2, plate F 2-9, fig. 3)	

Remarks: none.
Presumable sedimentary environment: Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles. The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

Sample: AV 47
Gauss-Kruger-coordinates: ^{34}40680 - ^{55}88020
Location: north of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: dark slates.
Stratigraphic correlation: Lower Carboniferous (Upper Tournaisian, BP — CM). LCC2003: ca. ci 7.5 — 13.3.
Fossils: (spores, acritarchs, det. by Vogt)

Grandispora (*Spelaeotriletes* Utting 1987) *echinata* (Hacquebard 1957) Playford & McGregor 1993 (AV 47-1, 37.4/107.5, 50µm)	[upper Famennian (Strunian, ca. DK1996: ds 19.2) — Namurian C]
Spelaeotriletes balteatus (Playford 1963) Higgs 1975 (AV 47-1, 31.0/109.2, 46.5/100.1 (45µm))	[BP — CM]
Knoxisporites sp. cf. *K. literatus* (Waltz in Luber & Waltz 1938, Playford 1963) Playford 1971 (AV 47-1, 30.7/91.9 (70x55µm))	[Upper Devonian (latest Famennian, in *pusillites-lepidophyta* (ca. ds 19.1) — Namurian A (Arnsbergian)]
cf. *Discernisporites micromanifestus* (Hacquebard 1957) Sabry & Neves 1971 (AV 47-1, 48.3/108.8, 43.8/107.3, 48.0/106.9, frequent)	[Tournaisian — VF]
Aneurospora sp. (AV 47-1, 52.5/108.5)	
Christatisporites sp. in Clayton et al. 1977: pl. 10, fig. 29 (AV 47-1, 27.5/94.7, 40µm, single sculptural elements 6x7µm, 10-11 elements circumequatorial)	[at least: NM]
Densosporites sp. (AV 47-2, 41.0/95.0, 40µm)	
Dictyotriletes sp. (AV 47-1, 37.5/104.2, 65µm)	
Verrucosisporites sp. (AV 47-1, 33.8/98.0, 55µm)	
Gorgonisphaeridium evexispinosum Wicander 1974 (AV 47-1, 32.1/96.5, 30µm)	[Frasnian — Viséan]
Gorgonisphaeridium plerispinosum Wicander 1974 (AV 47-1, 28.6/109.4, 35µm)	[upper Frasnian — Famennian; — ? Tournaisian]

Remarks: *Gorgonisphaeridium plerispinosum* Wicander 1974 shows the same state of preservation as the other fossils, hence seems not to be reworked.
Presumable sedimentary environment: Marine outer shelf, not too near to terrestrial areas, since acritarchs are present. Tectono-seismic activity maybe lead to redeposition of Famennian sediments. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 49
Gauss-Kruger-coordinates: ^{34}34580 - ^{55}83860
Location: northern slope of the Greifenberg, east of Limburg, within the "Kommerzienrat Cahensly Hain" (geological map 1:25000, 5614 Limburg).
Lithology: dark (blackish-violet) platy slates (compare AV 70).
Stratigraphic correlation: Lower Carboniferous (uppermost Tournaisian, CM - zone). LCC2003: ci 11.4 — 13.3; with reworked late Famennian (*pusillites-lepidophyta* — *lepidophyta-nitidus*-zone), DK1996: ds 18.5 — 20.0.
Fossils: (spores, acritarchs, prasinophycean algae (cysts), det. by Vogt)

Aneurospora greggsi (McGregor) Streel 1974 (AV 49-1, 50.1/113.3 (42µm))	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Bascaudaspora submarginata (Playford 1964) Higgs, Clayton & Keegan 1988 (AV 49-2, 48.3/111.0 (45µm), 37.1/109.2 (50µm), cf. 39.6/112.3 (40µm), cf. 47.3/111.8 (40µm))	[LL — CM]
Corbulispora cancellata (Waltz) Bharadwaj & Venkatachala 1961 (AV 49-2, 23.1/100.4 (30µm))	[late Upper Devonian — ME]
Grandispora (*Spelaeotriletes* Utting 1987) *echinata* (Hacquebard 1957) Playford & McGregor 1993 (AV 49-1, 32.9/114.9 (58x45µm))	[upper Famennian (Strunian) — Namurian C]
Grandispora saurota (Higgs, Clayton & Keegan 1988) Playford & McGregor 1993 (AV 49-1, 21.9/110.7 (55x45µm), 26.9/109.6 (broken piece: 42µm x ?))	[in Strunian (latest Famennian) — ? Tn2]
Raistrickia macrura (Luber in Luber & Waltz 1938) Dolby & Neves 1970 (AV 49-1, 36.2/106.7 (55x35µm))	[LL — PC]
Raistrickia minor (Kedo) Neves & Dolby 1967 (AV 49-2, 35.2/101.5 (central body 30µm - ornament up to 20µm), 42.4/98.7 (central body 20µm - ornament up to 11µm))	[LL — PC]

Retispora lepidophyta (KEDO) PLAYFORD 1976 (AV 49-1, 38.1/104.5 (40µm), 30.6/102.2 (45µm), AV 49-2, cf. 48.1/113.8 (> 80µm))	[Uppermost Famennian: *pusillites-lepidophyta* — *lepidophyta-nitidus*-zone]
Schopfites claviger SULLIVAN 1968 (AV 49-2, 48.8/111.4 (35µm), AV 49-1, cf. 43.0/114.4 (30µm), cf. 39.6/105.0 (25µm))	[CM — PU, in Atlantic Canada: — VF]
Bascaudaspora sp. cf. *B. collicula* (PLAYFORD 1971) HIGGS, CLAYTON & KEEGAN 1988 (cf.-determination, because of the generally smaller size (35-40µm) than in the original descriptions; AV 49-1, e.g.: 36.3/113.5 (35µm), 40.8/114.0 (35µm), 41.4/113.8 (35µm), 44.0/113.3 (40µm), 48.6/114.0 (35µm), 48.9/113.3 (35µm, oxidised, partly transparent), 53.1/112.7 (35µm), 21.8/109.2 (proximal view), 38.2/114.6 (40µm), AV 49-2, e. g. 22.8/113.0 (40µm, proximal view), 53.4/109.9 (35µm, proximal view)).	[LL — PC]
Raistrickia sp. cf. *R. variabilis* DOLBY & NEVES 1970 (AV 49-2, 38.1/114.4 (45µm))	[LL — CM]
cf. *Crassispora trychera* NEVES & IOANNIDES 1974 (AV 49-1, 50.2/100.3 (45µm))	[uppermost PC — VF]
Densosporites sp. (AV 49-1, different species: 39.8/108.1 (42x30µm), 38.1/105.2 (40µm))	
Dictyotriletes sp. (AV 49-1, 48.7/114.0 (35µm), 41.2/105.3 (30µm), 45.2/110.7 (45µm))	
Cymatiosphaera adaiochorata WICANDER 1974 (AV 49-1, 37.1/102.4, AV 49-2, 31.9/114.6)	[Famennian]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 49-1, 39.2/113.2 (105x35µm), 51.5/110.8, 29.5/105.3 (65x20µm))	[late Pragian — Lower Carboniferous (Tournaisian)]
Leiofusa sp. (AV 49-1, different species: 51.5/110.8 (min. 180x25µm, broken), 27.1/104.1 (min. 285x10µm, broken), 53.0/91.3 (350x4µm), 40.3/91.3 (twisted))	
Navifusa sp. (AV 49-1, 21.8/113.2 (70x20µm))	
Tasmanites sp. (AV 49-1, 51.8/114.5 (40µm), 43.4/113.7 (60µm), 40.0/112.4 (55µm), 30.1/112.2 (50µm))	
Veryhachium sp. (AV 49-1, 51.0/104.1 (20µm))	
Phycomata of ? *Tasmanites* sp. (AV 49-1, 23.5/114.5 (23µm), 30.3/111.0 (20µm), 35.5/109.6 (23µm))	

Remarks: The genus *Bascaudaspora* is the far most abundant component of the palynofacies.
Presumable sedimentary environment: Open marine, but not too far away from terrestrial areas (islands?), since the spore spectrum dominates well over the acritarch flora. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited finesilt. Tectono-seismic activity lead to redeposition of late Famennian sediments. Dominating bedding features are lenticular bedding and laminated finesilt or mud. Wave energy and mud supply control mud abundance. The platy to brittle appearance is probably induced by thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable. Silica precipitation seems to require weakly alkaline conditions.

Sample: AV 51 (= "Givetian-slates of the *normal-facies*" from MUNK 1981: 17f)
Gauss-Kruger-coordinates: ^{34}46050 - ^{55}91970
Location: small outcrop at a forest track, ca. 2 km northnortheast of Wirbelau (geological map 1:25000, 5515 Weilburg).
Lithology: succession of: a) graygreen to green, partly black, tuff-bearing slates, intercalated by b) thin, darkgray to blackgray, pure, platy, laterally inconsistant limestones; within "Schalstein" (reworked pyroclastic) deposits.
Stratigraphic correlation: ? Middle Devonian (? upper Givetian, in *lemurata-magnificus* — ? in *optivus-triangularis*-zone). DK1996: dm ? 14.4 — ? 20.0; with reworked acritarchs and chitinozoans from the Silurian.
Fossils: (spores, acritarchs, chitinozoans, from lithology a, det. by VOGT)

cf. *Aneurospora greggsi* (MCGREGOR) STREEL 1974 (AV 51-2, 35.3/91.1 (broken, min. 80µm))	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Leiofusa striatifera CRAMER 1964 (AV 51-1, 25.7/113.3)	[Silurian]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 51-1, 44.7/94.3)	[late Pragian — Lower Carboniferous (Tournaisian)]
Carminella cf. *maplewoodensis* CRAMER 1968 (AV 51-1, 42.2/112.0 (opaque, only periderm visible))	[Silurian]

Leiofusa cf. *pyrena* WICANDER & WOOD 1981 (AV 51-2, 23.3/103.6)	[Givetian]
cf. *Polyedrixium pharaonis* DEUNFF 1961 (AV 51-2, 34.2/104.1)	[Devonian]
Lophosphaeridium sp. in WICANDER & PLAYFORD 1985 (AV 51-1, 43.6/112.3; AV 51-2, 45.0/109.5)	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone)]
Veryhachium sp. (AV 51-1, different species: 50.2/106.2, 35.6/113.2, 34.2/113.0, 46.7/105.2)	
unidentified chitinozoan (AV 51-1, 36.7/95.8)	[reworked]

Remarks: The Givetian age is not directly provable, however many indet. pyritised big (>100µm) palynomorphs occur; the size range is typical for Middle Devonian strata. Also the petrological composition of the pelites with their considerable content of heavy minerals and former glassy material, which indicate the deposition of tuff (and maybe later reworking), together with the occurrence of the pelites within "Schalstein" deposits may lead to a Middle Devonian (Givetian) age correlation. MUNK (1981: 17f) was able to recover a small number of conodont-remnants from the limestone-layers. Their preservation was too bad to identify them. In addition he reported about the finding of indeterminable parts of brachiopods and sometimes masses of tentaculites on the bedding surfaces. I could not find any of these fossils and MUNK's samples in the collection of the Institute of Geology and Palaeontology at Marburg University do not show any of the described fossils.
Presumable sedimentary environment: Open marine, far away from terrestrial areas, since the acritarch spectrum dominates over the spore flora, but near the centres of submarine volvanic activity. Tectono-seismic activity (rifting?) lead to redeposition of Silurian (Wenlockian — Ludlowian) sediments. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt (mainly reworked pyroclastics). Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 52
Gauss-Kruger-coordinates: ^{34}44500 - ^{56}02250
Location: Flachsberg near Dillhausen (geological map 1:25000, 5415 Merenberg).
Lithology: Black flinty slate.
Stratigraphic correlation: Lower Carboniferous (Dark flinty-slate formation). LCC 1998: ca. ci 9.1 — 13.0.
Fossils: (det. by VOGT)
Conodonta indet.
Radiolaria indet.
Remarks: compare sample AV 1.
Presumable sedimentary environment: Deposition of mud from suspension within a basin. High equatorial radiolarian-productivity in connection with reduced clastic influx from an increasingly arid southern Laurussian continent (with reduced topography) allowed for a sedimentation of radiolarian-rich siliceous oozes. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: AV 53
Gauss-Kruger-coordinates: ^{34}44510 - ^{56}02250
Location: Flachsberg near Dillhausen (geological map 1:25000, 5415 Merenberg).
Lithology: Breccia of dark flinty slates (Kieselschieferbrekzie).
Stratigraphic correlation: Lower Carboniferous (upper part of dark flinty-slate formation or younger); younger than upper Tournaisian (? Viséan; the flinty-slate parts of the breccia, which bear the radiolarians, had been completely lithefied before brecciation). LCC2003: younger than ca. ci 11.0 — ?.
Fossils: (det. by VOGT)
Conodonta indet.
Radiolaria indet.
Remarks: compare sample AV 4.
Presumable sedimentary environment: Marine. Reworking of lithefied upper Tournaisian-Viséan flinty slates and pelites. The components of the evolved breccia consist of very angular flinty slate and pelite gravel. Reworking possible a) during sea-level fall with exposition of flinty slates sedimented on top of a submarine high or b) during volcanic (Deckdiabas-) activity with sudden destruction of a flinty slate succession at a flank of a submarine high and subsequent gliding of the shattered components towards the foot of the slope. I prefer alternative "b" because of the very angular components of the breccia which show no evidence for intensive (near-shore-) reworking and the spatial vicinity to an ancient submarine high built up by diabas.

Sample: AV 57
Gauss-Kruger-coordinates: ^{34}34633.89 - ^{55}84305.01
Location: drill site BK 2010/028 (date: Jan. 1993, depth: 12.3 - 12.6m) of the Deutsche Bahn AG, ca. 1.1 km southwest of Dietkirchen (directly north of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: formerly dark, lightgraybrown weathering, partly siliceous, slates, with pelitic and silty and finesandy subrounded components up to a diameter of 8cm. Debris flow sediment.
Stratigraphic correlation: Earliest Famennian (lowermost part of *torquata-gracilis*-zone; approx. Early *triangularis*-zone) with reworked middle Frasnian. DK1996: ds ca. 6.1 — 6.8 with reworked ca. ds 2.4 — 4.7.
Fossils: (spores, acritarchs, prasinophycean algae (cysts), det. by Vogt)

Cyrtospora cristifera (Luber) van der Zwan 1979 (AV 57-1, 34.4/104.6 (45x30µm))	[Famennian (*torquata-gracilis*) — Tournaisian (PC)]
Diaphanospora reticulata Guennel 1963 (AV 57-1, 29.3/94.8 (40µm)]	[Middle Frasnian (within *ovalis* - *bulliferus* - zone: ca. ds 2.4 — 4.7)]
Geminospora notata (Naumova 1953) Obukhovskaya var. *microspinosus* Tchibrikova (AV 57-2, 43.3/90.9 (35µm))	[Latest Frasnian — early Famennian (GS — CZ - zone of the Eastern European spore-zonation; approximately equivalent to uppermost *Palmatolepis gigas* — *Pa. crepida*-zone (ca. ds 10.6)]
Geminospora vasjamica (Tchibrikova) Obukhovskaya & Nekriata 1983 (AV 57-1, line 104.6 or 103.7 (48x38µm))	[Early Famennian (VV — CZ - zone of the Eastern European spore-zonation; approximately equivalent to *Palmatolepis triangularis* (ds 6.1) — *Pa. crepida*-zone (ds 10.6)]
Aneurospora cf. *greggsi* (McGregor) Streel 1974 (AV 57-2, 47.2/106.2 (50x40µm))	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Ancyrospora sp. (AV 57-1, 49.2/99.6 (45x30µm))	
Geminospora sp. (AV 57-1, 18.8/94.7 (30µm); AV 57-2, 34.8/106.8 (40µm), 23.7/96.8 (38µm), 26.2/96.2 (50x40µm))	
Grandispora sp. (AV 57-1, 49.2/97.4 (45µm))	
Punctatisporites sp. (AV 57-2, 30.3/94.4 (60x50µm))	
cf. *Retispora* sp. (AV 57-2, 35.4/104.3 (60µm), 30.4/101.8 (40µm))	
Gorgonisphaeridium cf. *G. andrewsi* (Stockmans & Williere 1962) Martin 1984 nov. comb. (AV 57-1, 19.4/97.3 (central body: 25µm))	[Uppermost Frasnian (upper *Palmatolepis gigas* — lowermost Famennian (lower *Pa. triangularis*-zone)]
Gorgonisphaeridium telum Wicander & Playford 1985 (AV 57-2, 52.1/96.9 (25µm))	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
cf. *Cymatiosphaera chelina* Wicander & Loeblich 1977 (AV 57-1, 49.6/102.6 (30x25µm))	[Upper Frasnian — lower Famennian]

Remarks: The poor preservation of the palynoclasts is most probably due to the enhanced weathering of the core.
Presumable sedimentary environment: Open marine, basinal, but still near terrestrial areas (islands?), since (often disaggregated) spores dominate the palynofacies which also contains considerable amounts of acritarchs. Deposition of clay from suspension punctuated by sudden incursions of silt by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay/silt sediment pile along a slope. Transport of large volumes of these sediments onto the deeper sea-floor, final deposition when a reduction in slope caused deceleration. Most striking sedimentary features are: plastic deformation prior to tectonic deformation, ungraded and mostly disorganised fabric, although original bedding features are sometimes still observable.

Sample: AV 67 + 69
Gauss-Kruger-coordinates: ^{34}34781.75 - ^{55}84536.40
Location: drill site BK 2010/036 (date: Sep. 1993) of the Deutsche Bahn AG, ca. 800m southwest of Dietkirchen (directly northeast of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Finegrained debris flow (see appendix F 1 for details)
Stratigraphic correlation: Early Famennian (near base *torquata-gracilis* zone); DK1996: ds 6.1 — ca. 7.5; with reworked A) middle — late Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0), B) Givetian (dm ca. 11.7 — ca. 17.7), C) Lower Devonian (di 0.6 — 17.4) and D) upper Silurian (probably reworked from Emsian sediments).
Fossils: (spores, acritarchs, prasinophycean algae (cysts), det. by Vogt)

AV 67 (depth 24.3 - 24.55m): DK1996: ds 6.1 — 7.5; ? with reworked ds 1.7 — 6.0 (a lot of disaggregated, unidentifiable acritarchs are present in the sample)

Aneurospora greggsi (McGregor) Streel 1974 (AV 67-A1, 46.3/111.4 (50µm), 67-2A, 50.1/109.4 (45µm), 45.3/104.8, 42.9/100.9 (50µm))	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Archaeoperisaccus ovalis Naumova 1953 (AV 67-2A, 50.5/105.8 (95x60µm), 36.9/92.5 (65x45µm))	[Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0)]

Geminospora lemurata (BALME 1962) PLAYFORD 1983 (AV 67-2A, 25.9/93.7 (80x60µm))	[Middle Givetian — early Famennian *(lemurata-magnificus* (dm 11.7) — near base *torquata-gracilis* (ca. ds 7.5))]
Geminospora notata (NAUMOVA 1953) OBUKHOVSKAYA (AV 67-A1, 24.2/107.8 (60x35µm))	[Middle Givetian — early Famennian (EX — CZ - zones of the Eastern European spore-zonation; approximately equivalent to *lemurata-magnificus* (dm 11.7) — *Pa. crepida*-zone (ca. ds 10.6)]
Geminospora vasjamica (TCHIBRIKOVA) OBUKHOVSKAYA & NEKRIATA 1983 (AV 67-A1, 32.5/95.0 (75x60µm))	[Early Famennian (VV — CZ - zone of the Eastern European spore-zonation; approximately equivalent to *Palmatolepis triangularis* (ds 6.1) — Late *Pa. crepida*-zone (ca. ds 10.6)]
Geminospora sp. (AV 67-2A, 49.5/113.6 (45µm))	
Verrucosisporites sp. (AV 67-2A, 42.8/97.2 (80x65µm))	
Pterospermella tenellula PLAYFORD 1981 (AV 67-A1, 48.2/105.4 (30µm), 45.3/97.4)	[Frasnian — Early Famennian]
Tapajonites sp. I in MARTIN 1984, pl. 7, fig. 9 (AV 67-2A, 35.3/102.6 (48µm))	[Early Famennian]
Cymatiosphaera cf. *C. labyrinthica* WICANDER 1974 (AV 67-2A, 45.8/114.5 (35µm))	[Famennian]
Tasmanites sp. in WICANDER 1974, pl. 19, fig. 11 (AV 67-A1, 40.2/107.3)	[at least: Famennian]
Dictyotriletes sp. (AV 67-2A, 34.2/100.9 (45µm) = AV 47-1, 37.5/104.2 (65µm) = AV 69-1, 30.8/113.0)	[?Famennian — ? Upper Tournaisian]
Pterospermella sp. (AV 67-2A, 50.6/110.9 (30µm))	
unidentified acritarch (AV 67-A1, 45.5/112.0 (85x30µm) = AV 10-1, 42.3/114.1 (130x40µm) = ? AV 227-1, 41.2/110.3 (115x25µm))	[? Famennian — ? Viséan]

AV 69 (depth: 26.65 - 27.00m): Early Famennian (*torquata-gracilis* — max. in *flexuosa cornuta*); DK1996: ds 6.0 — max. ca. 16.5; with reworked A) middle — late Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0), B) Givetian (dm ca. 11.7 — ca. 17.7), C) Lower Devonian (di 0.6 — 17.4) and D) upper Silurian (probably reworked from Emsian sediments).

Hystricosporites cf. *H. corystus* (RICHARDSON 1965) RIEGEL 1973 (AV 69-1, 22.8/104.8, broken piece)	[uppermost Emsian — uppermost Givetian (uppermost *annulatus-sextantii* (di ca. 18.5— in *optivus-triangulatus* (dm ca. 18.3)]
Retusotriletes maculatus MCGREGOR & CAMFIELD 1976 (AV 69-1, 28.7/111.0)	[Gedinnian — Emsian (*micrornatus - newportensis* (di 0.6) — in *annulatus - sextantii* (di 17.4))]
Ancyrospora cf. *incisa* (NAUMOVA 1953) M. RASKATOVA & OBUKHOVSKAYA (AV 69-1, 41.1/105.8)	[? latest Givetian — late Frasnian (IM — AS - zone of the Eastern European spore-zonation; approximately equivalent to ? *hermanni-cristatus* — upper *Pa. gigas*-zone)]
Ancyrospora cf. *voronensis* (ARKHANGELSKAYA 1972) ARKHANGELSKAYA 1985 (AV 69-1, 44.5/101.1, broken piece)	[at least: middle Frasnian]
Geminospora sp. cf. *G. tuberculata* (KEDO) ALLEN 1965 (AV 69-1, 23.9/100.0)	[Givetian (EX-zone of the Eastern European spore zonation, ca. dm 11.7 — dm 17.7)]
cf. *Ancyrospora involucra* OWENS 1971 (AV 69-1, 31.8/107.1)	[Upper Givetian (*optivus-triangularis* (dm ca. 18.7)) — middle Frasnian (in *ovalis-bulliferus* (ds ca. 4.2))]
cf. *Grandispora inculta* ALLEN 1965 (AV 69-1, 46.5/100.0)	[Upper Eifelian — upper Frasnian (near base *devonicus-naumovii* (dm ca. 4.6) — near top *ovalis-bulliferus* (ds ca. 5.2))]
Convolutispora sp. (AV 69-1, 34.1/104.0)	
Dictyotriletes sp. (AV 69-1, 30.8/113.0 = AV 47-1, 37.5/104.2 (65µm) = AV 67-2A, 34.2/100.9 (45µm))	[?Famennian — ? Upper Tournaisian]
Gorgonisphaeridium plerispinosum WICANDER 1974 (AV 69-1, 25.5/107.6, 22.0/106.5, 28.5/101.2)	[upper Frasnian — Famennian; — ? Tournaisian]
Multiplicisphaeridium rakoe (STOCKMANS & WILLIERE 1969) DIEZ & CRAMER 1977 (AV 69-1, 21.0/108.2)	[Early Famennian (*torquata-gracilis,* ca. ds 6.0 — in *flexuosa cornuta*, ca. ds 16.5)]
Polyedrixium pharaonis DEUNFF 1961 (AV 69-1, 32.0/113.8)	[Devonian]
Leiofusa pyrena WICANDER & WOOD 1981 (AV 69-1, 26.2/105.5)	[Givetian]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 69-1, 32.0/107.2)	[late Pragian — Lower Carboniferous (Tournaisian)]
Pterospermella tenellula PLAYFORD 1981 (AV 69-1, 42.0/99.7, 36.9/99.9)	[Frasnian — Early Famennian]

Leiofusa sp. cf. *L. exilata* DORNING 1981 (AV 69-1, 37.0/103.0)	[Upper Silurian (lower Ludlowian)]
Leiofusa sp. cf. *L. pyrena* WICANDER & WOOD 1981 (AV 69-1, 36.1/113.5)	[Givetian]
Visbysphaera sp. cf. *V.* n. sp. A MARTIN 1982 (AV 69-1, 47.2/109.0)	[Upper Frasnian]
cf. *Gorgonisphaeridium telum* WICANDER & PLAYFORD 1985 (AV 69-1, 49.6/104.0)	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
cf. *Unellium* sp. cf. *U. piriforme* RAUSCHER 1965 (AV 69-1, 34.9/96.2)	[? Lower Devonian — Famennian]
Micrhystridium sp. (AV 69-1, 35.0/112.8	
Veryhachium sp. (AV 69-1, 40.5/111.6)	
Villosacapsula sp. (AV 69-1, 48.2/100.0)	
Desmochitina sp. cf. *D. aranea* URBAN 1972 (AV 69-1, 31.1/110.2 (broken))	[Upper Middle Devonian (lower Givetian)]
unidentified chitinozoan (AV 69-1, 35.8/105.5)	[reworked Silurian ? species]
unidentified chitinozoan (AV 69-1, 42.0/99.6)	[reworked Silurian ? species or Middle Devonian?]

Remarks: Acritarchs dominate the Early Famennian palynofacies. Middle Devonian chitinozoans indicate an open marine environment at that time, however, the spores probably document near islands.

Presumable sedimentary environment: Open marine, basinal, but still near terrestrial areas (islands?), since (often disaggregated) spores are present in the palynofacies which is, however, dominated by acritarchs. Deposition of clay from suspension punctuated by sudden incursions of silt and, partly, greywacke by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay/silt/greywacke sediment pile along a slope. Transport of large volumes of these sediments onto the deeper sea-floor, final deposition when a reduction in slope caused deceleration. Most striking sedimentary features are: plastic deformation prior to tectonic deformation, ungraded and mostly disorganised fabric, although original bedding features are sometimes still observable. Debris-flow sediments with greywacke-clasts which were not completely lithefied at the time of redeposition.

Sample: AV 70

Gauss-Kruger-coordinates: ^{34}33505 - ^{55}85501

Location: drill site BK 2010/112 (date: 1994, depth: 32.8 - 33.0m) of the Deutsche Bahn AG, ca. 2 km westsouthwest of Dietkirchen (directly north of Limburg; geological map 1:25000, 5514 Hadamar).

Lithology: Dark slate with silty and cherty pseudonodules (compare AV 49).

Stratigraphic correlation: Lower Carboniferous (Viséan — ? Namurian A), with reworked Famennian. LCC2003: ci 13.3 — > 20.0, with reworked DK1996: ds 6.0 — 20.0.

Fossils: (spores, det. by VOGT)

Aneurospora greggsi (MCGREGOR) STREEL 1974 (AV 70-1, 54.8/99.0 (45µm))	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Knoxisporites cinctus (WALTZ in LUBER 1938) BUTTERWORTH & WILLIAMS 1958 in SMITH & BUTTERWORTH 1967: 219 (AV 70-1, 53.0/102.6 (broken remnant: diameter 90µm; in spite of incompleteness rather shure the species is sufficiently determinable)	[PU — Namurian A]
cf. *Grandispora gracilis* (KEDO) STREEL in BECKER et al. 1974, pl. 1 (AV 70-1, 40.0/107.3)	[Famennian]

Remarks: *Knoxisporites cinctus* shows a different state of thermal alteration (blackish, low reflectivity, compare chapter F 2.2, plate F 2-9, fig. 2) than the Famennian species (greyblackish, medium reflectivity).

Presumable sedimentary environment: Open marine, but not too far away from terrestrial areas (islands?), since only spores, no acritarchs are observable. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited finesilt. Tectono-seismic activity lead to redeposition of Famennian sediments. Dominating bedding features are lenticular bedding and laminated finesilt or mud. Wave energy and mud supply control mud abundance. The platy to brittle appearance is probably induced by thin finesilt intercalations which became separated during diagenesis and compaction. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable, but no, e. g., radiolarians or sponge-spicules.

Sample: AV 72
Gauss-Kruger-coordinates: ^{34}34809.35 - ^{55}84655.27
Location: drill site BK 2010/130 (date: Jun. 1994, depth: 35.1 m) of the Deutsche Bahn AG, ca. 750m southwest of Dietkirchen (directly northeast of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Finegrained debris flow (see appendix F 1 for details).
Stratigraphic correlation: Probably Earliest Famennian (ca. DK 1996: ds 6.1 — 6.8), but only Upper Devonian — Lower Carboniferous directly provable. DK1996: ds 0.0 — LCC2003: ci 20.0.
Fossils: (acritarchs, det. by VOGT)

Lophosphaeridium segregum PLAYFORD 1981 (AV 72-1, 42.2/105.7 (45µm))	[Frasnian — Visean]
Cymatiosphaera sp. (AV 72-1, 25.6/108.0 (40µm))	

Remarks: poorly preserved flora, all spore remnants indeterminable.
Presumable sedimentary environment: Open marine, basinal. Deposition of clay from suspension punctuated by sudden incursions of silt-finesand by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay/silt/finesand sediment pile along a slope. Transport of large volumes of these sediments onto the deeper sea-floor, final deposition when a reduction in slope caused deceleration. Most striking sedimentary features are: plastic deformation prior to tectonic deformation, ungraded and mostly disorganised fabric, although original bedding features are sometimes still observable.

Sample: AV 73 — 78 + 83 + 84 + 86 + 87 + 88
Gauss-Kruger-coordinates: ^{34}34954.91 - ^{55}84540.64
Location: drill site BK 2010/132 (date: Jul./Aug. 1994) of the Deutsche Bahn AG, ca. 750m southwest of Dietkirchen (directly northeast of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Debris flow (see appendix F 1 for details).
Stratigraphic correlation: Early Famennian (within *torquata-gracilis*-zone); DK1996: ca. ds 10.3 — 10.6; with reworked A) late Frasnian (in *ovalis-bulliferus*-zone, ca. ds 4.2 — 4.7), B) Givetian (ca. dm 11.7 — 17.7), C) latest Emsian/earliest Eifelian (ca. di 19.0 — dm 2.5), D) middle Emsian (ca. di 12.3 — 15.1) and E) middle — upper Silurian (Wenlockian — lower Ludlowian).
Fossils: (spores, acritarchs, prasinophycean algae (cysts), chitinozoans, det. by VOGT)

AV 73 (depth 15.5 - 15.95m): Early Famennian: DK1996: ds 6.4 — 10.6; with reworked A) late Frasnian (ds 4.2 — 5.1), B) Givetian (ca. dm 10.9 — ca. ds 0.8), C) Emsian (ca. di 11.2 — 19.0).

Archaeozonotriletes timanicus NAUMOVA 1953 (AV 73-3, 48.2/113.5 (40µm))	[Middle Givetian — early Frasnian (near top *devonicus-naumovii* (ca. dm 10.9) — near top *optivus-triangularis* (ca. ds 0.8))]
Convolutispora caperata WICANDER & PLAYFORD 1985 (AV 73-3, 50.9/93.5 (60µm))	[at least: late Frasnian (Lower *Pa. gigas*-zone, at least: ds 4.2 — 5.1)]
Diducites poljessicus (KEDO) VAN VEEN 1981 (AV 73-1, 55.8/114.5 (65µm))	[Early Famennian — in Lower Carboniferous (near base *torquata* - *gracilis* (DK 1996: ca. ds 6.4) — in L. Carbonif.)]
Emphanisporites rotatus MCGREGOR 1961 (AV 73-3, 33.8/113.4 (35µm))	[Devonian — lower Tournaisian]
Geminospora sp. cf. *G. vasjamica* (CHIBRIKOVA) OBUKHOVSKAYA & NEKRIATA; considerably smaller than the original size range of the species (AV 73-3, 27.0/112.6 (40µm), 47.1/111.0 (40µm))	[Early Famennian (VV — CZ - zone of the Eastern European spore-zonation; approximately equivalent to *Palmatolepis triangularis* (ds 6.1) — *Pa. crepida*-zone (ds 10.6)]
? *Apiculiretusispora* cf. *brandtii* STREEL 1967 in EDWARDS 1968, RICHARDSON & MCGREGOR 1986 (AV 73-3, 51.0/111.3 (60µm))	[Lower Siegenian — lower Eifelian (near base *polygonalis* - *emsiensis* (ca. di 7.6) — in *velatus* - *langii* (ca. dm 2.4))]
cf. *Brochotriletes robustus* (SCOTT & ROUSE) MCGREGOR 1973 (AV 73-3, 37.8/96.4 (30µm))	[Emsian (ca. *annulatus-sextantii*-zone (ca. di 11.2 — 19.0)]
Geminospora sp. (AV 73-1, 49.0/113.0)	
Gorgonisphaeridium absitum WICANDER 1974 (AV 73-3, 38.8/103.4 (40µm))	[Famennian]
Lophosphaeridium segregum PLAYFORD 1981 (AV 73-3, 35.5/98.3 (40µm))	[Frasnian — Visean]
Gorgonisphaeridium cf. *G. telum* WICANDER & PLAYFORD 1985 (AV 73-3, 42.5/95.9 (30µm))	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
Ammonidium sp. (AV 73-3, 39.7/100.6 (40µm))	
Gorgonisphaeridium sp. (AV 73-3, 41.3/98.4)	
Lophosphaeridium sp. (AV 73-3, 32.4/98.8 (60x40µm))	
Villosacapsula sp. (AV 73-3, 36.3/113.3 (30µm))	

AV 74 (depth 16.3 - 16.7m, see fig. D 2.7): Late Frasnian — Famennian: DK1996: ca. ds 4.0 — 20.0; with reworked A) Givetian (ca. dm 11.7 — ca. 17.7), B) Pragian — early Eifelian (probably Emsian; ca. di 6.7 — ca. dm 2.5).

Aneurospora greggsi (McGREGOR) STREEL 1974 (AV 74-1, 25.6/104.6 (40µm))	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Dictyotriletes cf. *D. emsiensis* (ALLEN 1965, McGREGOR 1973) McGREGOR & CAMFIELD 1976 (AV 74-2, 25.6/93.8 (50µm))	[Pragian — Eifelian (*polygonalis-emsiensis* (di 6.7) — in *velatus-langii* (ca. dm 2.5))]
Geminospora cf. *extensa* (NAUMOVA 1953) GAO (AV 74-1, 40.1/109.8 (40µm))	[Givetian (EX-zone of the Eastern European spore zonation, ca. dm 11.7 — dm 17.7)]
Gorgonisphaeridium evexispinosum WICANDER 1974 (AV 74-1, 30.0/109.2 (30µm))	[Frasnian — Viséan]
Gorgonisphaeridium plerispinosum WICANDER 1974 (AV 74-2, 41.7/100.0 (50µm))	[upper Frasnian — Famennian; — ? Tournaisian]
Cymatiosphaera cf. *nebulosa* (DEUNFF 1954) DEFLANDRE 1954 (AV 74-1, 25.3/97.4 (35µm))	[Silurian — early Famennian]
Gorgonisphaeridium cf. *G. evexispinosum* WICANDER 1974 (AV 74-1, 26.2/108.1 (30µm))	[Frasnian — Viséan]
Lophosphaeridium sp. (AV 74-2, 38.8/110.8 (30µm))	

AV 75 (depth 17.05 - 17.6m): Early Famennian: DK1996: ds 10.3 — 10.6; with reworked A) late Frasnian (ds 4.2 — 5.1), B) Givetian (ca. dm 11.7 — ca. dm 17.7), C) Emsian (ca. di 11.2 — 19.0).

Aneurospora greggsi (McGREGOR) STREEL 1974 (AV 75-1, 36.4/102.7 (60µm), 48.0/91.9 (38µm), AV 75-2, 38.1/101.6 (50µm))	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Auroraspora macra SULLIVAN 1968 (AV 75-2, 40.0/94.3 (70µm))	[Early Famennian — Lower Carboniferous (in *torquata - gracilis* (DK 1996: ca. ds 10.3) — ca. PU)]
Diducites poljessicus (KEDO) VAN VEEN 1981 (AV 75-2, 35.7/109.3 (45µm))	[Early Famennian — in Lower Carboniferous (near base *torquata - gracilis* (DK 1996: ca. ds 6.4) — in L. Carbonif.)]
Geminospora extensa (NAUMOVA 1953) GAO (AV 75-1, 42.5/104.1 (40µm))	[Givetian (EX-zone of the Eastern European spore zonation, ca. dm 11.7 — dm 17.7)]
Geminospora vasjamica (CHIBRIKOVA) OBUKHOVSKAYA & NEKRIATA; considerably smaller than the original size range of the species (AV 75-1, 41.4/100.5 (40µm))	[Early Famennian (VV — CZ - zone of the Eastern European spore-zonation; approximately equivalent to *Palmatolepis triangularis* (ds 6.1) — *Pa. crepida*-zone (ds 10.6)]
cf. *Brochotriletes robustus* (SCOTT & ROUSE) McGREGOR 1973 (AV 75-1, 36.4/110.0 (30µm))	[Emsian (ca. *annulatus-sextantii*-zone (ca. di 11.2 — 19.0)]
Densosporites sp. (AV 75-1, 29.0/95.0 (40µm))	
Comasphaeridium muscosum WICANDER & PLAYFORD 1985 (AV 75-1, 24.4/94.2 (30µm))	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
Cymatiosphaera limbatisphaera WICANDER & LOEBLICH 1977 (AV 75-2, 26.2/95.9 (40µm))	[Uppermost Givetian — Famennian]
Elektroriskos dolos WICANDER & LOEBLICH 1977 (AV 75-1, 21.5/110.5 (25x15µm))	[Late Frasnian — middle Famennian (ca. ds 5.4 — ca. ds 16.4)]
Gorgonisphaeridium plerispinosum WICANDER 1974 (AV 75-1, 28.0/114.0 (partly transparent), 34.3/104.3 (35µm), 75-2, 41.7/93.2 (40µm))	[upper Frasnian — Famennian; — ? Tournaisian]
Gorgonisphaeridium telum WICANDER & PLAYFORD 1985 (AV 75-1, 32.1/107.2 (30µm), 43.6/99.7 (30µm), AV 75-2, 38.1/112.2)	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
Lophosphaeridium segregum PLAYFORD 1981 (AV 75-1, 29.6/112.0, 39.4/92.5 (35µm))	[Frasnian — Visean]
Maranhites stockmansi MARTIN 1981 (AV 75-1, 33.8/105.2 (45µm))	[Late Frasnian (? *Pa. gigas*-zone) — early Famennian (? *Pa. crepida*-zone)]
Tasmanites sp. in WICANDER 1974, pl. 19, fig. 11 (AV 75-1, 45.6/92.9 (30x40µm))	[at least: Famennian]
Winwaleusia ranulaeforma MARTIN 1984 (AV 75-1, 50.0/112.9 (60µm tip-to-tip))	[Late Frasnian (? *Pa. gigas*-zone) — early Famennian (? *Pa. crepida*-zone)]
Ammonidium cf. *A. sprucegrovense* (STAPLIN 1961) LISTER 1970 (AV 75-1, 41.8/112.0)	[Middle Frasnian — Early Famennian (ca. ds 1.7 — ca. 11.3)]
Gorgonisphaeridium cf. *G. absitum* WICANDER 1974 (AV 75-1, 45.0/100.0 (30µm), 31.8/91.8 (35µm))	[Famennian]
Stellinium cf. *S. comptum* WICANDER & LOEBLICH 1977 (AV 75-1, 39.0/112.6)	[Givetian — early Famennian]

Unellium cf. *U. elongatum* Wicander 1974 (AV 75-2, 35.0/93.2 (18µm vesicle + 10µm process-lenght))	[Famennian — Lower Mississippian]
cf. *Muraticavea enteichia* Wicander 1974 (AV 75-1, 26.2/107.1 (30µm))	[Famennian]
Cymatiosphaera sp. (AV 75-2, 41.5/109.0, 27.0/94.3 (30µm))	
Maranhites sp. (AV 75-2, 39.3/108.0 (45µm), 25.0/104.8)	

AV 76 (depth 18.4 - 18.8m, see fig C 7.1, chapt. C 7): Late Frasnian — early Famennian; DK1996: ds ? 4.2 — ? 10.6. Debris-flow sediments with greywacke-clasts which were not completely lithefied at the time of redeposition.

cf. *Winwaleusia ranulaeforma* Martin 1984 (AV 76-1, 48.0/113.6)	[Late Frasnian (? *Pa. gigas*-zone) — early Famennian (? *Pa. crepida*-zone)]
Leiofusa sp. (AV 76-1, 31.6/105.7)	

AV 77 (depth 19.4 - 19.5m): Early Famennian (ca. *torquata-gracilis*-zone), DK1996: ca. ds 6.0 — ca. ds 15.6; with reworked: A) late Frasnian (*ovalis-bulliferus*-zone, ds 4.2 — 6.0), B) middle Emsian (ca. di 12.3 — 15.1)

Dibolisporites eifelensis (Lanninger 1968) McGregor 1973 (AV 77-2, 44.1/102.9, ? 41.0/101.0)	[Siegenian — lower Eifelian (*polygonalis* - *emsiensis* (ca. di 6.7) — in *velatus* - *langii* (ca. dm 2.0))]
Kedoesporis evlanensis (Naumova 1953) Obukhovskaya (AV 77-2, 24.9/94.2 (22µm); F 2.2, plate F 2-5, fig. 4)	[Late Frasnian (upper part of *ovalis-bulliferus* (ca. ds 4.2 — 6.0)]
Dibolisporites sp. cf. *D. echinaceus* Richardson 1965 (AV 77-2, 52.5/113.5, ? 25.9/110.4)	[Emsian — middle Frasnian (in *annulatus-sextantii* (ca. di 12.3) — in *ovalis-bulliferus* (ca. ds 4.3))]
cf. *Camarozonotriletes sextantii* McGregor & Camfield 1982 (AV 77-2, 44.7/113.4)	[Emsian (near top *polygonalis-emsiensis* (ca. di 10.2) — in *douglastownense-eurypterota* (ca. di 19.7)
cf. *Cymbosporites proteus* McGregor & Camfield 1982 (AV 77-2, 26.2/115.0)	[middle Gedinnian — middle Emsian (in *micrornatus-newportensis* (ca. di 2.2) — in *annulatus-sextantii* (ca. di 15.1)]
cf. *Dibolisporites microspicatus* Playford 1978 (AV 77-2, 48.5/109.8)	[Late Frasnian — Lower Carboniferous]
cf. *Emphanisporites decoratus* Allen 1965 (AV 77-2, 37.9/102.4)	[Lower Siegenian — lower Eifelian (near base *polygonalis* - *emsiensis* (ca. di 7.6) — *annulatus-sextantii* (di 19.0)]
cf. *Geminospora lemurata* (Balme 1962) Playford 1983 (AV 77-2, 40.1/113.6, 35.8/113.8)	[Middle Givetian — early Famennian *(lemurata-magnificus* (dm 11.7) — near base *torquata-gracilis* (ca. ds 7.5))]
Apiculiretusispora sp. (AV 77-2, 29.7/110.2)	
Cristatisporites sp. (AV 77-2, 35.8/92.6)	
Retusotriletes sp. (AV 77-2, 39.5/112.6, 38.0/108.9)	
Ammonidium grosjeani (Stockmans & Williere 1969) Martin 1981 (AV 77-2, 21.8/115.0)	[Frasnian (ca. ds 0)— middle Famennian (ca. ds 15.6)]
Comasphaeridium caesariatum Wicander 1974 (AV 77-2, 26.2/105.6; F 2.2, plate F 2-4, fig. 7)	[Famennian]
Cymatiosphaera limbatisphaera Wicander & Loeblich 1977 (AV 77-2, 28.9/111.5; F 2.2, plate F 2-4, fig. 16)	[Uppermost Givetian — Famennian]
Gorgonisphaeridium evexispinosum Wicander 1974 (AV 77-2, 29.3/94.0)	[Frasnian — Viséan]
Lophosphaeridium segregum Playford 1981 (AV 77-2, 48.0/111.4)	[Frasnian — Visean]
Onondagaella asymmetrica (Deunff 1954) Cramer 1966 (AV 77-2, 24.0/112.6; F 2.2, plate F 2-7, fig. 8)	[? Upper Silurian (Ludlowian) — Lower Devonian]
Solisphaeridium spinoglobosum (Staplin 1961) Wicander 1974 (AV 77-2, 52.9/105.9; F 2.2, plate F 2-4, fig. 14)	[? Silurian — Devonian (mostly reported from Upper Devonian deposits)]
Tasmanites sp. in Wicander 1974, pl. 19, fig. 11 (AV 77-2, 43.0/103.0; F 2.2, plate F 2-4, fig. 15)	[at least: Famennian]
Gorgonisphaeridium cf. *G. absitum* Wicander 1974 (AV 77-2, 38.5/98.2; F 2.2, plate F 2-4, fig. 11)	[Famennian]
cf. *Ammonidium* ? *alloiteaui* (Deunff 1955) Martin 1981 (AV 77-2, 32.5/114.8)	[Devonian]
cf. *Comasphaeridium muscosum* Wicander & Playford 1985 (AV 77-2, 34.0/114.9)	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
Baltisphaeridium sp. (AV 77-2, 34.0/112.6)	
Lophosphaeridium sp. (AV 77-2, 52.0/113.6)	

AV 78 (depth 20.05 - 20.3m): Early to middle Frasnian; DK1996: ca. ds 0.5 — ca. 4.7 (but probably all reworked)

Lophozonotriletes media TAUGOURDEAU-LANTZ 1967 (AV 78-1, 43.2/114.0)	[Early — middle Frasnian (in *optivus-triangularis* (ca. ds 0.5) — in *ovalis-bulliferus* (ca. ds 4.7))]
Densosporites sp. (AV 78-1, 45.0/103.5)	
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 78-1, 33.0/109.2)	[late Pragian — Lower Carboniferous (Tournaisian)]
Navifusa bacillum crescentis COMBAZ, LANGE & PANSART 1967 [but compare PLAYFORD 1977: 29 for discussion of *N. bacillum*] (AV 78-1, 34.1/108.0; F 2.2, plate F 2-5, fig. 1)	[at least: Frasnian (of Lybia)]
cf. *Palacanthus ledanoisii* (DEUNFF 1957) PLAYFORD 1977 (AV 78-1, 44.0/101.0, partly transparent)	[Emsian — Frasnian]

AV 83 (depth 25.4 - 25.75m): Early Famennian (early — middle *torquata-gracilis*-zone); DK1996: ds ca. 6.1 — ca. 10.6; with reworked A) late Frasnian (in *ovalis-bulliferus*-zone, ca. ds 4.2 — 5.1), B) Givetian (dm ca. 11.7 — ca. 17.7), C) Emsian (di 10.2 — 20.0) and D) middle — upper Silurian (Wenlockian — lower Ludlowian).

Geminospora tuberculata (KEDO 1955) ALLEN 1965, maybe var. *micrornata* MCGREGOR & CAMFIELD 1982, but 15µm smaller (AV 83-2, 46.0/99.2; F 2.2, plate F 2-6, fig. 6)	[Givetian (EX-zone of the Eastern European spore zonation, ca. dm 11.7 — dm 17.7)]
Convolutispora cf. *crassitunicata* (OBUKHOVSKAYA) OBUKHOVSKAYA (AV 83-2, 38.1/99.6; F 2.2, plate F 2-7, fig. 7)	["Middle" Frasnian of the Eastern European spore-zonation (OG - zone, CVe-subzone; approx. equivalent to lower *Pa. gigas*-zone)]
Geminospora sp. cf. *G. vasjamica* (CHIBRIKOVA) OBUKHOVSKAYA & NEKRIATA; considerably smaller than the original size range of the species (AV 83-2, 23.0/102.2 (38µm) ; F 2.2, plate F 2-5, fig. 8, 30.0/100.0 (40µm))	[Early Famennian (VV — CZ - zone of the Eastern European spore-zonation; approximately equivalent to *Palmatolepis triangularis* (ds 6.1) — *Pa. crepida*-zone (ds 10.6)]
cf. *Lophozonotriletes magnus* KEDO 1974 (AV 83-2, 37.6/96.6 (85µm); F 2.2, plate F 2-5, fig. 13)	[(?Givetian) Famennian — Lower Tournaisian]
Convolutispora sp. (AV 83-2, 27.5/103.3, and 2 more in AV 83-2)	
Stenozonotriletes sp. (AV 83-2, 45.5/98.0)	
cf. *Densosporites* sp. (AV 83-2, 32.8/99.8)	
Ammonidium ? *alloiteaui* (DEUNFF 1955) MARTIN 1981 (AV 83-2, 28.5/105.2; F 2.2, plate F 2-4, fig. 10)	[Devonian]
Cymatiosphaera nebulosa (DEUNFF 1954) DEFLANDRE 1954 (AV 83-2, 35.8/103.7; F 2.2, plate F 2-5, fig. 10)	[Silurian — early Famennian]
Dictyotidium cavernosulum PLAYFORD 1977 (AV 83-2, 27.1/102.2, 26.6/91.0)	[Emsian]
Gorgonisphaeridium plerispinosum WICANDER 1974 (AV 83-2, 25.8/110.8; F 2.2, plate F 2-4, fig. 5 - and 7 more in AV 83-2)	[upper Frasnian — Famennian; — ? Tournaisian]
Gorgonisphaeridium telum WICANDER & PLAYFORD 1985 (AV 83-2, 39.0/103.1; F 2.2, plate F 2-5, fig. 11)	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
Puteoscortum williereae MARTIN 1981 (AV 83-2, 34.5/96.8; F 2.2, plate F 2-4, fig. 3)	[Early Famennian (*Palm. triangularis*-zone — ?)]
Ammonidium cf. *A. waldronensis* (TAPPAN & LOEBLICH 1971) DORNING 1981 (AV 83-2, 26.0/95.0; F 2.2, plate F 2-7, fig. 6)	[Middle — upper Silurian (Wenlockian — lower Ludlowian)]
Gorgonisphaeridium cf. *G. absitum* WICANDER 1974 (AV 83-2, 44.1/103.4 (37µm); F 2.2, plate F 2-4, fig. 12)	[Famennian]
cf. *Dictyotidium cavernosulum* PLAYFORD 1977 (AV 83-2, 42.9/103.5; F 2.2, plate F 2-6, fig. 2, vesicle's reticulate sculpture only relictic preserved)	[Emsian]
cf. *Duvernaysphaera krauseli* (STOCKMANS & WILLIERE) STOCKMANS & WILLIERE 1962 (AV 83-2, 31.0/105.4; F 2.2, plate F 2-4, fig. 17)	[at least: lower Famennian]
Ammonidium sp. (AV 83-2, 42.6/ 110.2, 39.8/106.0; F 2.2, plate F 2-5, fig. 6 - and 3 more in AV 83-2)	
Baltisphaeridium sp. (AV 83-2, 33.5/93.0)	
Dictyotidium sp. (AV 83-2, 39.0/98.0)	
Estiastra sp. (AV 83-2, 29.8/110.8; chapt. F 2.2, plate F 2-7, fig. 1)	
Gorgonisphaeridium sp. (AV 83-2, 25.0/105.5)	
Lophosphaeridium sp. (AV 83-2, 43.5/107.9; F 2.2, plate F 2-5, fig. 7 - and 19 more in AV 83-2 (38µm))	
Desmochitina EISENACK 1931 sp. (AV 83-2, 45.0/102.0; F 2.2, plate F 2-6, fig. 4)	[at least: Middle Devonian]

AV 84 (depth 26.4 - 26.6m): Upper Devonian (DK1996: ds 0 — 20.0); with reworked: A) Givetian (ca. dm 11.7 — 17.7), B) Emsian (ca. di 10.2 — 20.0), C) ? Silurian.

Acanthotriletes bucerus CHIBRIKOVA (AV 84-2, 34.2/114.3; F 2.2, plate F 2-6, fig. 3)	["Early Frasnian" of the Eastern European spore-zonation (OK - zone, approx. equivalent to late Givetian (*optivus-triangulatus*-zone) — early Frasnian (*punctata*-zone); ca. dm 17.2 — ds 2.2)]
Contagisporites optivus (CHIBRIKOVA) OWENS 1971 var. *optivus* (AV 84-2, 38.6/99.5; F 2.2, plate F 2-7, fig. 10)	[Late Givetian — earliest Famennian (in *optivus-triangulatus* (ca. dm 17.8) — near base *torquata-gracilis* (ca. ds 6.9))]
Densosporites inaequus (MCGREGOR) MCGREGOR & CAMFIELD 1982 (AV 84-2, 42.0/98.5; F 2.2, plate F 2-6, fig. 1)	[Late Eifelian — late Frasnian (*devonicus-naumovii* (ca. dm 4.6) — *ovalis-bulliferus* (ca. ds 3.9))]
Geminospora cf. *extensa* (NAUMOVA 1953) GAO (AV 84-2, 38.1/111.8; F 2.2, plate F 2-6, fig. 5)	[Givetian (EX-zone of the Eastern European spore zonation, ca. dm 11.7 — dm 17.7)]
Densosporites sp. (AV 84-2, 39.2/106.5 (31µm); F 2.2, plate F 2-7, fig. 3)	
Cymatiosphaera cf. *perimembrana* STAPLIN 1961 (AV 84-2, 50.2/114.1, ? 47.1/105.0)	[(? Middle Devonian) Frasnian — uppermost Devonian / lowermost Carboniferous)]
Dictyotidium cavernosulum PLAYFORD 1977 (AV 84-2, 35.8/114.8)	[Emsian]
Lophosphaeridium segregum PLAYFORD 1981 (AV 84-2, 44.5/111.5; F 2.2, plate F 2-5, fig. 9, 25.0/103.2)	[Frasnian — Visean]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 84-2, 39.5/104.8)	[late Pragian — Lower Carboniferous (Tournaisian)]
Tasmanites sp. (AV 84-2, 38.0/113.6, 51.0/96.2)	
Chitinozoa indet., pyritised (AV 84-2, 32.6/114.5, 28.0/115.0)	[probably reworked Silurian species]

AV 86 (depth 28.1 - 28.3m): Famennian (DK1996: ca. ds 6.1 — ? 20.0); with reworked A) upper Siegenian — lowermost Eifelian (ca. di 9.0 — dm 1.1), B) ? Upper Silurian — ? lower Lochkovian.

Dictyotriletes cf. *D. emsiensis* (ALLEN 1965) MCGREGOR 1973 in PLAYFORD 1976 (AV 86-1, 42.1/103.7; F 2.2, plate F 2-7, fig. 9)	[upper Siegenian — lowermost Eifelian (ca. di 9.0 — dm 1.1)]
Micrhystridium erugatum WICANDER 1974 (AV 86-1, 33.1/94.4; F 2.2, plate F 2-4, fig. 9)	[Famennian]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 86-1, 44.1/99.3)	[late Pragian — Lower Carboniferous (Tournaisian)]
Solisphaeridium astrum WICANDER 1974 (AV 86-1, 40.0/99.6; F 2.2, plate F 2-4, fig. 6, 20.9/91.7)	[Famennian]
Tasmanites sp. (AV 86-1, 43.2/105.2)	
Villosacapsula sp. (AV 86-1, 46.0/94.0)	
cf. *Margachitina* EISENACK 1968 sp. (AV 86-1, 27.0/112.2; F 2.2, plate F 2-7, fig. 5)	[? Upper Silurian — ? lower Lochkovian]
Chitinozoa indet. (AV 86-1, 43.2/105.2)	

AV 87 (depth 28.6 - 28.7m): Early Famennian (within *torquata-gracilis*-zone); DK1996: ds ca. 10.3 — ca. 10.6; with reworked A) late Frasnian (in *ovalis-bulliferus*-zone, ca. ds 4.2 — 5.1), B) Middle Devonian (dm ca. 3.8 — ca. ds 0.5), C) latest Emsian — earliest Eifelian (*douglastownense - eurypterota* — in *velatus - langii*-zone (ca. di 19.0 — ca. dm 2.5))

Ancyrospora melvillensis OWENS 1971 (AV 87-1, 29.0/93.0; F 2.2, plate F 2-6, fig. 9)	[Uppermost Givetian — Frasnian (in *optivus-triangularis* (ca. dm 18.7 — *ovalis-bulliferus* (ds 6.0))]
Aneurospora greggsi (MCGREGOR) STREEL 1974 (AV 87-1, 39.2/114.4 (chapter F 2.2, plate F 2-6, fig. 7), 31.8/110.8, ? 39.2/114.2, 31.8/110.8 (chapt. F 2.2, plate F 2-6, fig. 9), 31.6/104.5)	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Apiculiretusispora plicata (ALLEN 1965) STREEL 1967 (AV 87-1, 35.0/112.9; F 2.2, plate F 2-7, fig. 2)	[Lower Gedinnian — Lower Eifelian (within *micrornatus - newportensis* (ca. di 1.4 — near top *velatus - langii* (ca. dm 3.0))]
Auroraspora macra SULLIVAN 1968 (AV 87-1, 45.0/91.2; F 2.2, plate F 2-5, fig. 3)	[Early Famennian — Lower Carboniferous (in *torquata - gracilis* (DK 1996: ca. ds 10.3) — ca. PU)]
Verrucosisporites premnus RICHARDSON 1965 (AV 87-1, 42.0/104.4; F 2.2, plate F 2-6, fig. 10)	[Middle Eifelian — Givetian (*devonicus-naumovii* (dm 3.8) — *optivus-triangularis* (ca. ds 0.5)]

Verrucosisporites evlanensis (NAUMOVA) OBUKHOVSKAYA (AV 87-1, 46.0/104.5; F 2.2, plate F 2-5, fig. 12)	[Uppermost Frasnian — lowermost Famennian (DE-VV-zones of the Eastern European spore-zonation, approximately equivalent to *gigas* (ca. ds 4.2) — *Palmatolepis triangularis*-zone (ds 8.1))]
Ancyrospora sp. (AV 87-1, 21.6/111.0; F 2.2, plate F 2-6, fig. 11)	
Geminospora notata (NAUMOVA 1953) OBUKHOVSKAYA var. *microspinosus* TCHIBRIKOVA (AV 87-1, 28.8/108.2; F 2.2, plate F 2-5, fig. 5)	[Early Famennian (zones GS — CZ of the Eastern European spore zonation; in Middle *triangularis* (ca. ds 7.1) — *crepida* (ca. ds 10.6))]
Diducites poljessicus (KEDO) VAN VEEN 1981 (AV 87-1, 33.0/106.4; F 2.2, plate F 2-5, fig. 2)	[Early Famennian — in Lower Carboniferous (near base *torquata* - *gracilis* (DK 1996: ca. ds 6.4) — in L. Carbonif.)]
cf. *Spinozonotriletes arduinnae* RIEGEL 1973 (AV 87-1, 22.9/107.9)	[uppermost Emsian — lower Eifelian (*douglastownense* - *eurypterota* (ca. di 19.0) — in *velatus* - *langii* (ca. dm 2.5))]
Convolutispora cf. *crassitunicata* (OBUKHOVSKAYA) OBUKHOVSKAYA (AV 87-1, 24.0/113.0)	["Middle" Frasnian of the Eastern European spore-zonation (OG - zone, CVe-subzone; approx. equivalent to lower *Pa. gigas*-zone, ds 4.2 — 5.1)]
Ammonidium cf. *hamatum* WICANDER 1974 (AV 87-1, 25.0/114.1; F 2.2, plate F 2-4, fig. 1+2)	[Famennian]
Veryhachium downiei STOCKMANS & WILLIERE 1962 (AV 87-1, 44.2/114.6; F 2.2, plate F 2-4, fig. 13, 41.6/99.0)	[Upper Silurian — Devonian]

AV 88 (depth 29.2 - 29.3m): Famennian (DK1996: ca. ds 6.1 — ? 20.0); with reworked late Frasnian (in *ovalis-bulliferus*-zone, ca. ds 4.2 — 5.1)

Aneurospora greggsi (MCGREGOR) STREEL 1974 (AV 88-1, 48.5/104.5)	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Convolutispora caperata WICANDER & PLAYFORD 1985 (AV 88, SEM-pict. 09909; F 2.2, plate F 2-7, fig. 4)	[at least: late Frasnian (Lower *Pa. gigas*-zone, at least: ds 4.2 — 5.1)]
Cymatiosphaera labyrinthica WICANDER 1974 (AV 88-1, 58.0/113.9; F 2.2, plate F 2-4, fig. 8)	[Famennian]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 88-1, 37.8/107.2)	[late Pragian — Lower Carboniferous (Tournaisian)]

Remarks: Acritarchs dominate the Early Famennian palynofacies (= open marine, basinal). The Emsian to Frasnian palynofacies is dominated by spores (= near terrestrial areas (?islands)); however, the sporadic occurrence of acritarchs and even chitinozoans generally indicate an open marine environment through all these times.

Presumable sedimentary environment: Open marine, basinal, but still near terrestrial areas (islands?), since (often disaggregated) spores are present in the palynofacies which is, however, dominated by acritarchs. Deposition of clay from suspension punctuated by sudden incursions of silt and, partly, greywacke by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay/silt/greywacke sediment pile along a slope. Transport of large volumes of these sediments onto the deeper sea-floor, final deposition when a reduction in slope caused deceleration. Most striking sedimentary features are: plastic deformation prior to tectonic deformation, ungraded and mostly disorganised fabric, although original bedding features are sometimes still observable. Debris-flow sediments with greywacke-clasts which were not completely lithefied at the time of redeposition.

Sample: AV 147
Gauss-Kruger-coordinates: ^{34}35071.54 - ^{55}84363.16
Location: drill site BK 3004/05 (depth: 22.2 - 22.4m, date: Oct. 1995) of the Deutsche Bahn AG, ca. 900m southwest of Dietkirchen (directly northeast of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Bruchberg sandstone formation (sandstone and dark slate, see appendix F 1 for details).
Stratigraphic correlation: The original correlation (see WV 1), which only allowed for a designation into the Viséan (LCC2003: ci: 13.3 — > 20.0 (with reworked flora from DK1996: ds 18.9 — LCC2003: ci: 13.3 (CM)), is herewith further confined to the **late Viséan** (TC — VF-zone): LCC2003: ci 16.6 — 19.2; with reworked flora from LCC2003: ci: 8.5 — 13.3; PC — CM.
Fossils: (initial fossil-list in Wierich & Vogt 1997, compare chapt. C 3.17, sample WV 1. Only additions are posted herein: spores, det. by Vogt)

Densosporites aculeatus Playford 1962 (AV 147-1, 36.1/106.4)	[PU — NC (— ?lower Namurian)]
Densosporites subcrenatus (Waltz in Luber & Waltz 1938) Potonié & Kremp 1955 (AV 147-4, 43.0/106.5 (50µm), partly transparent)	[PU — Upper Carboniferous]
Lycospora noctuina Butterworth & Williams 1958 (AV 147-1, 34.8/101.9 (28µm))	[PU — Upper Carboniferous]
Lycospora pusilla (Ibrahim) Somers 1972 (AV 147-1, 32.3/112.5, 39.3/99.2, partly transparent; frequent)	[PU — Upper Carboniferous]
Monilospora mutabilis Staplin 1960 (AV 147-4, 46.1/95.4 (45µm))	[TC — VF]
Radiizonates mirabilis Phillips & Clayton 1980 (AV 147-1, 43.9/108.5 (60µm), partly transparent)	[PC — CM]
Rugospora polyptycha Neves & Ioannides 1974 (AV 147-3, 34.5/107.6 (45µm))	[HD — Upper Carboniferous]
Convolutispora cf. *C. vermiformis* Hughes & Playford 1961 (AV 147-1, 43.0/109.7, "cf.-determination" because of more and narrower (1-2.5mm) muri than in original description)	[late Upper Devonian — CM]
Spelaeotriletes sp. (AV 147-5, 45.6/92.5; F 2.2, plate F 2-9, fig. 1	
Monoletes indet., AV 147-2, 38.9/91.0; F 2.2, plate F 2-10, fig. 1	
plant-remnant, 105 µm long & 25-15µm broad, broken part of a stem (? secondary xylem) with in pairs alternating "Hoftüpfel" (pitted tissue) (AV 147-4, 42.6/94.5)	

Remarks: The palynofacies is almost entirely dominated by spores and indicate an originally nearshore, shallow marine, depositional environment (both in late Tournaisian and late Viséan times). Lithofacies and petrographic analyses give evidence for a redeposition of these sediments during the late Viséan.
Presumable sedimentary environment: Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles. The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

Sample: AV 162
Gauss-Kruger-coordinates: ^{34}35106.07 - ^{55}84318.51
Location: drill site BK 3004/07 (depth: 17.4 - 17.5m, date: Oct. 1995) of the Deutsche Bahn AG, ca. 900m southwest of Dietkirchen (directly northeast of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Dark silty slate (basinal background sediment of the Bruchberg sandstone formation, see appendix F 1 for details), partly with flawy, disorganised structure.
Stratigraphic correlation: Uppermost Devonian — Viséan (*pusillites-lepidophyta* — ? TS -zone). DK1996: ca. 18.5 — LCC2003: ci ? 16.6.
Fossils: (spores, acritarchs, det. by Vogt)

Dictyotriletes cf. *trivialis* (Naumova 1953) Kedo 1963 (AV 162-3, 37.7/100.2 (60µm))	[*pusillites-lepidophyta* — ? TS]
Monoletes indet. (AV 162-3, 33.7/100.0)	
Veryhachium sp. (AV 162-3, 25.1/98.5)	

Remarks: poorly preserved flora.
Presumable sedimentary environment: Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles (not met in this drilling). The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the

eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin. Disorganised appearance probably induced by minor submarine gliding along a basinal slope (caused by short-term tectono-seismic activity) and tectonic deformation near the base of the nappe.

Sample: AV 174 + 177
Gauss-Kruger-coordinates: ^{34}35132.91 - ^{55}84264.14
Location: drill site BK 3004/09 (date: Oct. 1995) of the Deutsche Bahn AG, ca. 900m southwest of Dietkirchen (directly northeast of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Dark silty slate (basinal background sediment of the Bruchberg sandstone formation, see appendix F 1 for details), partly with flawy, disorganised structure.
Stratigraphic correlation: Viséan (PU — VF); LCC2003: ci 13.3 — 19.2 with reworked uppermost Devonian — Tournaisian (?*pusillites-lepidophyta* — CM), DK1996: ca. ds 18.5 — LCC2003: ci ?13.3.
Fossils: (spores, det. by VOGT)

AV 174 (depth 16.75 - 16.85m): probably Lower Carboniferous (Viséan), but only (?reworked) uppermost Devonian — Tournaisian (?*pusillites-lepidophyta* — CM), DK1996: ca. ds 18.5 — LCC2003: ci ?13.3, sufficiently provable.

Convolutispora vermiformis HUGHES & PLAYFORD 1961 (AV 174-2, 31.5/101.4 (50µm))	[late Upper Devonian — CM]
cf. *Lycospora pusilla* (IBRAHIM) SOMERS 1972 (AV 174-2, 46.5/114.7 (28µm))	[PU — Upper Carboniferous]
Leiotriletes sp. (AV 174-2, 44.0/96.8 (35µm), 43.7/95.0)	

AV 177 (depth 19.35 - 19.5m): Viséan (PU — VF); LCC2003: ci 13.3 — 19.2.

Lycospora pusilla (IBRAHIM) SOMERS 1972 (AV 177-3, 48.0/107.8 (35µm))	[PU — Upper Carboniferous]
Spelaeotriletes cf. *S. pretiosus* (PLAYFORD 1964) NEVES & BELT 1970 (AV 177-1, 30.0/104.9 (65µm))	[PC — VF]

Remarks: several indet. acritarchs (e. g. *Veryhachium* sp.) are also constituents of the palynofacies.
Presumable sedimentary environment: Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles (not met in this drilling). The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin. Disorganised appearance probably induced by minor submarine gliding along a basinal slope (caused by short-term tectono-seismic activity) and tectonic deformation near the base of the nappe.

Sample: AV 210
Gauss-Kruger-coordinates: ^{34}35208.64 - ^{55}84174.73
Location: drill site BK 3004/13 (depth: 25.5 - 25.6m, date: Jan./Feb. 1996) of the Deutsche Bahn AG, ca. 1km south of Dietkirchen (northeast of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Bruchberg sandstone formation (sandstone and dark slate, see appendix F 1 for details, but also analysis of cyclic sequences in chapter C 8.2 (AV 204)).
Stratigraphic correlation: Viséan (DP — VF); LCC2003: ci 16.9 — 19.2 with reworked uppermost Devonian — Tournaisian (*lepidophyta-nitidus* — CM), DK1996: ca. ds 19.7 — LCC2003: ci 13.3.
Fossils: (spores, acritarchs, radiolarians, det. by VOGT)

Colatisporites decorus (BHARADWAJ & VENKATACHALA) WILLIAMS 1973 (AV 210-3, 26.9/102.5 (35µm), 20.0/101.9 (40µm), 31.5/100.2 (35µm), 29.8/98.5 (30µm), 23.4/95.3 (40µm))	[PC — VF]
Densosporites pseudoannulatus BUTTERWORTH & WILLIAMS 1958 (AV 210-3, 28.1/110.0 (45µm))	[Lower Carboniferous — Namurian — ?]
Rotaspora knoxi BUTTERWORTH & WILLIAMS 1958 (AV 210-3, 35.3/101.5 (40µm))	[DP (ci 16.9) — early Namurian]
Schulzospora bilunata UTTING 1987 (AV 210-3, 33.7/114.6 (85x50µm))	[SM of Atlantic Canada, approx. equivalent to VF]
Tholisporites ? *biannulatus* NEVES (AV 210-3, 40.7/103.3 (50µm))	[at least: VF]
cf. *Verrucosisporites nitidus* (NAUMOVA 1953) PLAYFORD 1964 (AV 210-3, 33.3/107.1 (60µm))	[LN — PU]

Densosporites sp. (AV 210-3, 42.2/113.2 (40µm), 40.8/103.3 (40µm), 47.5/103.7 (50µm), 45.6/102.7 (40µm), 32.3/102.7 (30µm))

Monoletes indet. (AV 210-3, 36.1/112.3 (110x50µm), 37.9/105.5 (125x40µm))

cf. *Navifusa bacillum* (DEUNFF 1955) PLAYFORD 1977 (AV 210-3, 37.8/107.1 (150x30µm)) [late Pragian — Lower Carboniferous (Tournaisian)]

Leiofusa sp. (AV 210-3, 25.5/109.0 (160x40µm), 18.7/101.8 (90x35µm))

Unidentified acritarchs (AV 210-3, 30.2/100.2 (155x35µm), 22.5/95.7 (30µm), 45.3/107.8 (140x45µm), 35.0/103.4 (120x60µm, ? thorn), [46.0/94.3 (115x50µm), 39.5/94.2 (105x45µm)], [coil-like with characteristic ornamentation: 19.8/99.0 (110x35µm, pyritised), 20.8/96.8 (110x25µm), 21.1/95.5 (105x30µm, pyritised), 37.7/92.7 (85x35µm)])

Latentifistula concentrica (RÜST 1892) BRAUN 1990 (AV 210-3, 49.3/97.5 (100x90µm), pyritised) [*Latentifistula - concentrica* -zone (ci 16.4) — ?]

Archocyrtium DEFLANDRÉ 1972 sp., completely pyritised (AV 210-3, 36.5/104.6 [? Famennian — Namurian B]

Radiolarian-remnants, indet. (AV 210-3, 32.9/114.7, 37.3/113.2, 38.6/112.3, 44.6/113.4; frequent)

Worm-like spiral-winding fossil (? foraminifer) (AV 210-3, 32.3/101.5 (125x30µm), 23.2/95.3 (pyritised); compare AV 23-1, 51.7/110.8)

Remarks: In this sample the basinal and fully marine background biofacies with acritarchs and radiolarians is detectable/preserved; the spores, therefore, would represent the shallow-marine, near-shore palynofacies before redeposition and their relatively good preservation a rapid, single-event, transport.

Presumable sedimentary environment: Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt (cyclic sequences); partly thick, but short-termed, turbiditic deposition of finesand piles. The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

Sample: AV 221

Gauss-Kruger-coordinates: ^{34}35241.25 - ^{55}84128.20

Location: drill site BK 3004/15 (depth: 15.7 - 15.8m, date: Dec. 1995 / Jan. 1996) of the Deutsche Bahn AG, ca. 1km south of Dietkirchen (northeast of Limburg; geological map 1:25000, 5614 Limburg).

Lithology: Bruchberg sandstone formation (sandstone and dark slate, see appendix F 1 for details).

Stratigraphic correlation: Viséan — Upper Carboniferous (TC — ? Namurian); LCC2003: ci 16.6 — > 20.0 with reworked late Tournaisian (PC — CM), LCC2003: ca. ci 8.5 — 13.3.

Fossils: (spores, det. by VOGT)

Convolutispora vermiformis HUGHES & PLAYFORD 1961 (AV 221-1, 23.1/114.2 (45µm)) [late Upper Devonian — CM]

Densosporites brevispinosus HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 221-1, 25.3/96.2 (40µm)) [PU — Upper Carboniferous]

Densosporites spinifer HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 221-1, 49.3/104.2 (40µm)) [PU — Upper Carboniferous]

Radiizonates mirabilis PHILLIPS & CLAYTON 1980 (AV 221-1, 23.3/95.4 (60µm), partly transparent) [PC — CM]

Schulzospora rara KOSANKE 1950 (AV 221-1, 26.5/95.2 (ca. 80µm, broken - only ca. 60µm preserved)) [TC — Upper Carboniferous]

Dictyotriletes cf. *D. submarginatus* PLAYFORD 1971 (AV 221-1, 47.8/112.9 (60µm)) [? VI — ? TC]

Lycospora cf. *pusilla* (IBRAHIM) SOMERS 1972 (AV 221-1, 28.9/106.2 (30µm)) [PU — Upper Carboniferous]

Rugospora cf. *R. polyptycha* NEVES & IOANNIDES 1974 (AV 221-1, 33.0/109.8 (50µm)) [HD — Upper Carboniferous]

Dictyotriletes sp. (AV 221-1, 43.5/110.5 (30µm))

Remarks: occurence of acritarchs questionable.

Presumable sedimentary environment: Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt; partly thick, but short-termed, turbiditic deposition of several metres thick finesand piles. The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old

Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

Sample: AV 227
Gauss-Kruger-coordinates: ^{34}35255.81 - ^{55}84081.75
Location: drill site BK 3005/01 (depth: 6.9 - 7.0m, date: May 1994) of the Deutsche Bahn AG, ca. 1km south of Dietkirchen (northeast of Limburg; geological map 1:25000, 5614 Limburg).
Lithology: Dark silty slate (basinal background sediment of the Bruchberg sandstone formation ?; see appendix F 1 for details).
Stratigraphic correlation: Late Viséan (VF -zone — Upper Carb.). LCC2003: ca. ci 17.5 — > 20.0.
Fossils: (spores, acritarchs, det. by VOGT)

Lycospora pusilla (IBRAHIM) SOMERS 1972 (AV 227-1, 31.2/104.6 (30µm))	[PU — Upper Carboniferous]
Schulzospora plicata BUTTERWORTH & WILLIAMS in SMITH & BUTTERWORTH 1967, p. 276 (AV 227-1, 43.5/114.9 (42x25µm))	[Viséan (VF) — Westphalian A]
cf. *Schulzospora rara* KOSANKE 1950 (AV 227-2, 41.6/111.6 (60x40µm))	[TC — Upper Carboniferous]
Lycospora sp. (AV 227-1, 51.6/114.9 (38µm))	[PU — Upper Carboniferous]
Navifusa cf. *N. bacillum* (DEUNFF 1955) PLAYFORD 1977 (AV 227-1, 26.9/114.2 (65x25µm))	[late Pragian — Lower Carboniferous (Tournaisian)]
Leiofusa sp. (AV 227-1, 45.5/93.8 (broken, min. 225x18µm))	
Lophosphaeridium sp. (AV 227-1, 26.0/106.6 (120x45µm))	
Navifusa sp. (AV 227-1, 35.6/112.9 (120x18µm), 36.2/92.3 (100x38µm), 227-2, 49.1/104.2 (85x35µm))	
Veryhachium sp. (AV 227-1, 34.0/93.8 (40µm))	
Unidentified acritarchs (AV 227-1, 35.7/100.1 (95x25µm), [47.0/114.7, 46.8/101.1, compare AV 32-1, 52.3/92.6], [AV 227-1, 41.2/110.3 (115x25µm), compare AV 67-A1, 45.5/112.0 (85x30µm) = AV 10-1, 42.3/114.1 (130x40µm)], [41.2/109.9, (60x28µm, opaque), 43.1/110.0 (60x25µm, transparent sac with numerous phycomata), compare 10-1, 31.4/109.8, AV 10-2, 52.1/112.8], ?31.1/109.7 (55x33µm), AV 227-2, [coil-shaped: 27.8/99.4 (85x35µm), 44.4/93.9 (95x25µm), 33.8/93.8 (75x22µm)], [bone-shaped: 46.1/94.6 (65x25µm), compare AV 6-1, 39.6/95.4 (75x25µm)])	
Seedling (AV 227-1, 36.5/101.8 (broken, min. 180x10µm))	

Remarks: The (unidentified) acritarch spectrum is similar to the ones observed in samples AV 5/6, 10 and 11. The palynofacies is dominated by acritarchs (open marine). All spores are reworked fossils from shallow marine, near-shore first-cycle depositional areas.
Presumable sedimentary environment: Marine outer shelf or basin, not too near to terrestrial areas, since the acritarch spectrum dominates over the spore flora. Deposition of mud from suspension, punctuated by sudden (tempestitic) incursions of rapidly deposited silt. Dominating bedding features are lenticular bedding and laminated silt or mud. Probably background sediment of the Bruchberg-sandstone formation: The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbidity currents along submarine canyons into the Rhenish Basin.

Sample: AV 231
Gauss-Kruger-coordinates: ^{34}39866.38 - ^{55}80423.89
Location: drill site BK 4036/15 (depth: 14.5m, date: Dec. 1995) of the Deutsche Bahn AG, southwest of Niederbrechen; geological map 1:25000, 5614 Limburg).
Lithology: Sandstone (finesand) with slate layers.
Stratigraphic correlation: Lower Devonian (in *breconensis* - *zavallatus* — near base *douglastownense* - *eurypterota*-zone). DK1996: ca. di 4.4 — 19.2.
Fossils: (spores, acritarchs, det. by VOGT)

Apiculiretusispora plicata (ALLEN 1965) STREEL 1967 (AV 231-1, 34.3/96.4 (40µm))	[Lower Gedinnian — Lower Eifelian (within *micrornatus* - *newportensis* (ca. di 1.4 — near top *velatus* - *langii* (ca. dm 3.0))]
Clivosispora verrucata MCGREGOR var. *verrucata* MCGREGOR 1973 (AV 231-1, 32.8/113.7 (30µm), 32.3/107.5 (40µm), 32.3/101.6 (30µm), 41.8/97.4 (70µm))	[uppermost Gedinnian — Emsian (in *breconensis* - *zavallatus* (di 4.4) — near base *douglastownense* - *eurypterota* (di 19.2))]
Stellinium sp. (AV 231-1, 39.0/109.6 (30µm))	

Remarks: poorly preserved flora, but spores are much more abundant than acritarchs.
Presumable sedimentary environment: Marine (inner) shelf, not too far away from terrestrial areas, since the spore spectrum dominates over the acritarch flora. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt - finesand. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 242
Gauss-Kruger-coordinates: ^{34}31510 - ^{55}80220
Location: Outcrop opposite of Aardecker Mühle (geological map 1:25000, 5614 Limburg, see ch. C 3, fig. C 3.3).
Lithology: Dark slate (compare chapter C 11, fig. C 11.2 and enclosure 1).
Stratigraphic correlation: Latest Emsian — early Eifelian, DK1996: ca. di 19.0 — ca. dm 2.5; with reworked middle to Upper Silurian (Wenlockian — lower Ludlowian).
Fossils: (spores, acritarchs, chitinozoans, det. by VOGT)

Unidentified spore (AV 242-1,36.5/104.8 (70µm))	
Deunffia brevispinosa DOWNIE 1960 (AV 242-1, 35.0/111.0)	[Middle Silurian (lower Wenlockian)]
Eupoikilofusa filifera (DOWNIE 1959) DORNING 1981 (AV 242-1, 35.3/104.9 (broken))	[Middle Silurian (upper Llandoverian — lower Ludlowian)]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 242-1, 39.8/112.4, AV 242-2, 33.3/112.8, 33.0/110.2, 38.9/109.8)	[late Pragian — Lower Carboniferous (Tournaisian)]
Deunffia cf. *D. brevifurcata* HILL 1974 (AV 242-1, 32.6/111.2)	[Middle Silurian (lower Wenlockian)]
Domasia cf. *D. quadrispinosa* HILL 1974 (AV 242-1, 36.1/112.3, broken remnant)	[Middle Silurian (upper Llandoverian — lower Wenlockian)]
Leiofusa cf. *L. pyrena* WICANDER & WOOD 1981 (AV 242-1, 36.6/106.9, 21.0/105.4)	[at least: Givetian]
Lophosphaeridium cf. *L. dumalis* PLAYFORD 1977 (AV 242-1, 38.8/104.5 (60µm), 27.0/102.4)	[Latest Emsian (ca. di 19.0) — early Eifelian (ca. dm 2.5)]
cf. *Geron amabilis* CRAMER 1969 (AV 242-1, 19.0/100.9 (90µm), AV 242-2, 25.0/108.2 (100µm))	[Upper Silurian (Ludlowian)]
Baltisphaeridium sp. (AV 242-2, 33.2/98.7)	
Leiofusa sp. (AV 41.2/97.1 (100µm, with characteristic grana)	
Tasmanites sp. (AV 242-1, 35.2/91.8, AV 242-2, 30.0/114.6)	
Unidentified acritarch (AV 242-1, 34.0/101.3 (50µm))	
Pterochitina perivelata EISENACK 1937 (AV 242-2, 20.8/109.6)	[Middle Silurian (upper Llandoverian) — Lower Gedinnian]
Conochitina sp. (AV 242-1, 44.4/96.7 (90µm))	
Desmochitina sp. (AV 242-1, 22.4/106.8, broken)	
Margachitina ? sp. (AV 242-1, 48.2/101.0)	
Rhabdochitina ? sp. (AV 242-1, 36.8/110.8 (>80µm), 34.6/101.0, 37.1/91.8)	
Unidentified chitinozoans (AV 242-1, 24.2/112.3, [36.1/109.6, 40.5/94.1], 38.9/102.9 (2 specimens), AV 242-2, 28.0/114.9, [22.8/111.3, 29.0/109.8], 38.7/110.3, 29.8/110.0, 37.5/105.0)	

Remarks: All Emsian/Eifelian spores and most acritarchs are disaggregated - the palynofacies is not exactly determinable, but since acritarchs are present a fully marine environment prevailed; reworked Silurian chitinozoans indicate a completely off-shore marine environment far from terrestrial areas at that time.
Presumable sedimentary environment: Marine (inner) shelf, not too far away from terrestrial areas, since the spore spectrum dominates over the acritarch flora. Tectonic activity (rifting ?) lead to redeposition of middle to upper Silurian (Wenlockian — lower Ludlowian) sediments. Deposition of mud from suspension below or within wave

base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 246
Gauss-Kruger-coordinates: ^{34}31510 - ^{55}80210
Location: Outcrop opposite of Aardecker Mühle (geological map 1:25000, 5614 Limburg, see ch. C 3, fig. C 3.3).
Lithology: Calcareous nodule in dark slate (compare chapter C 11, fig. C 11.2 and enclosure 1).
Stratigraphic correlation: somewhere inbetween late Pragian — Givetian, DK1996: ca. di 9.0 — ca. dm 20.0; with reworked middle to upper Silurian (upper Llandoverian — lower Ludlowian).
Fossils: (acritarchs, ?chitinozoans, det. by Vogt)

Navifusa bacillum (Deunff 1955) Playford 1977 (AV 246-3, 33.5/114.6, 18.9/111.1, 44.6/108.7, 39.1/99.0, frequent)	[late Pragian — Lower Carboniferous (Tournaisian)]
Pterospermella foveolata Lister ex Dorning 1981 (AV 246-3, 38.1/97.6 (50µm))	[Middle to upper Silurian (upper Llandoverian — lower Ludlowian)]
cf. *Polyedrixium decorum* Deunff 1955 (AV 246-3, 23.9/114.8)	[Middle Pragian — Givetian]
Veryhachium sp. (AV 246-1, 46.2/111.0)	

Remarks: poorly preserved flora. Sample AV 9, which allowed for a correlation with Upper Emsian — ? Eifelian times (with reworked upper Silurian flora), was taken a few decimetres above AV 246, hence indicate a similar age-range for this sample.
Presumable sedimentary environment: Open marine (?shelf). Tectonic activity (rifting ?) lead to redeposition of middle to upper Silurian (upper Llandoverian — lower Ludlowian) sediments. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited silt and calcareous debris from submarine highs. Dominating bedding features are lenticular bedding and laminated silt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 258
Gauss-Kruger-coordinates: ^{34}40980 - ^{55}89460
Location: West of Eschenau (geological map 1:25000, 5515 Weilburg).
Lithology: Dark slate with greywacke - intercalations (pseudonodules in ? debris flow).
Stratigraphic correlation: Famennian, DK1996: ds 6.0 — 20.0; with reworked A) Frasnian (*ovalis-bulliferus*-zone (ca. ds 1.7 — 6.0)) and B) ? Upper Silurian (Ludlowian) — Lower Devonian.
Fossils: (spores, acritarchs, chitinozoans, det. by Vogt)

Archaeoperisaccus cf. *A. concinnus* Naumova 1953 (AV 258-2, 45.4/98.9)	[Frasnian (OG-zone of the eastern European spore zonation, approx. equivalent to the *ovalis-bulliferus*-zone (ca. ds 1.7 — 6.0))]
cf. *Cyrtospora cristifera* (Luber) van der Zwan 1979 (AV 258-1, 20.0/99.4)	[Famennian (*torquata-gracilis*) — Tournaisian (PC)]
Estriastra rugosa Wicander 1974 (AV 258-2, 36.6/91.3)	[Famennian]
Onondagaella asymmetrica (Deunff 1954) Cramer 1966 (AV 258-1, 29.9/108.0)	[? Upper Silurian (Ludlowian) — Lower Devonian]
Villosacapsula sp. (AV 258-2, 35.8/111.4)	
Cyathochitina ? cf. *C.*? *infundibuliformis* Taugourdeau & Jekhowsky 1960 in Martin 1982 (AV 258-1, 41.1/105.5, partly transparent)	[Devonian]

Remarks: poorly preserved, often disaggregated, flora. The spore/acritarch spectrum with reworked species from Frasnian and Silurian/Lower Devonian times is similar to the one observed in Famennian debris flow sediments from drill sites near Limburg (e. g. AV 69, 76). It seems probable that at this location also debris flow sediments occur.
Presumable sedimentary environment: Open marine, basinal, but still near terrestrial areas (islands?), since (often disaggregated) spores are present in the palynofacies which is, however, dominated by acritarchs. Deposition of clay from suspension punctuated by sudden incursions of silt and, partly, greywacke by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay/silt/greywacke sediment pile along a slope. Transport of large volumes of these sediments onto the deeper sea-floor, final deposition when a reduction in slope caused deceleration.

Sample: AV 259
Gauss-Kruger-coordinates: ^{34}31500 - ^{55}80250
Location: Outcrop opposite of Aardecker Mühle (geological map 1:25000, 5614 Limburg, see ch. C 3, fig. C 3.3).
Lithology: Finegrained debris flow with calcareous nodules and greywacke-pseudonodules (ch. C 11, fig. C 11.2).
Stratigraphic correlation: Early to middle Famennian (near base *torquata-gracilis* — ? in *flexuosa-cornuta*-zone). DK1996: ca. ds 7.1 — ? 16.5; with reworked A) early — middle Frasnian (in *optivus-triangularis* — in *ovalis-bulliferus* (ca. ds 0.5 — ca. ds 4.7)) and B) middle Givetian — early Frasnian (near top *devonicus-naumovii* — near top *optivus-triangularis* (ca. dm 10.9 — ca. ds 0.8)).
Fossils: (spores, acritarchs, chitinozoans, det. by Vogt)

Archaeozonotriletes timanicus Naumova 1953 (AV 259-1, 36.8/94.5)	[Middle Givetian — early Frasnian (near top *devonicus-naumovii* (ca. dm 10.9) — near top *optivus-triangularis* (ca. ds 0.8))]
Archaeozonotriletes variabilis Naumova 1953 (AV 259-2, 42.8/97.6 (60µm))	[Givetian (within *devonicus-naumovii*, ca. dm 8.9) — Famennian (*lepidophyta-nitidus*, ca. ds 20.0)]
Lophozonotriletes lebedianensis Naumova 1953 (AV 259-2, 32.9/99.6, 20.0/91.0)	[Famennian (near base *torquata-gracilis*, ca. ds 7.1 — *lepidophyta-nitidus*, ca. ds 20.0)]
Verrucosisporites bulliferus (Taugourdeau-Lantz 1967) Richardson & McGregor 1986 (AV 259-1, 41.1/106.8 (60µm, equatorial view), 34.0/92.3 (40µm), ? 34.7/109.2, ? 45.2/106.8, AV 259-2, 35.1/95.4 (partly transparent))	[Frasnian (*ovalis-bulliferus* (ds 1.7)) — late Famennian (in *flexuosa-cornuta* (ca. ds 16.5))]
cf. *Lophozonotriletes media* Taugourdeau-Lantz 1967 (AV 259-1, 45.1/106.7)	[Early — middle Frasnian (in *optivus-triangularis* (ca. ds 0.5) — in *ovalis-bulliferus* (ca. ds 4.7))]
Navifusa bacillum (Deunff 1955) Playford 1977 (AV 259-2, 31.5/109.3)	[late Pragian — Lower Carboniferous (Tournaisian)]
Navifusa bacillum crescentis Combaz, Lange & Pansart 1967 [but compare Playford 1977: 29 for discussion of *N. bacillum*] (AV 259-1, 34.8/91.5, 33.7/91.5, AV 259-2, 38.7/113.7)	[at least: Frasnian (of Lybia)]
Sphaerochitina cf. *S. sphaerocephala* (Eisenack) Eisenack 1955 in Martin 1982, page 12, pl. 3 (AV 259-2, 26.3/101.0)	[Silurian (Wenlockian) — Upper Devonian]
Unidentified chitinozoan (AV 259-2, 44.9/93.5)	

Remarks: within these slates from a location nearby (AV 301, see chapt. C 7 and app. F 4) also greywacke-pseudonodules have been found. Kegler 1967 (compare chapt. C 3.7, K 1) recovered from a calcareous nodule within these slates a conodont fauna (probably polygnathid-palmatolepid-biofacies (far-shore, basinal)), which allowed for a correlation with the middle Nehdenian (**Early *rhomboidea***-zone, DK1996: ds: 10.5 — 11.3); with two redeposited ghost-faunas from the A) lower Nehdenian, (**Late *triangularis*** — **Early *crepida*** -zone, DK1996: ds: 7.5 — 8.7) and B) upper Adorfian (toI γ/δ, **Early *rhenana*** — ***linguiformis*** zone, DK1996: ds: 4.2 — 6.1).
Presumable sedimentary environment: Open marine, basinal, but still near terrestrial areas (islands?), since land-derived spores are present in the palynofacies as well as acritarchs and chitinozoans. Deposition of clay from suspension punctuated by sudden incursions of silt, calcareous debris and, partly, greywacke by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay/silt/greywacke sediment pile along a slope. Transport of large volumes of these sediments onto the deeper sea-floor, final deposition when a reduction in slope caused deceleration. Most striking sedimentary features are: plastic deformation prior to tectonic deformation, ungraded and mostly disorganised fabric. Debris-flow sediments with greywacke-clasts which were not completely lithefied at the time of redeposition.

Sample: AV 262
Gauss-Kruger-coordinates: ^{34}31830 - ^{55}80245
Location: Outcrop below the ruin Aardeck (geological map 1:25000, 5614 Limburg).
Lithology: Limestone beds (grey, beds up to 0.2m) with grey-blackgrey slaty intercalations (see fig. D 2.4).
Stratigraphic correlation: Due to findings of Kegler (K 21, appendix F 1.7) middle to upper Givetian (in lower *varcus* — lower *hermanni-cristatus* -zone), DK1996: dm 13.5 — 18.3, but maybe reworked, hence ?early Frasnian.
Fossils: (conodonts, echinoderms, det. by Vogt)
Conodonta indet.
Echinoderm remnants (spines, etc.)
Remarks: All found conodonts indeterminable (mostly broken because of tectonically induced microfissures). Due to Keglers fossil-list maybe bellodellid-polygnathid biofacies (near-shore, fore-reef) sensu Oetken 1996: 125f.
Presumable sedimentary environment: Deposition at the slope of a submarine ridge (reef-complex on top of submarine volcanoes). Deposition of clay from suspension punctuated by (repeated, discyclic?) sudden incursions of calcareous debris from higher parts of the submarine ridge. Towards the top of the succession follow ?early Frasnian deposits of reworked pyroclastic deposits (see fig. D 2.4 for details).

Sample: AV 268
Gauss-Kruger-coordinates: ^{34}42380 - ^{55}90880
Location: South of former railway station Schupbach (geological map 1:25000, 5515 Weilburg).
Lithology: Black flinty slate (Kieselgallenschiefer, pseudonodules to layers) with intercalations of dark slate
Stratigraphic correlation: Upper Emsian (within *annulatus-sextantii* (?*douglastownense-eurypterota*) — within *douglastownense-eurypterota*-zone). DK1996: ca. di 16.0 (?19.0) — 19.7.
Fossils: (spores, acritarchs, det. by Vogt from the dark slate)

Acinosporites lindlarensis Riegel 1968 var. *lindlarensis* McGregor & Camfield 1976 (AV 268-1, 45.2/96.2 (60µm))	[Upper Emsian — middle Givetian (within *annulatus-sextantii*, ca. di 16.0 — within *lemurata-magnificus*, ca. dm 13.6)]
Dibolisporites echinaceus (Eisenack) Richardson 1965 (AV 268-1, 37.2/110.7 (60µm))	[Emsian (in *annulatus-sextantii*, ca. di 12.3) — Frasnian (in *ovalis-bulliferus*, ca. ds 4.3)]
?*Stenozonotriletes furtivus* Allen 1965 (AV 268-1, 47.5/102.3 (35µm))	[Pragian — Emsian (within *polygonalis-emsiensis*, ca. di 7.6 — within *douglastownense-eurypterota*, ca. di 19.7)]
Dibolisporites cf. *D. eifelensis* (Lanninger 1968) McGregor 1973 (AV 268-2, 25.3/106.2 (35µm))	[Siegenian — lower Eifelian (*polygonalis - emsiensis* (ca. di 6.7) — in *velatus - langii* (ca. dm 2.0))]
cf. *Acinosporites apiculatus* (Streel 1964) Streel 1967 (AV 268-1, 28.3/105.8 (80x60µm))	[Uppermost Emsian — Givetian (*douglastownense-eurypterota*, di 19.0 — near base *optivus-triangulatus*, ca. dm 17.7)]
Navifusa bacillum (Deunff 1955) Playford 1977 (AV 268-1, 29.8/102.9 (100x28µm), 30.0/96.7 (100x25µm, pyritised))	[late Pragian — Lower Carboniferous (Tournaisian)]

Remarks: The observed palynofacies is dominated by (poorly preserved) spores, which indcate a still near-terrestrial position; however, since acritarchs are present an open marine, but still shelf-influenced off-shore palaeoposition seems most probable.
Presumable sedimentary environment: Deposition of mud from suspension within a basin. High equatorial productivity in connection with reduced clastic influx from the Old Red continent (with reduced topography) allowed for a temporary sedimentation of siliceous oozes. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: AV 271
Gauss-Kruger-coordinates: ^{34}42395 - ^{55}90910
Location: South of former railway station Schupbach (geological map 1:25000, 5515 Weilburg).
Lithology: Calcareous nodule (brownish to darkgrey) in dark slate with finesand intercalations and -partly- horizons of cherty nodules.
Stratigraphic correlation: Early Eifelian (*velatus* - *langii* — near base *devonicus* - *naumovii*-zone). DK1996: ca. dm 1.1 — 4.6; with reworked middle Silurian (Wenlockian).
Fossils: (spores, acritarchs, chitinozoans, det. by Vogt)

Acinosporites acanthomammilatus Richardson 1965, specimen with relatively small, corroded, sculptural elements: chains of rounded verrucae on anastomosing ridges (AV 271-2, 31.9/106.8 (100 x 80µm)	[*velatus* - *langii* (ca. dm 1.1) — in *lemurata* - *magnificus* (ca. dm 14.5)]
Calyptosporites radiatus (ex Riegel 1975) Ashraf & Utescher 1991 (AV 271-2, 35.1/102.8 (65µm))	[*douglastownense* - *eurypterota* (ca. di 19.0) — near base *devonicus* - *naumovii* (ca. dm 4.6)]
Brochotriletes sp. (AV 271-2, 25.9/90.8 (105µm, partly transparent, disaggregated))	
Granulatisporites sp. in Windisch 1998, pl. 5, fig. 12 (AV 271-2, 26.4/111.4 (80 x 60µm))	[at least lower Eifelian]
cf. *Rhabdosporites langii* (Eisenack 1944) Richardson 1960 (AV 271-2, 28.1/97.4 (135 x 80µm)	[near base *velatus* - *langii* (ca. dm 1.4) — *ovalis* - *bulliferus* (ca. ds 6.0)]
Domasia quadrispinosa Hill 1974 (AV 271-2, 33.8/105.5 (85 µm))	[Silurian (upper Llandovery — in Wenlockian)]
Salopidium sp. cf. *Salopidium wenlockensis* (Downie 1959) Dorning 1981 (AV 271-2, 44.3/112.4 (vesicle 30 x 20µm, processes min. 7-10µm, partly disaggregated and transparent)	[Silurian (upper Llandovery — within upper Ludlowian)]
cf. *Leiofusa thomissa* Loeblich 1970 (AV 271-1, 37.9/99.0 (min.: 90 x 40µm))	[Silurian (in lower Llandovery — in lower Ludlowian)]
Sphaerochitina cf. *S. sphaerocephala* (Eisenack) Eisenack 1955 in Martin 1982, page 12, pl. 3 (AV 271-1, 38.5/93.2 (160µm long, aperture 25µm)	[Silurian (Wenlockian) — Upper Devonian]

Remarks: Poorly preserved flora.

Presumable sedimentary environment: Open marine, but not too far away from terrestrial areas, since spores are still observable in the palynofacies. Deposition of mud from suspension below or within wave base, punctuated by sudden (tempestitic) incursions of rapidly deposited finesilt and calcareous debris from submarine highs. Tectonic activity (rifting ?) lead to redeposition of Silurian (Wenlockian) sediments. Dominating bedding features are lenticular bedding and laminated finesilt or mud. Wave energy and mud supply control mud abundance.

Sample: AV 275
Gauss-Kruger-coordinates: ^{34}44660 - ^{55}93260
Location: Directly at the street, Kahlhau (geological map 1:25000, 5515 Weilburg).
Lithology: *Posidonia* - slate: dark, blackblue, bluegrey to grey slate, partly flaser bedding (= "untere Faunenbank" of DILLMANN, compare chapter C 3.3: D9).
Stratigraphic correlation: Late Viséan (TC (?NM)-zone — Namurian), LCC2003: ca. ci 16.6 (?16.9) — > 20.0; ?with reworked Tournaisian (ca. VI — PC), LCC2003: ca. ci 0.0 — 11.4.
Fossils: (spores, acritarchs, prasinophycean algae (cysts), det. by VOGT)

Schulzospora campyloptera (WALTZ) HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 275-1, 27.3/106.1 (min. 70x40µm, broken), 29.6/96.4 (60x40µm))	[TC — Westphalian A]
Schulzospora cf. *rara* KOSANKE 1950 (AV 275-1, 21.1/113.2 (55x38µm))	[TC — Upper Carboniferous]
cf. *Cyrtospora cristifera* (LUBER) VAN DER ZWAN 1979 (AV 275-1, 26.9/100.2 (40x25µm))	[Famennian (*torquata-gracilis*) — Tournaisian (PC)]
cf. *Murospora margodentata* BÉJU 1970 (AV 275-1, 31.7/112.8 (50µm))	[at least: NM]
cf. *Rotaspora ergonulii* (AGRALI) SULLIVAN & MARSHALL 1966 (AV 275-1, 28.9/114.1 (38x25µm))	[NM — Namurian]
Cheiledonites sp. (AV 275-1, 43.9/114.2 (85x35µm))	
Laevigatosporites sp. (AV 275-1, 29.6/109.6 (80x45µm), 14.8/98.5 (40x25µm))	
Diexallophasis absonda WICANDER 1974 (AV 275-2, 24.6/90.7 (40µm))	[Lower Carboniferous (Tournaisian)]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 275-2, 44.3/96.8 (90x25µm))	[late Pragian — Lower Carboniferous (Tournaisian)]
Lophosphaeridium sp. (AV 275-2, 29.5/99.0 (70x35µm))	
Navifusa sp. (AV 275-2, 36.2/105.3 (100x25µm))	
Veryhachium sp. (AV 275-1, 23.8/105.4 (40µm))	
Unidentified acritarchs (AV 275-2, 17.0/103.8 (35µm), 18.8/100.6 (45µm), 28.6/95.7 (min. 65µm), 46.4/94.9 (35µm), 34.6/92.0 (60x20µm))	
? Thorn in *knorria*-preservation (AV 275-1, 16.2/104.2)	

Remarks: revised stratigraphic correlation of DILLMANNS fossil-list (D9): Late Go IIIα — Early Go IIIβ, LCC2003: ci: 17.3 — 18.3. The palynofacies is dominated by acritarchs which indicates an open marine palaeoenvironment, but the occurrence of (often badly preserved) spores testify that terrestrial areas (?islands) were not too far away.
Presumable sedimentary environment: Deposition of mud from suspension within a basin (?at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited, partly fossil-bearing, silt-finesand. Appearance of flaser bedding indicates punctuate low-energy to medium-energy bottom currents, which probably often lead to erosion of just before accumulated sediment. Occurrence of plant remnants indicates a position near a subaerial environment (?island). Episodic submarine volcanic activity lead to deposition of tuff layers.

Sample: AV 278
Gauss-Kruger-coordinates: ^{34}42170 - ^{55}89670
Location: South of Christianshütte (compare B4, chapt. C 3.2; geological map 1:25000, 5515 Weilburg).
Lithology: Dark to grey slate with calcareous nodules /layers above Schalstein (reworked pyroclastics).
Stratigraphic correlation: Late Famennian (late Hembergian — Wocklumian, Early *postera* — ? *praesulcata*-zone). DK1996: ca. ds 15.2 — ? 20.0.
Fossils: (conodonts, ?fish-tooth, all in Franke-cell 278, det. by VOGT)

Palmatolepis gracilis gracilis BRANSON & MEHL 1934	[late Nehdenian — L. Carbonif. (Late *rhomboidea* (ds 11.3) — in *sulcata* (LCC2003: ca. ci 0.8))]
Polygnathus communis communis (juvenile) BRANSON & MEHL 1934	[late Hembergian — L. Carbonif. (Early *postera* (ds 15.2) — ? in *texanus* (LCC2003: ca. ci 14.1))]
Palmatolepis sp.	
? Tooth of a fish	

Remarks: conodonts small (mostly ?juvenile) and broken along tectonically induced microfissures.
Presumable sedimentary environment: Deposition of mud from suspension at the slope of a submarine ridge, punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous debris from higher parts of the submarine ridge. Short-term carbonate production probably on top of the submarine highs built-up during enhanced volcanic activity (ridges of pyroclastic deposits).

Sample: AV 280
Gauss-Kruger-coordinates: ^{34}42220 - ^{55}89870
Location: South of Christianshütte (geological map 1:25000, 5515 Weilburg).
Lithology: Dark to grey slate with calcareous nodules
Stratigraphic correlation: Late Famennian (Dasbergian (— ? early Wocklumian), in Early — (?in) Late *expansa*-zone). DK1996: ca. ds 16.8 — ca. ds 18.4.
Fossils: (conodonts, all in Franke-cell 280, det. by Vogt, with maintenance of Bender)

Bispathodus jugosus (Branson & Mehl 1934) (SEM-picture 17875; F 2.2, plate F 2-4, fig. 8)	[Dasbergian (in Early (DK 1996: ca. ds 16.8) — (?in) Late *expansa* (ca. ds 18.4))]
Mehlina strigosa (Branson & Mehl 1934) (SEM-picture 17868; F 2.2, plate F 2-4, fig. 4)	[Late Nehdenian — Wocklumian (Early *marginifera* (DK 1996: ds 11.9) — ? in Middle *praesulcata* (ca. ds 19.2))]
Palmatolepis gracilis gracilis Branson & Mehl 1934 (SEM-picture 17888 (fig. 9), SEM-picture 17873 (fig. 10); F 2.2, plate F 2-4, fig. 9-10)	[Late Nehdenian — early Tournaisian (Late *rhomboidea* (DK 1996: ds 11.3) — in *sulcata* (LCC2003: ca. ci 0.8))]
Palmatolepis gracilis sigmoidalis Ziegler 1962 (SEM-picture 17862; F 2.2, plate F 2-4, fig. 11)	[Late Hembergian — Wocklumian (Late *trachytera* DK 1996: ds 14.6) — Late *praesulcata* (ds 20.0))]
Polygnathus communis communis Branson & Mehl 1934 (SEM-picture 17883 (fig. 5), SEM-picture 17864 (fig. 6), SEM-picture 17874 (fig. 7); F 2.2, plate F 2-4, fig. 5-7)	[Late Hembergian — Lower Carboniferous (Early *postera* (DK1996: ds 15.2) — ? in *texanus* (LCC2003: ca. ci 14.1))

Remarks: conodonts small (mostly ?juvenile) and broken along tectonically induced microfissures.
Presumable sedimentary environment: Deposition of mud from suspension at the slope of a submarine ridge, punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous debris from higher parts of the submarine ridge. Short-term carbonate production probably on top of the submarine highs built-up during enhanced volcanic activity (ridges of pyroclastic deposits).

Sample: AV 282
Gauss-Kruger-coordinates: ^{34}42320 - ^{55}89900
Location: Southeast of Christianshütte (geological map 1:25000, 5515 Weilburg).
Lithology: Dark slate with finesand-intercalations and indet. brachiopod- and ?coral- remnants.
Stratigraphic correlation: Early Famennian (within *torquata-gracilis*-zone); DK1996: ca. ds 6.0 — 10.6; with reworked A) late Frasnian (in *ovalis-bulliferus*-zone, ca. ds 4.2 — 4.7), B) Givetian (ca. dm 8.2 — 20.0), C) ? upper Silurian (Ludlowian) — Emsian.
Fossils: (spores, acritarchs, prasinophycean algae (cysts), chitinozoans, scolecodonts, det. by Vogt)

cf. *Lophozonotriletes media* Taugourdeau-Lantz 1967 (AV 282-2, 37.5/95.0, 23.7/102.7)	[Early — middle Frasnian (in *optivus-triangularis* (ca. ds 0.5) — in *ovalis-bulliferus* (ca. ds 4.7))]
cf. *Verrucosisporites bulliferus* (Taugourdeau-Lantz 1967) Richardson & McGregor 1986 (AV 282-2, 36.6/108.2)	[Frasnian (*ovalis-bulliferus* (ds 1.7)) — late Famennian (in *flexuosa-cornuta* (ca. ds 16.5))]
Exochoderm triangulata Wicander & Wood 1981 (AV 282-2, 23.1/110.2)	[Givetian]
Navifusa bacillum (Deunff 1955) Playford 1977 (AV 282-2, 33.7/98.3)	[late Pragian — Lower Carboniferous (Tournaisian)]
Onondagaella asymmetrica (Deunff 1954) Cramer 1966 (AV 282-2, 25.8/104.4)	[? Upper Silurian (Ludlowian) — Lower Devonian]
Polyedrixium pharaonis Deunff 1961 (AV 282-1, 26.5/97.4)	[Devonian]
Pterospermella cf. *P. radiata* Wicander 1974 (AV 282-2, 33.7/110.6)	[Famennian]
Veryhachium reductum Deunff 1958 (AV 282-2, 25.6/105.4, 22.9/105.3)	[Silurian — ?Emsian]
Winwaleusia ranulaeforma Martin 1984 (AV 282-2, 26.6/113.0)	[Late Frasnian (? *Pa. gigas*-zone, ca. ds 4.2) — early Famennian (? *Pa. crepida*-zone, ca. ds 10.6)]
cf. *Visbysphaera* n. sp. A Martin 1982 (AV 282-2, 24.7/90.7)	[Late Frasnian (ca. *Pa. gigas*-zone, ca. ds 4.2 — 6.0)]
Leiofusa sp. (AV 282-2, 49.4/98.5)	
Ancyrochitina cf. *A. aequoris* Urban & Kline 1970 (AV 282-2, 47.4/95.5)	[upper Middle Devonian (probably Givetian)]
Cyathochitina ? *infundibuliformis* Taugourdeau & Jekhowsky 1960 in Martin 1982 (AV 258-1, 41.1/105.5)	[Devonian]
Desmochitina sp. (AV 282-2, 33.0/108.2, broken piece)	

Unidentified chitinozoan (AV 282-2, 31.3/93.5)
Unidentified scolecodont (AV 282-1, 40.3/99.3)
Remarks: Acritarchs dominate the Famennian palynofacies (= open marine palaeoenvironment).
Presumable sedimentary environment: Open marine, basinal, but still near terrestrial areas (islands?), since land-derived spores are present in the palynofacies as well as acritarchs and chitinozoans. Deposition of clay from suspension punctuated by sudden incursions of silt-finesand by currents (probably turbidity currents) of waning strength. Probably also debris-flow-sediment, since the same spectrum of reworked fossils is present as from the locations near Eschenau or Limburg. Elevation of the depositional environment lead to low-medium velocity gliding of the clay/silt/finesand sediment pile along a slope. Transport of large volumes of these sediments onto the deeper sea-floor, final deposition when a reduction in slope caused deceleration.

Sample: AV 283
Gauss-Kruger-coordinates: ^{34}42340 - ^{55}89940
Location: Southeast of Christianshütte (geological map 1:25000, 5515 Weilburg).
Lithology: Dark slate with greywacke-intercalations and indet. brachiopod- and ?coral- remnants.
Stratigraphic correlation: Early Famennian (*torquata-gracilis* — within *flexuosa-cornuta*-zone); DK1996: ca. ds 6.0 (? 7.1) — 15.6; with reworked A) Frasnian (*ovalis-bulliferus*-zone, ca. ds 1.7 — 6.0), B) Givetian (ca. dm 11.7 — 17.7), C) Upper Emsian/early Eifelian (ca. di 17.7 — dm 7.7) and D) upper Silurian (Ludlowian).
Fossils: (spores, acritarchs, prasinophycean algae (cysts), chitinozoans, scolecodonts, det. by Vogt)

Aneurospora greggsi (McGregor) Streel 1974 (AV 283-3, 42.5/94.2)	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Apiculiretusispora gaspiensis McGregor 1973 (AV 283-3, 44.5/99.5)	[Upper Emsian — Eifelian (near top *annulatus - sextantii* (ca. di 17.7) — in *devonicus - naumovii* (ca. dm 7.7)]
Archaeoperisaccus ovalis Naumova 1953 (AV 283-3, 42.3/96.1, partly transparent)	[Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0)]
Contagisporites optivus (Chibrikova) Owens 1971 var. *optivus* (AV 283-2, 27.1/110.3)	[Late Givetian — earliest Famennian (in *optivus-triangulatus* (ca. dm 17.8) — near base *torquata-gracilis* (ca. ds 6.9))]
Cyrtospora cristifera (Luber) van der Zwan 1979 (AV 283-1, 27.0/94.9, 37.4/105.0)	[Famennian (*torquata-gracilis*) — Tournaisian (PC)]
Dibolisporites echinaceus (Eisenack) Richardson 1965 (AV 283-1, 42.0/95.7, partly transparent)	[Emsian (in *annulatus-sextantii*, ca. di 12.3) — Frasnian (in *ovalis-bulliferus*, ca. ds 4.3)]
Geminospora micromanifesta (Naumova 1953) Arkhangelskaya (AV 283-1, 37.5/105.0)	[Givetian — early Frasnian (EX — SD-zones of the Eastern European spore zonation, approx. equivalent to DK1996: ca. dm 11.7 — ca. ds 2.7)]
Geminospora notata (Naumova 1953) Obukhovskaya (AV 283-2, 52.3/96.3)	[Middle Givetian — early Famennian (EX — CZ - zones of the Eastern European spore-zonation; approximately equivalent to *lemurata-magnificus* (dm 11.7) — *Pa. crepida*-zone (ca. ds 10.6)]
Geminospora tuberculata (Kedo) Allen 1965 (AV 283-2, 34.5/103.4)	[Givetian (EX-zone of the Eastern European spore zonation, ca. dm 11.7 — dm 17.7)]
Verrucosisporites bulliferus (Taugourdeau-Lantz 1967) Richardson & McGregor 1986 (AV 283-2, 45.4/95.5, AV 283-3, 27.2/104.0 (partly transparent), 41.9/96.8, ?48.3/99.9, AV 283-1, ? 49.6/101.5)	[Frasnian (*ovalis-bulliferus* (ds 1.7)) — late Famennian (in *flexuosa-cornuta* (ca. ds 16.5))]
Archaeoperisaccus cf. *A. concinnus* Naumova 1953 (AV 283-1, 26.8/114.2)	[Frasnian (OG-zone of the eastern European spore zonation, approx. equivalent to the *ovalis-bulliferus*-zone (ca. ds 1.7 — 6.0))]
Archaeoperisaccus cf. *A. echinatus* Raskatova (AV 283-1, 29.1/114.5, partly transparent)	[Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0)]
cf. *Hymenozonotriletes celeber* Chibrikova (AV 283-1, 54.5/91.9)	[Middle Givetian (*lemurata-magnificus*, dm 11.7) — middle Frasnian (in *ovalis-bulliferus*, ca. ds 4.2]
cf. *Lophozonotriletes lebedianensis* Naumova 1953 (AV 283-1, 51.9/111.0)	[Famennian (near base *torquata-gracilis*, ca. ds 7.1 — *lepidophyta-nitidus*, ca. ds 20.0)]
Hystricosporites sp. (AV 283-1, 38.1/113.0)	
Verrucosisporites sp. (AV 283-3, 36.1/91.9)	
Cymatiosphaera multisepta Deunff 1955 (AV 283-3, 45.5/105.2, partly transparent)	[Emsian — Givetian]
Exochoderm triangulata Wicander & Wood 1981 (AV 283-2, 37.1/101.0)	[Givetian]
Leiofusa estrecha Cramer 1964 (AV 283-2, 51.2/103.3)	[Silurian]
Leiofusa exilata Dorning 1981 (AV 283-2, 42.9/102.5)	[Upper Silurian (lower Ludlowian)]

Leiofusa pumilia DEUNFF 1966 (AV 283-1, 35.2/101.6, AV 283-2, 28.3/94.6)	["Upper Devonian of Tunisia"]
Micrhystridium coronatum STOCKMANS & WILLÉRE 1963 (AV 283-3, 42.4/96.1, ? 29.0/93.7)	[Frasnian — early Famennian (ca. ds 15.6)]
Onondagaella asymmetrica (DEUNFF 1954) CRAMER 1966 (AV 283-2, 40.8/113.7)	[? Upper Silurian (Ludlowian) — Lower Devonian]
cf. *Stellinium micropolygonale* (STOCKMANS & WILLIÉRE) PLAYFORD 1977 (AV 283-1, 36.9/108.3)	[Upper Emsian — Tournaisian]
Dictyotidium sp. (AV 283-1, 43.0/105.5)	
Leiofusa sp. (AV 283-2, 46.1/107.8, AV 283-1, [46.0/91.8, 38.1/92.6, 35.8/93.8])	
Lophosphaeridium sp. (AV 283-2, 29.2/100.1)	
Pterospermella sp. (AV 283-2, 52.1/98.3)	
Winwaleusia sp. (AV 283-1, 47.5/94.2)	
Unidentified acritarchs (AV 283-3, 35.5/112.8, 48.2/97.0, 41.1/92.3, [44.1/105.5, 21.5/99.0], 22.9/103.7, 26.2/101.8)	
Cyathochitina ? *infundibuliformis* TAUGOURDEAU & JEKHOWSKY 1960 in MARTIN 1982 (AV 283-2, 34.0/106.8)	[Devonian]
Unidentified chitinozoans (AV 283-2, 36.8/103.3, AV 283-1, 24.0/96.2)	
Unidentified scolecodont (AV 283-2, 33.1/91.7)	
Unidentified spiral-wound object (AV 283-1, 38.7/108.0; compare AV 297-1, 25.0/99.6)	

Remarks: Spores and acritarchs together dominate the early Famennian palynofacies (= open marine, but not too far from terrestrial areas (?islands)). The Emsian to Frasnian palynofacies is dominated by spores (= near terrestrial areas (?islands)); however, the sporadic occurrence of acritarchs and even chitinozoans generally indicate an open marine environment through all these times.
Presumable sedimentary environment: Open marine, basinal, but still near terrestrial areas (islands?), since land-derived spores are present in the palynofacies as well as acritarchs and chitinozoans. Deposition of clay from suspension punctuated by sudden incursions of silt, calcareous debris and, partly, greywacke by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay/silt/greywacke sediment pile along a slope. Transport of large volumes of these sediments onto the deeper sea-floor, final deposition when a reduction in slope caused deceleration. Debris-flow sediments.

Sample: AV 290
Gauss-Kruger-coordinates: ^{34}40890 - ^{55}88770
Location: Abandoned quarry south of Eschenau (geological map 1:25000, 5515 Weilburg).
Lithology: Flinty slate, bedded, reddish and grey to black, sample taken from lightgrey bed (see also chapter C 8, analysis of cyclic sequences).
Stratigraphic correlation: Lower Carboniferous (probably "Light flinty-slate formation", Viséan). LCC2003: ca. ci 13.0 — ca. ci 16.9.
Fossils: (conodonts, echinoderms, sponges, radiolarians, all in Franke-cell 290, det. by VOGT)

Gnathodus sp.	[? *isosticha*/ upper *crenulata* (ca. ci 8.3) — early Namurian B ?]

Radiolarians, indet.
Echinoderm-remnants (spines)
Sponge-remnants (masses of spicules)
Remarks: all conodonts broken along tectonically induced microfissures. All radiolarians unidentifiable due to enhanced recrystallisation during diagenesis and metamorphism. Due to the classification of GURSKY (1997: 52) "spiculitic flinty-slate", since the sample contains > 1% spicules of sponges. "Such stones have almost entirely been observed in the niveau of the Light Flinty-Slates and Flinty Limestones ..." GURSKY (1997: 52, in german). This would correlate to an age-range from LCC2003: ca. ci 13.0 to ca. ci 16.9.
Presumable sedimentary environment: Deposition of mud from suspension within a basin. High equatorial radiolarian-productivity in connection with reduced clastic influx from an increasingly arid southern Laurussian continent (with reduced topography) allowed for a sedimentation of radiolarian-rich siliceous oozes. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: AV 292
Gauss-Kruger-coordinates: ^{34}40680 - ^{55}87985
Location: North of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: Thin layer of dark slate in bedded black flinty slates.
Stratigraphic correlation: Lower Carboniferous (?LN — ?PU-zone); since AV 292 was taken from the same lithological unit (see fig. F 2.1) as AV 1 it is assumed to have the same stratigraphic range: Upper Tournaisian (ca. *Albaillella deflandrei — A. indensis* - zone). LCC2003: ci: (8.7 — 14.4).
Fossils: (spores, acritarchs, prasinophycean algae (cysts), det. by VOGT)
cf. *Verrucosisporites nitidus* (NAUMOVA 1953) PLAYFORD 1964 (AV 292-2, 18.6/110.0) [LN — PU]
Estiastra sp. (AV 292-1, 36.5/95.2)
Navifusa sp. (AV 292-1, 35.4/105.3)
Tasmanites sp. (AV 292-2, 44.6/110.0)
Veryhachium sp. (AV 292-1, 22.3/108.1, AV 292-2, 42.3/101.2)
Unidentified acritarchs (AV 292-1, ?39.0/112.0, 46.5/112.3, 26.7/111.1 (characteristic shape), 23.8/107.8, 37.7/105.3, AV 292-2, 30.3/109.9, 21.2/96.4, ?22.7/96.7)
Remarks: The observed palynofacies is dominated by (poorly preserved) acritarchs, which are characteristic for an open marine, but still shelf-influenced off-shore palaeoposition.
Presumable sedimentary environment: Deposition of mud from suspension within a basin. High equatorial radiolarian-productivity in connection with reduced clastic influx from an increasingly arid southern Laurussian continent (with reduced topography) allowed for a sedimentation of radiolarian-rich siliceous oozes. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.

Sample: AV 293
Gauss-Kruger-coordinates: ^{34}40675 - ^{55}87990
Location: North of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg).
Lithology: Greengrey slate, laminated, with silt- finesand intercalations and conodonts on bedding planes.
Stratigraphic correlation: Early Famennian (early Nehdenian, in Late *triangularis* — ? Late *triangularis* (Latest *crepida*)-zone). DK1996: ca. ds 7.8 — ? 8.1 (10.6).
Fossils: (conodonts on bedding planes, det. by VOGT, partly with maintenance of ZIEGLER)
Palmatolepis crepida crepida SANNEMANN 1955 [(in Late *triangularis) Early* — Latest *crepida*]
cf. *Palmatolepis marginata clarki* ZIEGLER 1962 [in Middle — Late *triangularis*]
cf. *Palmatolepis triangularis* SANNEMANN 1955 [Early *triangularis* — Early *crepida*]
Polygnathus sp.
Conodonta, indet.
Remarks: only moulds of conodonts preserved.
Presumable sedimentary environment: Deposition of mud from suspension under reducing conditions within a basin (? at the basal parts of the slope of a submarine ridge), punctuated by sudden (turbiditic) incursions of rapidly deposited silt to finesand.

Sample: AV 295
Gauss-Kruger-coordinates: ^{34}40560 - ^{55}87710
Location: Southwest of Oberhofer Mühle near Hofen (geological map 1:25000, 5515 Weilburg, see fig. F 2.3).
Lithology: Dark slate with calcareous layer (0.6 x 4.0m).
Stratigraphic correlation: Middle — Upper Devonian. DK1996: dm 0.0 — ds 20.0.
Fossils: (spores, acritarchs, prasinophycean algae (cysts), det. by VOGT)
Retusotriletes sp. (AV 295-2, 25.5/103.3 (90µm, pyritised))
cf. *Quisquilites buckhornensis* WILSON & URBAN 1963 (AV 295-2, 31.6/95.2 (90x40µm)) [Upper Devonian]
Eisenackidium sp. (AV 295-2, 34.0/100.8 (80µm tip-to-tip)) [Devonian]
Leiofusa sp. (AV295-3, 50.8/101.5 (60µm))
Tasmanites sp. (AV 295-1, 30.0/114.5 (140µm))
Remarks: Very bad preserved flora, probably altered by ascending hydrothermal fluids. Many large (>100µm) indet. spores are constituent of the palynofacies; this would indicate - at least - a Middle Devonian age. No conodonts have been found in the sample from the calcareous layer after treatment with formic acid. A few metres away, in direction of the tectonic strike, a sandstone-pseudonodule (AV 266, Lower Devonian sandstone) was found within these slates. It seems probable that at this location also the early Famennian debris flow sediments occur. But since the obtained evidence is not sufficient, no formal designation was undertaken.

Presumable sedimentary environment: Deposition of mud from suspension at the slope of a submarine ridge, punctuated by sudden (turbiditic) incursions of rapidly deposited calcareous debris from higher parts of the submarine ridge.

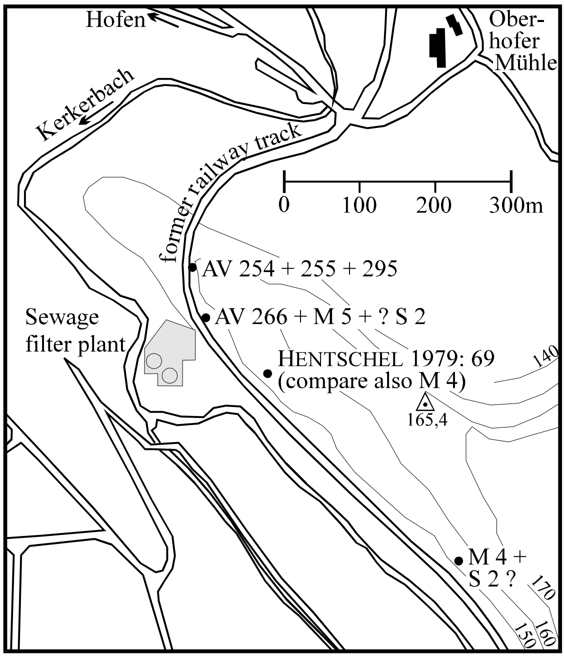


Fig. F 2.3: Sample locations along the former railway track of the Kerkerbach railway south of Hofen and the Oberhofer Mühle.

Sample: AV 297
Gauss-Kruger-coordinates: ^{34}34150 - ^{55}83580
Location: Directly behind the Kreuzweg- (pilgrims path-) signpost XIV near the Kreuz-Chapel, Greifenberg near Limburg (geological map 1:25000, 5614 Limburg).
Lithology: Dark slate, platy.
Stratigraphic correlation: Early Famennian (within *torquata*-*gracilis*-zone); DK1996: ca. ds 6.1 — 10.6; with reworked A) Frasnian (*ovalis-bulliferus*-zone, ca. ds 4.2 — 5.1), B) Givetian (ca. dm 11.7 — 17.4), C) Upper Emsian (ca. di 11.2 — di 19.7) and D) Silurian (upper Llandoverian — Wenlockian).
Fossils: (spores, acritarchs, prasinophycean algae (cysts), chitinozoans, det. by VOGT)

Archaeozonotriletes variabilis NAUMOVA 1953 (AV 297-2, 36.0/103.4 (35µm), 36.0/94.8)	[Givetian (within *devonicus-naumovii*, ca. dm 8.9) — Famennian (*lepidophyta-nitidus*, ca. ds 20.0)]
Bulbosporites bulbosus (OBUKHOVSKAYA) OBUKHOVSKAYA (AV 297-2, 50.0/111.4 (min. 50µm, broken))	[Frasnian (MR — AS-zone of the Eastern European spore zonation; ca. equivalent lower to upper *gigas*-zone, ca. ds 4.2 — 5.5)]
Camarozonotriletes obtusus NAUMOVA 1953 (AV 297-2, 34.8/101.2)	[at least: Frasnian (SD-zone of the Eastern European spore zonation; ca. equivalent upper *asymmetricus*-zone, ca. ds 2.4 — 3.0)]
Geminospora aurita ARKHANGELSKAYA 1972 (AV 297-2, 38.0/103.6 (broken))	[Frasnian (SD — MR-zone of the Eastern European spore zonation; ca. equivalent upper *asymmetricus* to lower *gigas*-zone, ca. ds 2.4 — 5.1)]
Geminospora vasjamica (TCHIBRIKOVA) OBUKHOVSKAYA & NEKRIATA 1983 (AV 297-1, 49.9/98.2 (45µm))	[Early Famennian (VV — CZ - zone of the Eastern European spore-zonation; approximately equivalent to *Palmatolepis triangularis* (ds 6.1) — *Pa. crepida*-zone (ds 10.6)]
Archaeoperisaccus cf. *A. concinnus* NAUMOVA 1953 (AV 297-1, 50.0/94.1 (100x55µm)	[Frasnian (OG-zone of the eastern European spore zonation, approx. equivalent to the *ovalis-bulliferus*-zone (ca. ds 1.7 — 6.0))]
Brochotriletes cf. *B. foveolatus?* (NAUMOVA 1953) MCGREGOR 1973 (AV 297-1, 46.2/102.3 (45µm))	[Pragian (in *polygonalis-emsiensis*, ca. di 8.2) — Emsian (in *douglastownense-eurypterota*, ca. di 19.7)]

Emphanisporites cf. *annulatus* McGregor 1961 (AV 297-1, 19.8/113.4 (35µm))	[Emsian — Givetian (*annulatus* - *sextantii* (di 11.2) — near base *optivus* - *triangulatus* (dm 17.4))]
Lophozonotriletes cf. *L. torosus* Naumova 1953 (AV 297-1, 45.0/93.2 (50x40µm))	[at least: Frasnian (OG-zone of the eastern European spore zonation, approx. equivalent to the *ovalis-bulliferus*-zone (ca. ds 1.7 — 6.0))]
Verrucosisporites cf. *V. bulliferus* (Taugourdeau-Lantz 1967) Richardson & McGregor 1986 (AV 297-2, 50.8/109.4 (55µm), 35.0/99.0 (40µm))	[Frasnian (*ovalis-bulliferus* (ds 1.7)) — late Famennian (in *flexuosa-cornuta* (ca. ds 16.5))]
cf. *Aneurospora greggsi* (McGregor) Streel 1974 (AV 297-1, 26.1/94.6 (80µm))	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
cf. *Dibolisporites turriculatus* Balme 1988 (AV 297-2, 40.4/92.8 (85µm))	[Late Givetian — Frasnian (*optivus* - *triangulatus*, ca. dm 17.2 — *ovalis-bulliferus*-zone, ca. ds 6.0)]
cf. *Geminospora notata* (Naumova 1953) Obukhovskaya (AV 297-1, 28.0/95.3 (40µm))	[Middle Givetian — early Famennian (EX — CZ - zones of the Eastern European spore-zonation; approximately equivalent to *lemurata-magnificus* (dm 11.7) — *Pa. crepida*-zone (ca. ds 10.6)]
cf. *Geminospora venusta?* (Naumova 1953) McGregor & Camfield 1982 (AV 297-2, 40.2/94.9 (90x65µm))	[at least: middle Givetian]
Archaeoperisaccus sp. (AV 297-1, 45.4/113.7 (60x40µm))	[Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0)]
Camarozonotriletes sp. (AV 297-2, 22.6/94.8 (28µm))	
Geminospora sp. (AV 297-1, 27.8/111.3 (60µm))	
Retusotriletes sp. (AV 297-2, 31.9/97.1 (35µm))	
Comasphaeridium muscosum Wicander & Playford 1985 (AV 297-1, 27.2/107.2 (45µm))	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
Gorgonisphaeridium echinodermum (Stockmans & Williére 1963) Eisenack, Cramer & Diez 1979 (AV 297-1, 32.9/106.9 (35µm))	[Silurian (— ? Lower Devonian)]
Gorgonisphaeridium telum Wicander & Playford 1985 (AV 297-1, 44.7/112.9 (25µm))	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
Lophosphaeridium galeatum (Hill 1974) Le Herisse 1989 (AV 297-1, 24.7/111.5 (25µm))	[Silurian (upper Llandoverian — Wenlockian)]
Cymatiosphaera cf. *C. ambotrocha* Wicander & Loeblich 1977 (AV 297-1, 33.8/96.6 (55µm))	[Upper Frasnian — Lower Famennian]
cf. *Cymatiosphaera octoplana* Downie 1959 (AV 297-1, 23.9/91.8 (45µm))	[Silurian (upper Llandoverian — lower Ludlowian)]
cf. *Polyedrixium pharaonis* Deunff 1961 (AV 297-2, 43.8/105.0 (30µm))	[Devonian]
Veryhachium sp. (AV 297-1, 27.0/113.7 (35µm), 44.4/104.5 (25µm))	
Unidentified chitinozoan (AV 297-1, 46.4/98.2 (min. 85µm, broken))	
Unidentified spiral-wound object (AV 297-1, 25.0/99.6 (55x20µm preserved); compare AV 283-1, 38.7/108.0)	

Remarks: Spores and acritarchs together dominate the early Famennian and Frasnian palynofacies (= open marine, but not too far from terrestrial areas (?islands)). The Emsian to Givetian palynofacies is dominated by spores (= near terrestrial areas (?islands)); however, the sporadic occurrence of acritarchs and even chitinozoans generally indicate an open marine environment through all these times.

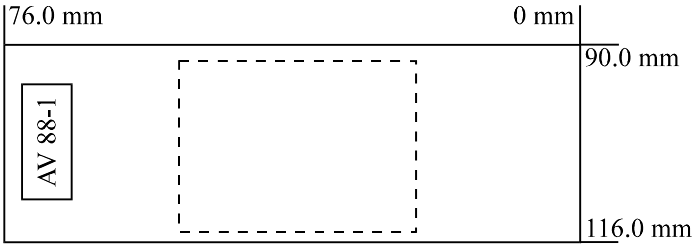
Presumable sedimentary environment: Open marine, basinal, but still near terrestrial areas (islands?), since land-derived spores are present in the palynofacies as well as acritarchs. Deposition of clay from suspension punctuated by sudden incursions of silt by currents (probably turbidity currents) of waning strength. Probably finegrained debris-flow sediments (compare locations with similar lithology near Limburg (e. g. AV 73-88), Eschenau (AV 258), Aardecker Mühle (AV 259) and south of Christianshütte (AV 282-283).

F 2.2 Plates 1-10 with fossils and palynological objects

All magnifications x 1000, unless otherwise stated.

Information is given in the following order:

- species name;
- sample no. (AV-label on the slide, for coordinate-reference always on the "left" side);
- fossil / object coordinates on the slide:



- locality or name of the drilling from which the sample was recovered;
- known stratigraphic range for the illustrated fossil;
- lithology from which the sample was recovered;
- used photographic method: T = transmitted light photomicrograph, R = reflected light photomicrograph, T/R = combined transmitted/reflected light photomicrograph).

The preservation of most recovered fossils is generally medium to low (compare chapter C 4). Determinations have been undertaken during microscopy, not from photomicrographs. It is estimated that up to 50% of the additional information gainable during T/R - microscopy is lost on a photograph. In order to overcome this insufficiency for all fossils mentioned coordinates on the actual slides are given.

List of *illustrated* fossils / objects:

Spores:

Acanthotriletes bucerus CHIBRIKOVA, pl. F 2-6, fig. 3
Acinosporites lindlarensis RIEGEL 1968 var. *minor*, pl. F 2-3, fig. 3
Ancyrospora melvillensis OWENS 1971, pl. F 2-6, fig. 8
Ancyrospora sp., pl. F 2-6, fig. 11
Aneurospora greggsi (MCGREGOR) STREEL 1974, pl. F 2-6, fig. 7, 9
Apiculiretusispora plicata (ALLEN 1965) STREEL 1967, pl. F 2-7, fig. 2
Auroraspora macra SULLIVAN 1968, pl. F 2-5, fig. 3
Camarozonotriletes sp., pl. F 2-1, fig. 4
Camptozonotriletes caperatus MCGREGOR 1973, pl. F 2-1, fig. 3
Chelinospora ? vermiculata (CHALONER & STREEL 1968) MCGREGOR & CAMFIELD 1976, pl. F 2-2, fig. 5
Chelinospora favosa STEEMANS 1989 [= *Dictyotriletes favosus* MCGREGOR & CAMFIELD 1976], pl. F 2-1, fig. 1
Contagisporites optivus (CHIBRIKOVA) OWENS 1971 var. *optivus*, pl. F 2-7, fig. 10
Convolutispora caperata WICANDER & PLAYFORD 1985, pl. F 2-7, fig. 4
Convolutispora cf. *crassitunicata* (OBUKHOVSKAYA) OBUKHOVSKAYA, pl. F 2-7, fig. 7
Convolutispora clivosa KAISER 1971, pl. F 2-1, fig. 10
Convolutispora sp., pl. F 2-3, fig. 1; pl. F 2-10, fig. 9
Cymbosporites paulus MCGREGOR & CAMFIELD 1976, pl. F 2-1, fig. 8
Densosporites brevispinosus HOFFMEISTER, STAPLIN & MALLOY 1955, pl. F 2-10, fig. 7

Densosporites inaequus (MCGREGOR) MCGREGOR & CAMFIELD 1982, pl. F 2-6, fig. 1
Densosporites sp., pl. F 2-7, fig. 3
Densosporites spinifer HOFFMEISTER, STAPLIN & MALLOY 1955, pl. F 2-10, fig. 10
Densosporites subcrenatus (WALTZ in LUBER & WALTZ 1938) POTONIÉ & KREMP 1955, pl. F 2-10, fig. 2
Dibolisporites abitibiensis MCGREGOR & CAMFIELD 1976, pl. F 2-1, fig. 7
Dictyotriletes cf. *D. emsiensis* (ALLEN 1965) MCGREGOR 1973 in PLAYFORD 1976, pl. F 2-7, fig. 9
Dictyotriletes cf. *D. emsiensis* (ALLEN 1965, MCGREGOR 1973) MCGREGOR & CAMFIELD 1976, pl. F 2-1, fig. 6
Dictyotriletes favosus: see *Chelinospora favosa*
Dictyotriletes subgranifer MCGREGOR 1973, pl. F 2-1, fig. 9
Diducites poljessicus (KEDO) VAN VEEN 1981, pl. F 2-5, fig. 2
Geminospora cf. *extensa* (NAUMOVA 1953) GAO, pl. F 2-6, fig. 5
Geminospora notata (NAUMOVA 1953) OBUKHOVSKAYA var. *microspinosus* TCHIBRIKOVA, pl. F 2-5, fig. 5
Geminospora tuberculata (KEDO 1955) ALLEN 1965, maybe var. *micrornata* MCGREGOR & CAMFIELD 1982, pl. F 2-6, fig. 6
Geminospora cf. *G. vasjamica* (CHIBRIKOVA) OBUKHOVSKAYA & NEKRIATA, pl. F 2-5, fig. 8
Kedoesporis evlanensis (NAUMOVA 1953) OBUKHOVSKAYA, pl. F 2-5, fig. 4
Knoxisporites cinctus (WALTZ in LUBER 1938) BUTTERWORTH & WILLIAMS 1958 in SMITH & BUTTERWORTH 1967: 219, pl. F 2-9, fig. 2
Knoxisporites stephanephorus LOVE 1960, pl. F 2-10, fig. 6
Knoxisporites triradiatus HOFFMEISTER, STAPLIN & MALLOY 1955, pl. F 2-10, fig. 3
cf. *Lophozonotriletes magnus* KEDO 1974, pl. F 2-5, fig. 13
Monoletes indet., pl. F 2-10, fig. 1, 8
Radiizonates mirabilis PHILLIPS & CLAYTON 1980, pl. F 2-10, fig. 5
cf. *Retusotriletes clandestinus* CHIBRIKOVA, pl. F 2-3, fig. 2
Retusotriletes maculatus MCGREGOR & CAMFIELD 1976, pl. F 2-2, fig. 1, 4
Retusotriletes sp., pl. F 2-1, fig. 2
Spelaeotriletes sp., pl. F 2-9, fig. 1; pl. F 2-10, fig. 4, 12
Tholisporites chulus (CRAMER) MCGREGOR 1973 var. *nanus* [= *Archaeozonotriletes chulus* var. *nanus* RICHARDSON & LISTER 1969] , pl. F 2-2, fig. 6
Verrucosisporites evlanensis (NAUMOVA) OBUKHOVSKAYA, pl. F 2-5, fig. 12
Verrucosisporites premnus RICHARDSON 1965, pl. F 2-6, fig. 10

Chitinozoans:

Angochitina ? *thadeui* PARIS 1981, pl. F 2-2, fig. 7
Desmochitina EISENACK 1931 sp., pl. F 2-6, fig. 4
cf. *Margachitina* EISENACK 1968 sp., pl. F 2-7, fig. 5

Acritarchs and prasinophycean algae:

Acritarcha indet., pl. F 2-2, fig. 9
Ammonidium ? *alloiteaui* (DEUNFF 1955) MARTIN 1981, pl. F 2-4, fig. 10
Ammonidium cf. *A. waldronensis* (TAPPAN & LOEBLICH 1971) DORNING 1981, pl. F 2-7, fig. 6
Ammonidium cf. *hamatum* WICANDER 1974, pl. F 2-4, fig. 1, 2
Ammonidium sp., pl. F 2-5, fig. 6
Comasphaeridium caesariatum WICANDER 1974, pl. F 2-4, fig. 7
Cymatiosphaera labyrinthica WICANDER 1974, pl. F 2-4, fig. 8
Cymatiosphaera limbatisphaera WICANDER & LOEBLICH 1977, pl. F 2-4, fig. 16
Cymatiosphaera nebulosa (DEUNFF 1954) DEFLANDRE 1954, pl. F 2-5, fig. 10
Dictyotidium cavernosulum PLAYFORD 1977, pl. F 2-1, fig. 12
cf. *Dictyotidium cavernosulum* PLAYFORD 1977, pl. F 2-6, fig. 2
Diexallophasis absonda WICANDER 1974, pl. F 2-8, fig. 4
cf. *Duvernaysphaera krauseli* (STOCKMANS & WILLIERE) STOCKMANS & WILLIERE 1962, pl. C5-4, fig. 17
Estiastra sp., pl. F 2-7, fig. 1
Gorgonisphaeridium cf. *G. absitum* WICANDER 1974, pl. F 2-4, fig. 11, 12
Gorgonisphaeridium evexispinosum WICANDER 1974, pl. F 2-4, fig. 4
Gorgonisphaeridium plerispinosum WICANDER 1974, pl. F 2-4, fig. 5
Gorgonisphaeridium telum WICANDER & PLAYFORD 1985, pl. F 2-5, fig. 11
Leiofusa exilata DORNING 1981, pl. F 2-2, fig. 8
Leiofusa sp., pl. F 2-8, fig. 1

Lophosphaeridium segregum PLAYFORD 1981, pl. F 2-5, fig. 9
Lophosphaeridium sp., pl. F 2-5, fig. 7
Micrhystridium erugatum WICANDER 1974, pl. F 2-4, fig. 9
Micrhystridium cf. *vigintispinum* STAPLIN 1961, pl. F 2-1, fig. 5
Multiplicisphaeridium cf. *M. eltonensis* DORNING 1981, pl. F 2-2, fig. 3
Multiplicisphaeridium ramusculosum (DEFLANDRE 1942) LISTER 1970, pl. F 2-1, fig. 11
Multiplicisphaeridium cf. *M. variabile* (LISTER 1970) DORNING 1981, pl. F 2-2, fig. 2
Navifusa bacillum crescentis COMBAZ, LANGE & PANSART 1967, pl. F 2-5, fig. 1
Onondagaella asymmetrica (DEUNFF 1954) CRAMER 1966, pl. F 2-7, fig. 8
Puteoscortum williereae MARTIN 1981, pl. F 2-4, fig. 3
Solisphaeridium astrum WICANDER 1974, pl. F 2-4, fig. 6
Solisphaeridium spinoglobosum (STAPLIN 1961) WICANDER 1974, pl. F 2-4, fig. 14
Tasmanites sp. in WICANDER 1974 (pl. 19, fig. 11), pl. F 2-4, fig. 15
Veryhachium downiei STOCKMANS & WILLIERE 1962, pl. F 2-4, fig. 13

Conodonts:

Bispathodus jugosus (BRANSON & MEHL 1934), pl. F 2-3, fig. 8
Mehlina strigosa (BRANSON & MEHL 1934), pl. F 2-3, fig. 4
Palmatolepis gracilis gracilis BRANSON & MEHL 1934, pl. F 2-3, fig. 9, 10
Palmatolepis gracilis sigmoidalis ZIEGLER 1962, pl. F 2-3, fig. 11
Polygnathus communis communis BRANSON & MEHL 1934, pl. F 2-3, fig. 5, 6, 7

Unidentified palynomorphs:

pl. F 2-8, fig. 2 (acritarch); pl. F 2-8, fig. 5, 6, 7 (acritarch?); pl. F 2-10, fig. 11 (?); wood fragment with thorn in *Knorria* preservation, pl. F 2-9, fig. 3; thorn in *Knorria*-preservation, pl. F 2-8, fig. 3

Sedimentary pyrite:

pl. F 2-2, fig. 10 - 17

Plate F 2-1

Fig. 1: *Chelinospora favosa* STEEMANS 1989 [= *Dictyotriletes favosus* MCGREGOR & CAMFIELD 1976] (AV 8-1; 24.5/98.5; north of Oberhofer Mühle near Hofen; Pragian — Lower Emsian (within *polygonalis* - *emsiensis* (ca. di 7.5) — within *annulatus* - *sextantii* (ca. di 12.3)); Upper Emsian black slate; T/R)

Fig. 2: *Retusotriletes* sp. (AV 8-4, 49.5/99.2; north of Oberhofer Mühle near Hofen; Upper Emsian black slate; T/R)

Fig. 3: *Camptozonotriletes caperatus* MCGREGOR 1973 (AV 8-3; 49.3/107.7; north of Oberhofer Mühle near Hofen; middle Siegenian — lower Eifelian (in *polygonalis* - *emsiensis* (DK 1996: di 8.1) — in *velatus* - *langii* (dm 1.6)); Upper Emsian black slate; T/R)

Fig. 4: *Camarozonotriletes* sp. (AV 8-3; 23.8/113.9; north of Oberhofer Mühle near Hofen; Upper Emsian black slate; T/R)

Fig. 5: *Micrhystridium* cf. *vigintispinum* STAPLIN 1961 (AV 8-3; 45.0/110.1; north of Oberhofer Mühle near Hofen; Upper Siegenian — Upper Devonian; Upper Emsian black slate; T/R)

Fig. 6: *Dictyotriletes* cf. *D. emsiensis* (ALLEN 1965, MCGREGOR 1973) MCGREGOR & CAMFIELD 1976 (AV 8-2; 18.7/92.8; north of Oberhofer Mühle near Hofen; Pragian — Eifelian (*polygonalis-emsiensis* (DK 1996: di 6.7) — in *velatus-langii* (ca. dm 2.5)); Upper Emsian black slate; T/R; ca. ½ of the specimen preserved)

Fig. 7: *Dibolisporites abitibiensis* MCGREGOR & CAMFIELD 1976 (AV 8-1; 29.5/113.0; north of Oberhofer Mühle near Hofen; Emsian (ca. *annulatus* - *sextantii* - zone (DK 1996: di 11.2 - 19.0)); Upper Emsian black slate; T/R)

Fig. 8: *Cymbosporites paulus* MCGREGOR & CAMFIELD 1976 (AV 8-1; 34.0/105.0; north of Oberhofer Mühle near Hofen; "Middle" Pragian — Emsian (within *polygonalis* - *emsiensis* (DK 1996: ca. di 8.2) — *annulatus* - *sextantii* -zone (ca. di 19.0)); Upper Emsian black slate; T/R)

Fig. 9: *Dictyotriletes subgranifer* MCGREGOR 1973 (AV 8-1; 21.2/97.0; north of Oberhofer Mühle near Hofen; Emsian (ca. *annulatus* -*sextantii* -zone); Upper Emsian black slate; T/R; reticulate sculpture partly destroyed)

Fig. 10: *Convolutispora clivosa* KAISER 1971 (AV 8-3; 20.6/107.9; north of Oberhofer Mühle near Hofen; Emsian (DK 1996: di 10.2) — Upper Devonian; Upper Emsian black slate; T/R)

Fig. 11: *Multiplicisphaeridium ramusculosum* (DEFLANDRE 1942) LISTER 1970 (AV 8-3; 49.5/99.5; north of Oberhofer Mühle near Hofen; Upper Ordovician — Middle Devonian; Upper Emsian black slate; T/R)

Fig. 12: *Dictyotidium cavernosulum* PLAYFORD 1977 (AV 8-3; 30.2/110.9; north of Oberhofer Mühle near Hofen; Emsian; Upper Emsian black slate; T/R)

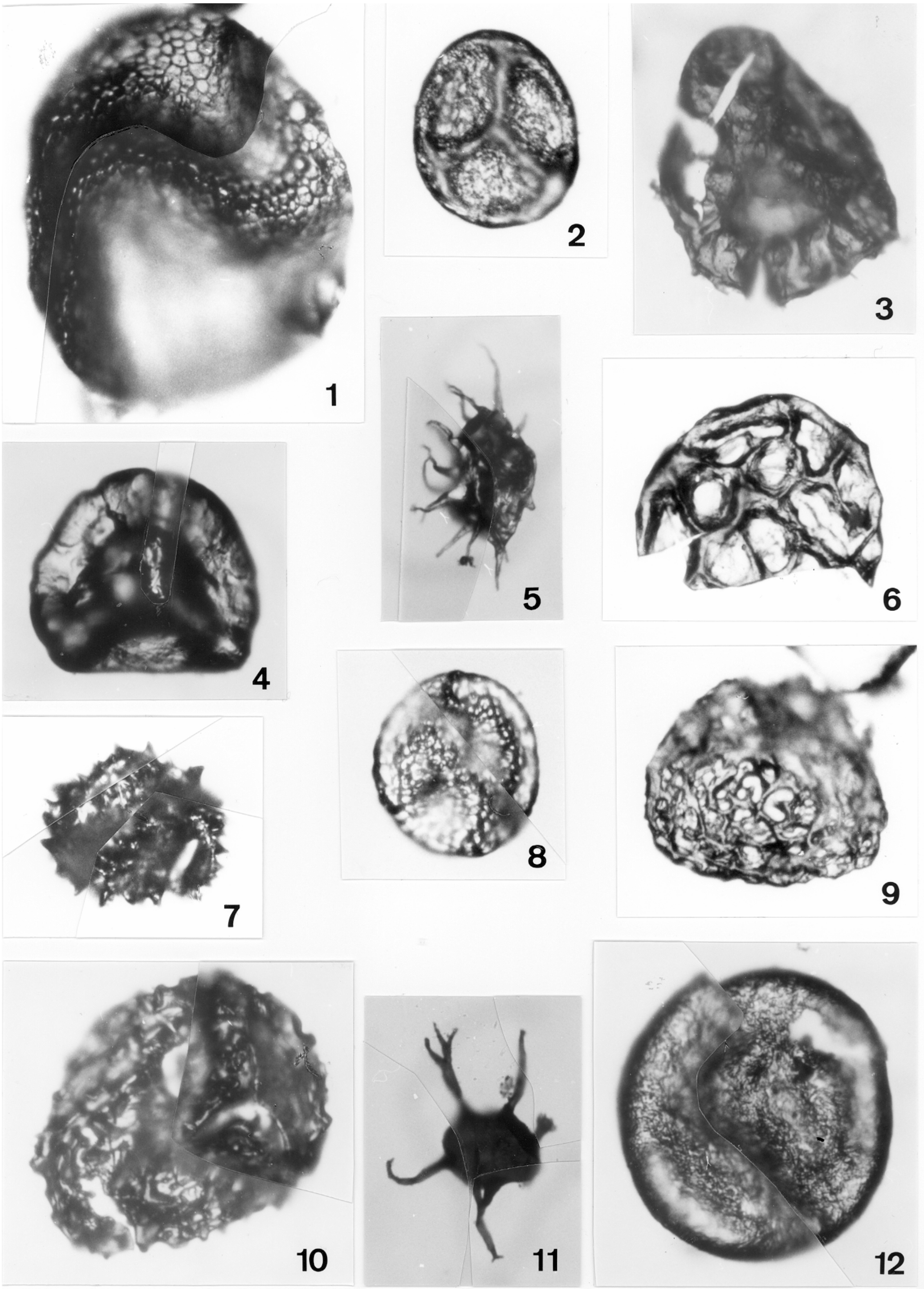


Plate F 2-2

Fig. 1, 4: *Retusotriletes maculatus* McGregor & Camfield 1976 (AV 8-3; 43.0/114.0 and AV 8-2, 25.5/ 92.1; north of Oberhofer Mühle near Hofen; Gedinnian — Emsian (*micrornatus* - *newportensis* (DK 1996: di 0.6) — in *annulatus* - *sextantii* (di 17.4)); Upper Emsian black slate; T/R)

Fig. 2: *Multiplicisphaeridium* cf. *M. variabile* (Lister 1970) Dorning 1981 (AV 8-1; 38.8/91.0; north of Oberhofer Mühle near Hofen; Upper Silurian (Ludlowian); reworked acritarch in Upper Emsian black slate; T/R)

Fig. 3: *Multiplicisphaeridium* cf. *M. eltonensis* Dorning 1981 (AV 8-3; 51.8/97.2; north of Oberhofer Mühle near Hofen; Upper Silurian (upper Wenlockian — lower Ludlowian); reworked acritarch in Upper Emsian black slate; T/R)

Fig. 5: *Chelinospora* ? *vermiculata* (Chaloner & Streel 1968) McGregor & Camfield 1976 (AV 8-1; 19.2/91.5; north of Oberhofer Mühle near Hofen; Upper Silurian — Gedinnian; reworked spore in Upper Emsian black slate; T/R)

Fig. 6: *Tholisporites chulus* (Cramer) McGregor 1973 var. *nanus* [= *Archaeozonotriletes chulus* var. *nanus* Richardson & Lister 1969] (AV 8-1; 35.0/114.0; north of Oberhofer Mühle near Hofen; Silurian (upper Llandovery) — upper Gedinnian (ca. di 3.0); reworked spore in Upper Emsian black slate; T/R)

Fig. 7: *Angochitina* ? *thadeui* Paris 1981 (AV 8-3; 43.2/107.3; north of Oberhofer Mühle near Hofen; upper Silurian (upper Wenlockian — Ludlowian); reworked chitinozoan in Upper Emsian black slate; T/R)

Fig. 8: *Leiofusa exilata* Dorning 1981 (AV 8-3; 25.2/92.1; north of Oberhofer Mühle near Hofen; upper Silurian (lower Ludlowian); reworked acritarch in Upper Emsian black slate; T/R; broken; x500)

Fig. 9: Acritarcha indet. (AV 8-3; 21.8/94.7; north of Oberhofer Mühle near Hofen; probably reworked Silurian acritarch in Upper Emsian black slate; T/R)

Fig. 10: Cluster of >15 pyrite framboids. (AV 86-1; 42.9/101.6; BK 2010/132, depth 28.1 - 28.3m; Upper Devonian (Famennian) debris flow; T/R)

Fig. 11: Cluster of 3 pyrite framboids with predominantly octahedral crystallites (AV 86-1; 39.5/110.3; BK 2010/132, depth 28.1 - 28.3m; Upper Devonian (Famennian) debris flow; T/R)

Fig. 12: Rosette-like cluster of 7 pyrite framboids (AV 8-3; 25.5/109.0; north of Oberhofer Mühle near Hofen; Emsian; Upper Emsian black slate; T/R)

Fig. 13: Irregular spaced cluster of reworked pyrite framboids (AV 86-1; 39.2/110.7; BK 2010/132, depth 28.1 - 28.3m; Upper Devonian (Famennian) debris flow; T/R; abraded)

Fig. 14: Equant cubic pyrite. The edges of the cube are modified by pyritohedral (?) and the corners by octahedral faces (AV 86-1; 36.2/94.2; BK 2010/132, depth 28.1 - 28.3m; Upper Devonian (Famennian) debris flow; T/R)

Fig. 15: Single pyrite framboid. The crystal habit is the combination of octahedron and cube in both morphotypes (AV 88-1; 44.8/107.0; BK 2010/132, depth 29.2 - 29.3m; Famennian; Upper Devonian (Famennian) debris flow; T/R)

Fig. 16: Octahedral equant pyrite (AV 86-1; 34.1/103.7; BK 2010/132, depth 28.1 - 28.3m; Upper Devonian (Famennian) debris flow; T/R)

Fig. 17: Equant pyrite (AV 86-1; 39.5/99.1; BK 2010/132, depth 28.1 - 28.3m; Upper Devonian (Famennian) debris flow; T/R)

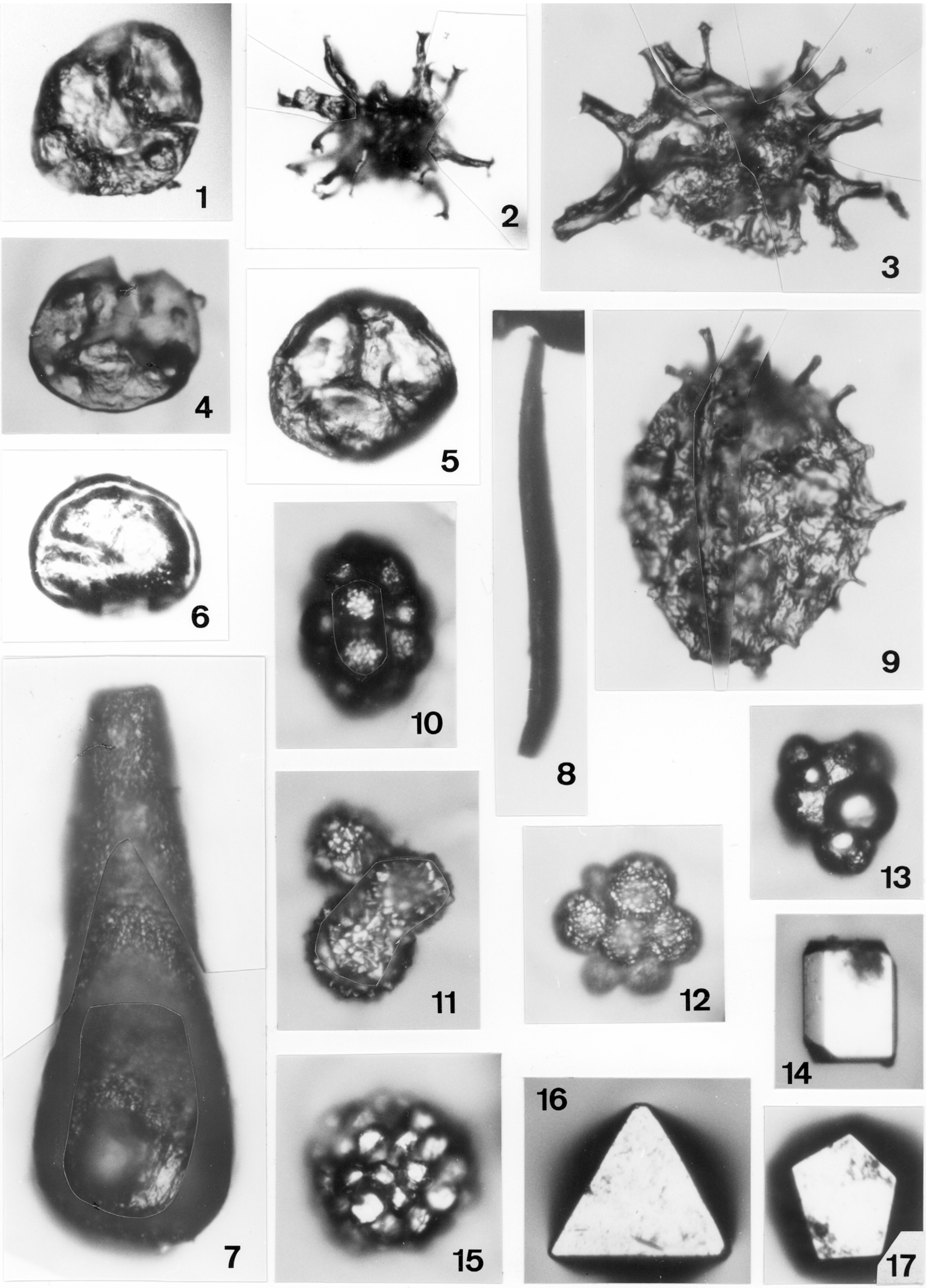

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Plate F 2-3

Fig. 1: *Convolutispora* sp. (AV 3/1; SEM-picture 17857; north of Oberhofer Mühle near Hofen; Upper Emsian black slate; broken)

Fig. 2: cf. *Retusotriletes clandestinus* CHIBRIKOVA (AV 3/1; SEM-picture 17859; north of Oberhofer Mühle near Hofen; Emsian (? early *annulatus-sextantii* — late *annulatus-sextantii*-zone, approx. RC-zone of the Eastern European zonation (DK 1996: ca. di ?11.2 — 19.0)); Upper Emsian black slate)

Fig. 3: *Acinosporites lindlarensis* RIEGEL 1968 var. *minor* (AV 3/1; SEM-picture 17860; north of Oberhofer Mühle near Hofen; Upper Emsian — middle Givetian (in *annulatus-sextantii* (DK 1996: ca. di 16.7) — in *lemurata-magnificus* (ca. dm 13.6)); Upper Emsian black slate)

Fig. 4: *Mehlina strigosa* (BRANSON & MEHL 1934) (AV 280; SEM-picture 17868; SE of Christianshütte: E 3442220 N 5589870; late Nehdenian — Wocklumian (Early *marginifera* (DK 1996: ds 11.9) — ? in Middle *praesulcata* (ca. ds 19.2)); Upper Devonian (Famennian) slate with calcareous nodules (Kalkknotenschiefer); x100)

Fig. 5, 6, 7: *Polygnathus communis communis* BRANSON & MEHL 1934 (AV 280; SEM-picture 17883 (fig. 5), SEM-picture 17864 (fig. 6), SEM-picture 17874 (fig. 7); SE of Christianshütte: E 3442220 N 5589870; late Hembergian — Lower Carboniferous (Early *postera* (DK1996: ds 15.2) — ? in *texanus* (LCC2003: ca. ci 14.1)); Upper Devonian (Famennian) slate with calcareous nodules (Kalkknotenschiefer); x100)

Fig. 8: *Bispathodus jugosus* (BRANSON & MEHL 1934) (AV 280; SEM-picture 17875; SE of Christianshütte: E 3442220 N 5589870; Dasbergian (in Early (DK 1996: ca. ds 16.8) — (?in) Late *expansa* (ca. ds 18.4)); Upper Devonian (Famennian) slate with calcareous nodules (Kalkknotenschiefer); x100)

Fig. 9, 10: *Palmatolepis gracilis gracilis* BRANSON & MEHL 1934 (AV 280; SEM-picture 17888 (fig. 9), SEM-picture 17873 (fig. 10); SE of Christianshütte: E 3442220 N 5589870; late Nehdenian — early Tournaisian (Late *rhomboidea* (DK 1996: ds 11.3) — in *sulcata* (LCC2003: ca. ci 0.8)); Upper Devonian (Famennian) slate with calcareous nodules (Kalkknotenschiefer); x100)

Fig. 11: *Palmatolepis gracilis sigmoidalis* ZIEGLER 1962 (AV 280; SEM-picture 17862; SE of Christianshütte: E 3442220 N 5589870; late Hembergian — Wocklumian (Late *trachytera* DK 1996: ds 14.6) — Late *praesulcata* (ds 20.0)); Upper Devonian (Famennian) slate with calcareous nodules (Kalkknotenschiefer); x100)

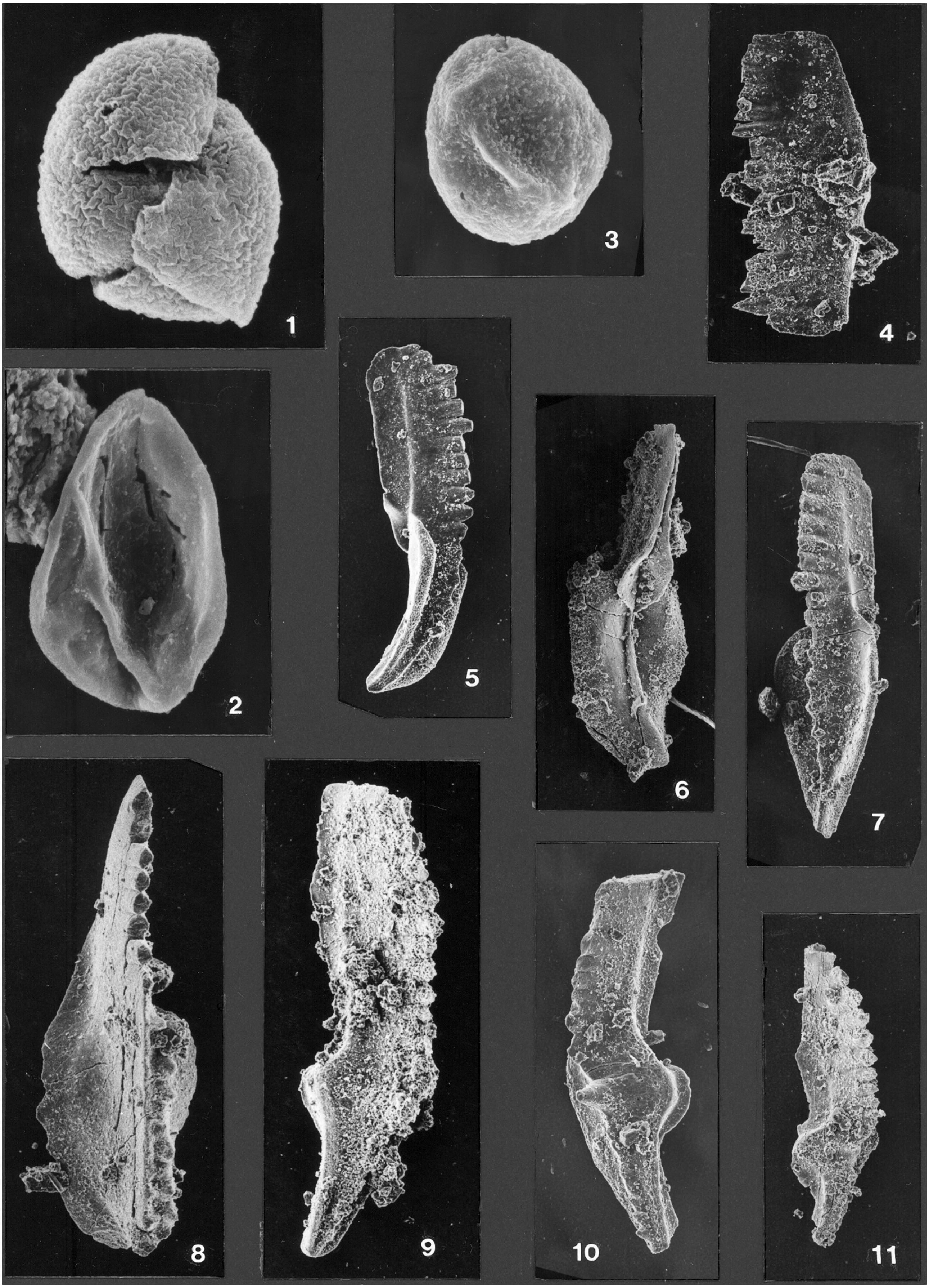
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Plate F 2-4

Fig. 1, 2: *Ammonidium* cf. *hamatum* WICANDER 1974 (AV 87-1; 25.0/114.1; BK 2010/132, depth 28.6 - 28.7m; Famennian; Upper Devonian (Famennian) debris flow; T/R and T)

Fig. 3: *Puteoscortum williereae* MARTIN 1981 (AV 83-2; 34.5/96.8; BK 2010/132, depth 25.4 - 25.75m; Early Famennian (*Palm. triangularis*-zone — ?); Upper Devonian (Famennian) debris flow; T/R)

Fig. 4: *Gorgonisphaeridium evexispinosum* WICANDER 1974 (AV 77-2; 29.3/94.0; BK 2010/132, depth 19.4 - 19.5m; Famennian; Upper Devonian debris flow; T/R)

Fig. 5: *Gorgonisphaeridium plerispinosum* WICANDER 1974 (AV 83-2; 25.8/110.8; BK 2010/132, depth 25.4 - 25.75m; upper Frasnian — Famennian, — ?Tournaisian; Upper Devonian debris flow; T/R)

Fig. 6: *Solisphaeridium astrum* WICANDER 1974 (AV 86-1; 40.0/99.6; BK 2010/132, depth 28.1 - 28.3m; Famennian; Upper Devonian (Famennian) debris flow; T)

Fig. 7: *Comasphaeridium caesariatum* WICANDER 1974 (AV 77-2; 26.2/105.6; BK 2010/132, depth 19.4 - 19.5m; Famennian; Upper Devonian debris flow; T/R)

Fig. 8: *Cymatiosphaera labyrinthica* WICANDER 1974 (AV 88-1; 58.0/113.9; BK 2010/132, depth 29.2 - 29.3m; Famennian; Upper Devonian (Famennian) debris flow; T/R)

Fig. 9: *Micrhystridium erugatum* WICANDER 1974 (AV 86-1; 33.1/94.4; BK 2010/132, depth 28.1 - 28.3m; lower Famennian; Upper Devonian (Famennian) debris flow; T/R)

Fig. 10: *Ammonidium* ? *alloiteaui* (DEUNFF 1955) MARTIN 1981 (AV 83-2, 28.5/105.2; BK 2010/132, depth 25.4 - 25.75m; Devonian; Upper Devonian debris flow; T)

Fig. 11: *Gorgonisphaeridium* cf. *absitum* WICANDER 1974 (AV 77-2; 38.5/98.2; BK 2010/132, depth 19.4 - 19.5m; Famennian; Upper Devonian debris flow; T/R)

Fig. 12: *Gorgonisphaeridium* cf. *G. absitum* WICANDER 1974 (AV 83-2; 44.1/103.4; BK 2010/132, depth 25.4 - 25.75m; Famennian; Upper Devonian debris flow; T/R; broken)

Fig. 13: *Veryhachium downiei* STOCKMANS & WILLIERE 1962 (AV 87-1; 44.2/114.6; ; BK 2010/132, depth 28.6 - 28.7m; Upper Silurian — Devonian; Upper Devonian (Famennian) debris flow; T/R)

Fig. 14: *Solisphaeridium spinoglobosum* (STAPLIN 1961) WICANDER 1974 (AV 77-2; 52.9/105.9; BK 2010/132, depth 19.4 - 19.5m; ? Silurian — Devonian (mostly reported from Upper Devonian deposits); Upper Devonian debris flow; T/R)

Fig. 15: *Tasmanites* sp. in WICANDER 1974, pl. 19, fig. 11 (AV 77-2; 43.0/103.0; BK 2010/132, depth 19.4 - 19.5m; at least: Famennian; Upper Devonian debris flow; T/R)

Fig. 16: *Cymatiosphaera limbatisphaera* WICANDER & LOEBLICH 1977 (AV 77-2; 28.9/111.5; BK 2010/132, depth 19.4 - 19.5m; Uppermost Givetian — Famennian; Upper Devonian debris flow; T/R)

Fig. 17: cf. *Duvernaysphaera krauseli* (STOCKMANS & WILLIERE) STOCKMANS & WILLIERE 1962 (AV 83-2; 31.0/105.4; BK 2010/132, depth 25.4 - 25.75m; at least: lower Famennian; Upper Devonian debris flow; T/R)

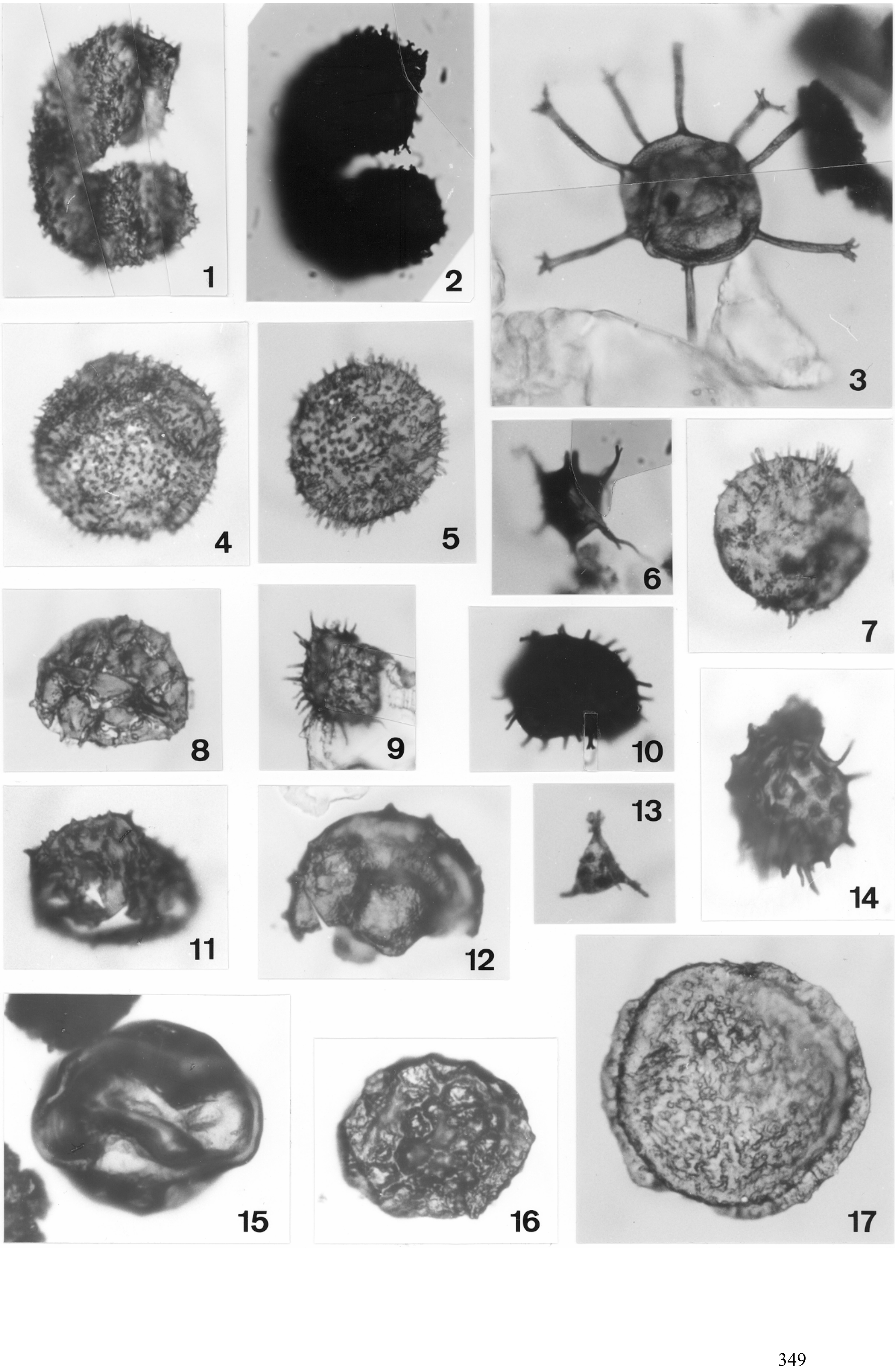
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Plate F 2-5

Fig. 1: *Navifusa bacillum crescentis* COMBAZ, LANGE & PANSART 1967 [but compare PLAYFORD 1977: 29 for discussion of *N. bacillum*] (AV 78-1; 34.1/108.0; BK 2010/132, depth 20.05 - 20.3m; Frasnian (of Lybia); Upper Devonian debris flow; T; x 500)

Fig. 2: *Diducites poljessicus* (KEDO) VAN VEEN 1981 (AV 87-1; 33.0/106.4; BK 2010/132, depth 28.6 - 28.7m; Early Famennian — in Lower Carboniferous (near base *torquata - gracilis* (DK 1996: ca. ds 6.5) — in L. Carbonif.); Upper Devonian (Famennian) debris flow; T/R)

Fig. 3: *Auroraspora macra* SULLIVAN 1968 (AV 87-1; 45.0/91.2; BK 2010/132, depth 28.6 - 28.7m; Early Famennian — Lower Carboniferous (in *torquata - gracilis* (DK 1996: ca. ds 10.3) — ca. PU); Upper Devonian (Famennian) debris flow; T/R)

Fig. 4: *Kedoesporis evlanensis* (NAUMOVA 1953) OBUKHOVSKAYA (AV 77-2; 24.9/94.2; BK 2010/132, depth 19.4 - 19.5m; Late Frasnian (upper part of *ovalis-bulliferus* (ca. DK 1996: ds 4.2 — 6.0); Upper Devonian debris flow; T/R; proximal view)

Fig. 5: *Geminospora notata* (NAUMOVA 1953) OBUKHOVSKAYA var. *microspinosus* TCHIBRIKOVA (AV 87-1; 28.8/108.2; BK 2010/132, depth 28.6 - 28.7m; Early Famennian (zones GS — CZ of the Eastern European spore zonation; in Middle *triangularis* (ca. ds 7.1) — Middle *crepida* (ca. ds 9.4)); Upper Devonian (Famennian) debris flow; T/R)

Fig. 6: *Ammonidium* sp. (AV 83-2; 42.6/ 110.2; BK 2010/132, depth 25.4 - 25.75m; Upper Devonian debris flow; T/R; simple split in vesicle wall visible (excystment structure))

Fig. 7: *Lophosphaeridium* sp. (AV 83-2; 43.5/107.9, and 19 more in AV 83-2; BK 2010/132, depth 25.4 - 25.75m; Upper Devonian debris flow; T/R)

Fig. 8: *Geminospora* cf. *G. vasjamica* (CHIBRIKOVA) OBUKHOVSKAYA & NEKRIATA (AV 83-2; 23.0/102.2 and 30.0/100.0; BK 2010/132, depth 25.4 - 25.75m; Early Famennian (VV — CZ - zone of the Eastern European spore-zonation; approximately equivalent to *Palmatolepis triangularis* — Late *crepida*-zone; Upper Devonian debris flow; T/R; considerably smaller than the original size range of the species)

Fig. 9: *Lophosphaeridium segregum* PLAYFORD 1981 (AV 84-2; 44.5/111.5; BK 2010/132, depth 26.4 - 26.6m; Frasnian — Viséan; ?reworked acritarch in Upper Devonian (Famennian) debris flow; T/R)

Fig. 10: *Cymatiosphaera nebulosa* (DEUNFF 1954) DEFLANDRE 1954 (AV 83-2; 35.8/103.7; BK 2010/132, depth 25.4 - 25.75m; Silurian — early Famennian; Upper Devonian debris flow; T/R)

Fig. 11: *Gorgonisphaeridium telum* WICANDER & PLAYFORD 1985 (AV 83-2; 39.0/103.1; BK 2010/132, depth 25.4 - 25.75m; up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone); Upper Devonian debris flow; T)

Fig. 12: *Verrucosisporites evlanensis* (NAUMOVA) OBUKHOVSKAYA (AV 87-1; 46.0/104.5; BK 2010/132, depth 28.6 - 28.7m; Uppermost Frasnian — lowermost Famennian (DE-VV-zones of the Eastern European spore-zonation); Upper Devonian (Famennian) debris flow; T/R)

Fig. 13: cf. *Lophozonotriletes magnus* KEDO 1974 (AV 83-2; 37.6/96.6; BK 2010/132, depth 25.4 - 25.75m; (?Givetian) Famennian — Lower Tournaisian; Upper Devonian (Famennian) debris flow; T/R)

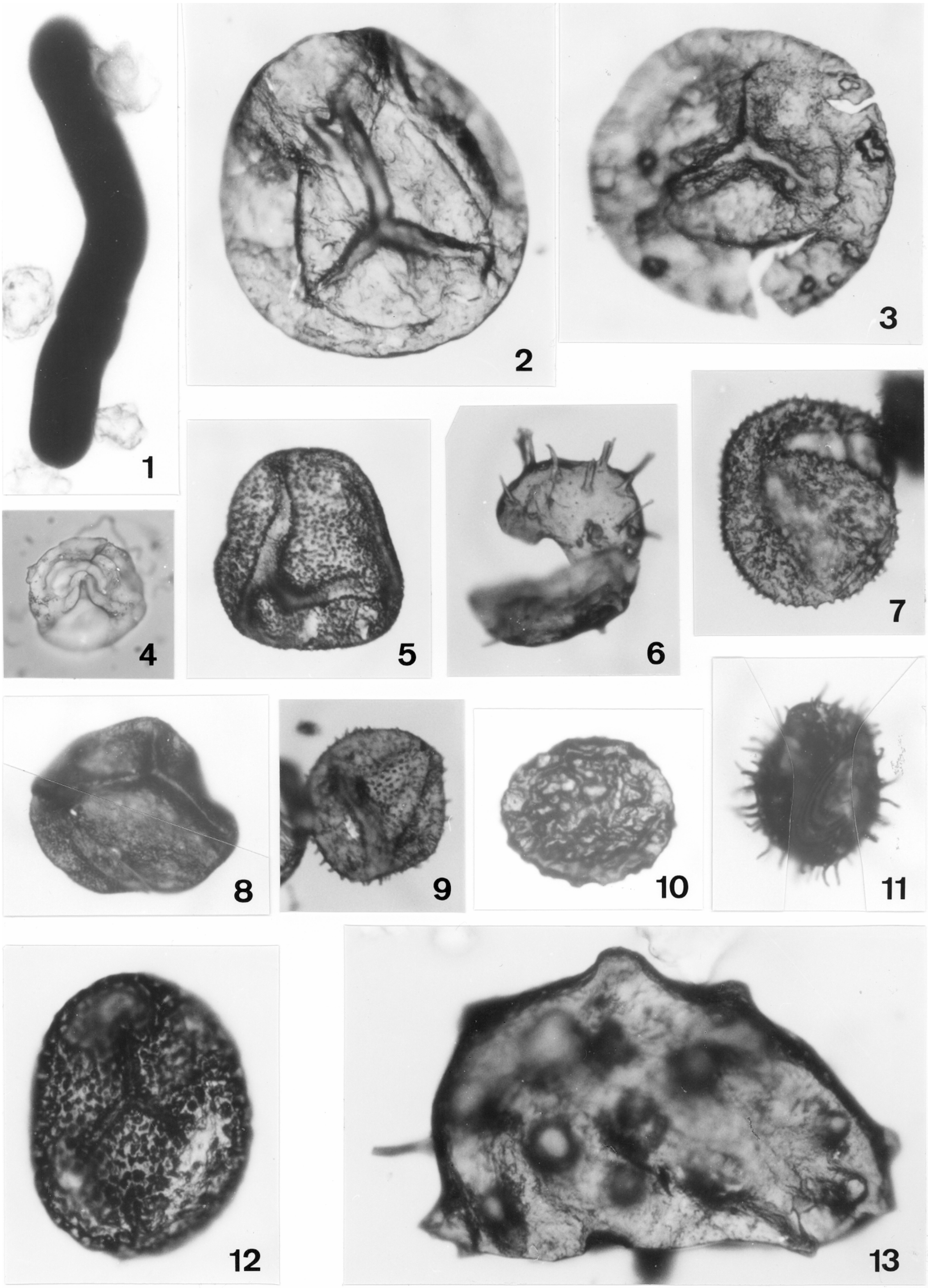

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Plate F 2-6

Fig. 1: *Densosporites inaequus* (McGregor) McGregor & Camfield 1982 (AV 84-2; 42.0/98.5; BK 2010/132, depth 26.4 - 26.6m; Late Eifelian — late Frasnian (*devonicus-naumovii* (ca. DK 1996: dm 4.6) — *ovalis-bulliferus* (ca. ds 3.9)); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 2: cf. *Dictyotidium cavernosulum* Playford 1977 (AV 83-2; 42.9/103.5; BK 2010/132, depth 25.4 - 25.75m; Emsian; Upper Devonian debris flow; T/R; vesicle's reticulate sculpture only relictic preserved)

Fig. 3: *Acanthotriletes bucerus* Chibrikova (AV 84-2; 34.2/114.3; (AV 83-2; 26.0/95.0; BK 2010/132, depth 26.4 - 26.6m; Early Frasnian of the Eastern European spore-zonation (OK - zone, approx. equivalent to a) upper part of *optivus-triangularis*, b) lower *M. asymmetricus*-zone; DK 1996: ca. ds 0 —- 1.7); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 4: *Desmochitina* Eisenack 1931 sp. (AV 83-2; 45.0/102.0; BK 2010/132, depth 25.4 - 25.75m; at least: Middle Devonian; reworked chitinozoan in Upper Devonian (Famennian) debris flow; T/R)

Fig. 5: *Geminospora* cf. *extensa* (Naumova 1953) Gao (AV 84-2; 38.1/111.8; BK 2010/132, depth 26.4 - 26.6m; Givetian (EX-zone of the Eastern European spore-zonation); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 6: *Geminospora tuberculata* (Kedo 1955) Allen 1965, maybe var. *micrornata* McGregor & Camfield 1982, but 15µm smaller (AV 83-2; 46.0/99.2; BK 2010/132, depth 25.4 - 25.75m; Givetian (EX - zone of the Eastern European spore-zonation); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 7, 9: *Aneurospora greggsi* (McGregor) Streel 1974 (AV 87-1; 39.2/114.4 and 31.8/110.8; BK 2010/132, depth 28.6 - 28.7m; Givetian (in *lemurata-magnificus*) — Uppermost Famennian: (*lepidophyta-nitidus*-zone); Upper Devonian (Famennian) debris flow; T/R)

Fig. 8: *Ancyrospora melvillensis* Owens 1971 (AV 87-1; 29.0/93.0; BK 2010/132, depth 28.6 - 28.7m; Uppermost Givetian — Frasnian (in *optivus-triangularis* (ca. DK 1996: dm 18.7 — *ovalis-bulliferus* (ds 6.0)); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 10: *Verrucosisporites premnus* Richardson 1965 (AV 87-1; 42.0/104.4; BK 2010/132, depth 28.6 - 28.7m; Middle Eifelian — Givetian (*devonicus-naumovii* (DK 1996: dm 3.8) — *optivus-triangularis* (ca. ds 0.5); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 11: *Ancyrospora* sp. (AV 87-1; 21.6/111.0; BK 2010/132, depth 28.6 - 28.7m; reworked spore in Upper Devonian (Famennian) debris flow; T/R)

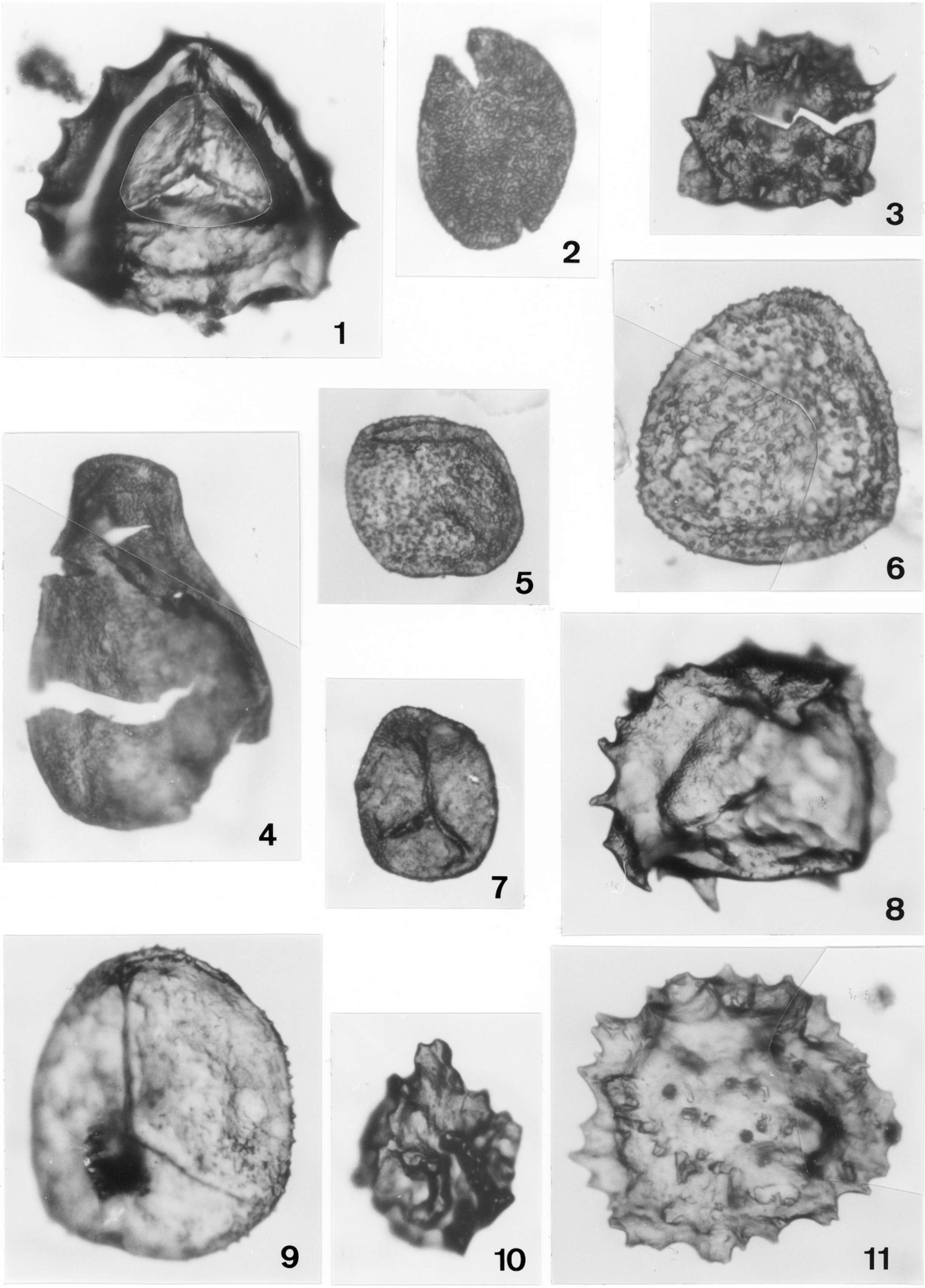
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Plate F 2-7

Fig. 1: *Estiastra* sp. (AV 83-2; 29.8/110.8; BK 2010/132, depth 25.4 - 25.75m; Upper Devonian (Famennian) debris flow; T/R)

Fig. 2: *Apiculiretusispora plicata* (ALLEN 1965) STREEL 1967 (AV 87-1; 35.0/112.9; BK 2010/132, depth 28.6 - 28.7m; Lower Gedinnian — Lower Eifelian (within *micrornatus - newportensis* (ca. DK 1996: di 1.4 — near top *velatus - langii* (ca. dm 3.0)); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 3: *Densosporites* sp. (AV 84-2; 39.2/106.5; BK 2010/132, depth 26.4 - 26.6m; Upper Devonian (Famennian) debris flow; T/R)

Fig. 4: *Convolutispora caperata* WICANDER & PLAYFORD 1985 (AV 88; SEM-picture 09909; BK 2010/132, depth 29.2 - 29.3m; Late Frasnian (Lower *Pa. gigas*-zone); Upper Devonian (Famennian) debris flow)

Fig. 5: cf. *Margachitina* EISENACK 1968 sp. (AV 86-1; 27.0/112.2; BK 2010/132, depth 28.1 - 28.3m; ? Upper Silurian — ? lower Lochkovian; reworked chitinozoan (from reworked Emsian slate?) in Upper Devonian (Famennian) debris flow; T/R)

Fig. 6: *Ammonidium* cf. *A. waldronensis* (TAPPAN & LOEBLICH 1971) DORNING 1981 (AV 83-2; 26.0/95.0; BK 2010/132, depth 25.4 - 25.75m; Middle — upper Silurian (Wenlockian — lower Ludlowian); reworked acritarch (from reworked Emsian slate?) in Upper Devonian (Famennian) debris flow; T/R)

Fig. 7: *Convolutispora* cf. *crassitunicata* (OBUKHOVSKAYA) OBUKHOVSKAYA (AV 83-2; 38.1/99.6; BK 2010/132, depth 25.4 - 25.75m; "Middle" Frasnian of the Eastern European spore-zonation (OG - zone, CVe-subzone; approx. equivalent to lower *Pa. gigas*-zone); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 8: *Onondagaella asymmetrica* (DEUNFF 1954) CRAMER 1966 (AV 77-2; 24.0/112.6; BK 2010/132, depth 19.4 - 19.5m; ? Upper Silurian (Ludlowian) — Lower Devonian, reworked acritarch in Upper Devonian debris flow; T/R)

Fig. 9: *Dictyotriletes* cf. *D. emsiensis* (ALLEN 1965) MCGREGOR 1973 <u>in</u> PLAYFORD 1976 (AV 86-1; 42.1/103.7; BK 2010/132, depth 28.1 - 28.3m; upper Siegenian — lowermost Eifelian (ca. DK 1996: di 9.0 — dm 1.1); reworked spore in Upper Devonian (Famennian) debris flow; T/R)

Fig. 10: *Contagisporites optivus* (CHIBRIKOVA) OWENS 1971 var. *optivus* (AV 84-2; 38.6/99.5; BK 2010/132, depth 26.4 - 26.6m; Late Givetian — earliest Famennian (in *optivus-triangulatus* (DK 1996: ca. dm 17.8) — near base *torquata-gracilis* (ca. ds 6.9)); Upper Devonian (Famennian) debris flow; T/R)

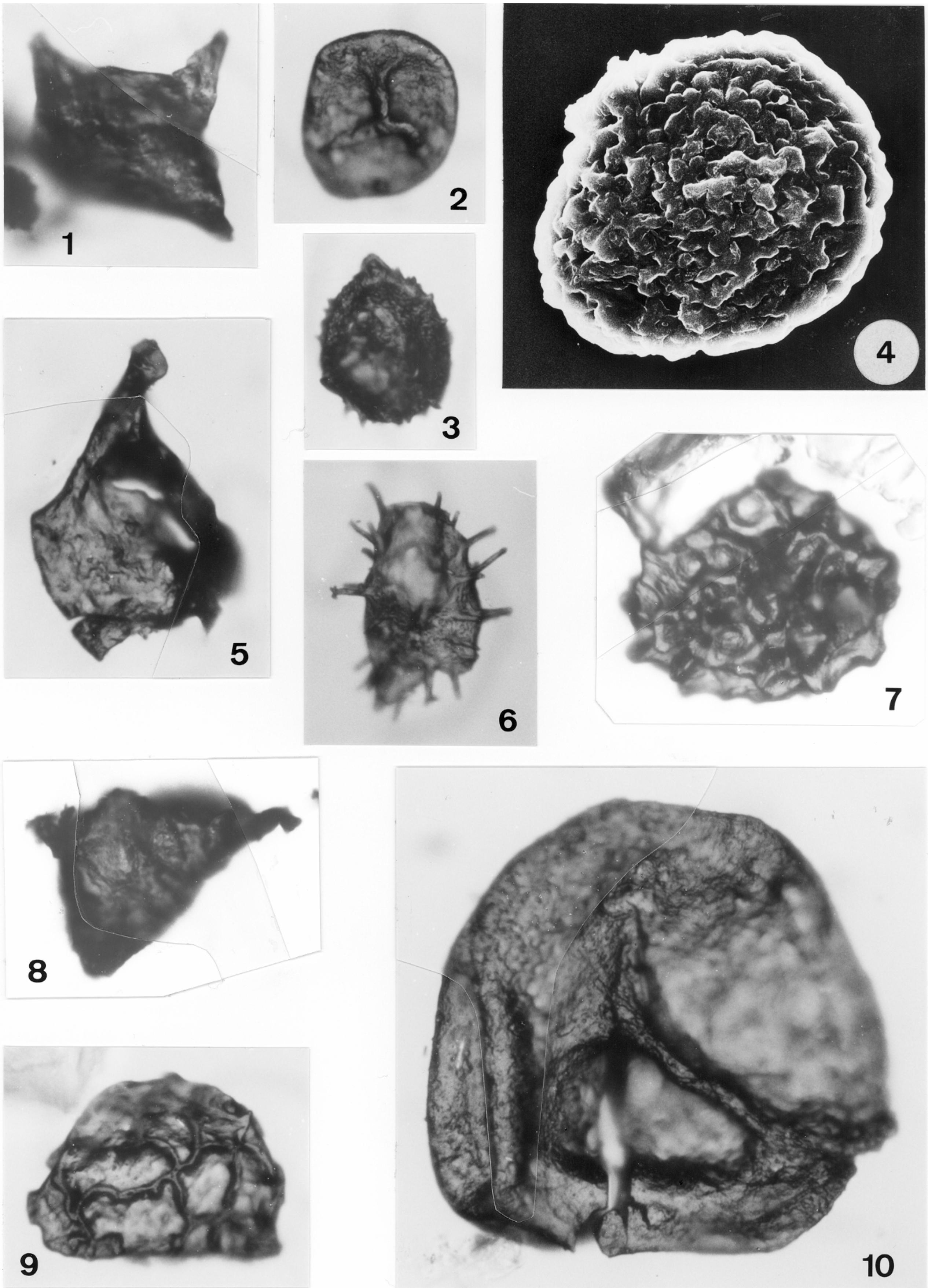
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Plate F 2-8

Fig. 1: *Leiofusa* sp. (AV 1-4; 29.0/110.6; north of Oberhofer Mühle near Hofen; Upper Tournaisian black flinty slate; T/R; enhanced reflectivity due to alteration of optical properties, not pyritization)

Fig. 2: Unidentified acritarch (AV 1-4; 41.2/105.9; north of Oberhofer Mühle near Hofen; Upper Tournaisian black flinty slate; T/R; enhanced reflectivity due to alteration of optical properties, not pyritization)

Fig. 3: Thorn in *knorria*-preservation (AV 1-4; 41.6/102.8; north of Oberhofer Mühle near Hofen; Upper Tournaisian black flinty slate; T/R; enhanced reflectivity due to alteration of optical properties, not pyritization)

Fig. 4: *Diexallophasis absonda* WICANDER 1974 (AV 1-2; 29.0/99.2; north of Oberhofer Mühle near Hofen; Tournaisian; Upper Tournaisian black flinty slate; T)

Fig. 5: Unidentified palynomorph (acritarch?) (AV 1-2; 39.5/98.8; north of Oberhofer Mühle near Hofen; Upper Tournaisian black flinty slate; T/R; enhanced reflectivity due to alteration of optical properties, not pyritization)

Fig. 6: Unidentified palynomorph (acritarch?) (AV 1-2; 32.7/102.0; north of Oberhofer Mühle near Hofen; Upper Tournaisian black flinty slate; T/R; enhanced reflectivity due to alteration of optical properties, not pyritization)

Fig. 7: Unidentified palynomorph (acritarch?) (AV 1-4; 39.8/106.3; north of Oberhofer Mühle near Hofen; Upper Tournaisian black flinty slate; T/R; enhanced reflectivity due to alteration of optical properties, not pyritization)

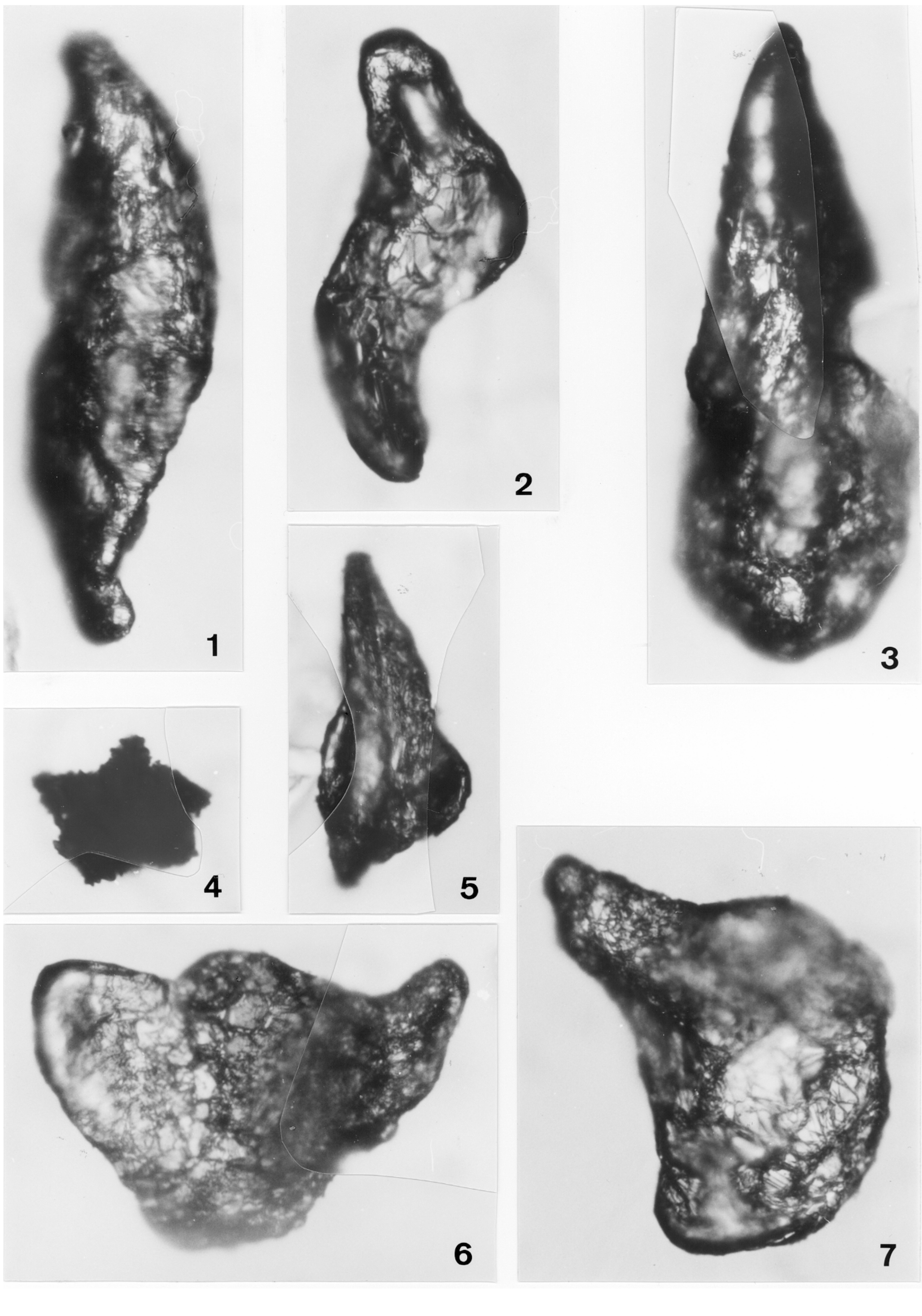
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Plate F 2-9

Fig. 1: *Spelaeotriletes* sp. (AV 147-5; 45.6/92.5; BK 3004/05, depth 22.2 - 22.4m; Viséan Bruchberg sandstone; T/R)

Fig. 2: *Knoxisporites cinctus* (WALTZ in LUBER 1938) BUTTERWORTH & WILLIAMS 1958 in SMITH & BUTTERWORTH 1967: 219 (AV 38-5; 50.7/91.7; southwestern slope of the Niedernberge, ca. 1.1 km southwest of Weipoltshausen; Viséan (PU) — Namurian A; Bruchberg sandstone; T/R; unusual reflectivity due to alteration of optical properties, not pyritization)

Fig. 3: Wood fragment with thorn in *Knorria* preservation (AV 38-4; 40.2/111.9; southwestern slope of the Niedernberge, ca. 1.1 km southwest of Weipoltshausen; Viséan Bruchberg sandstone; T/R)

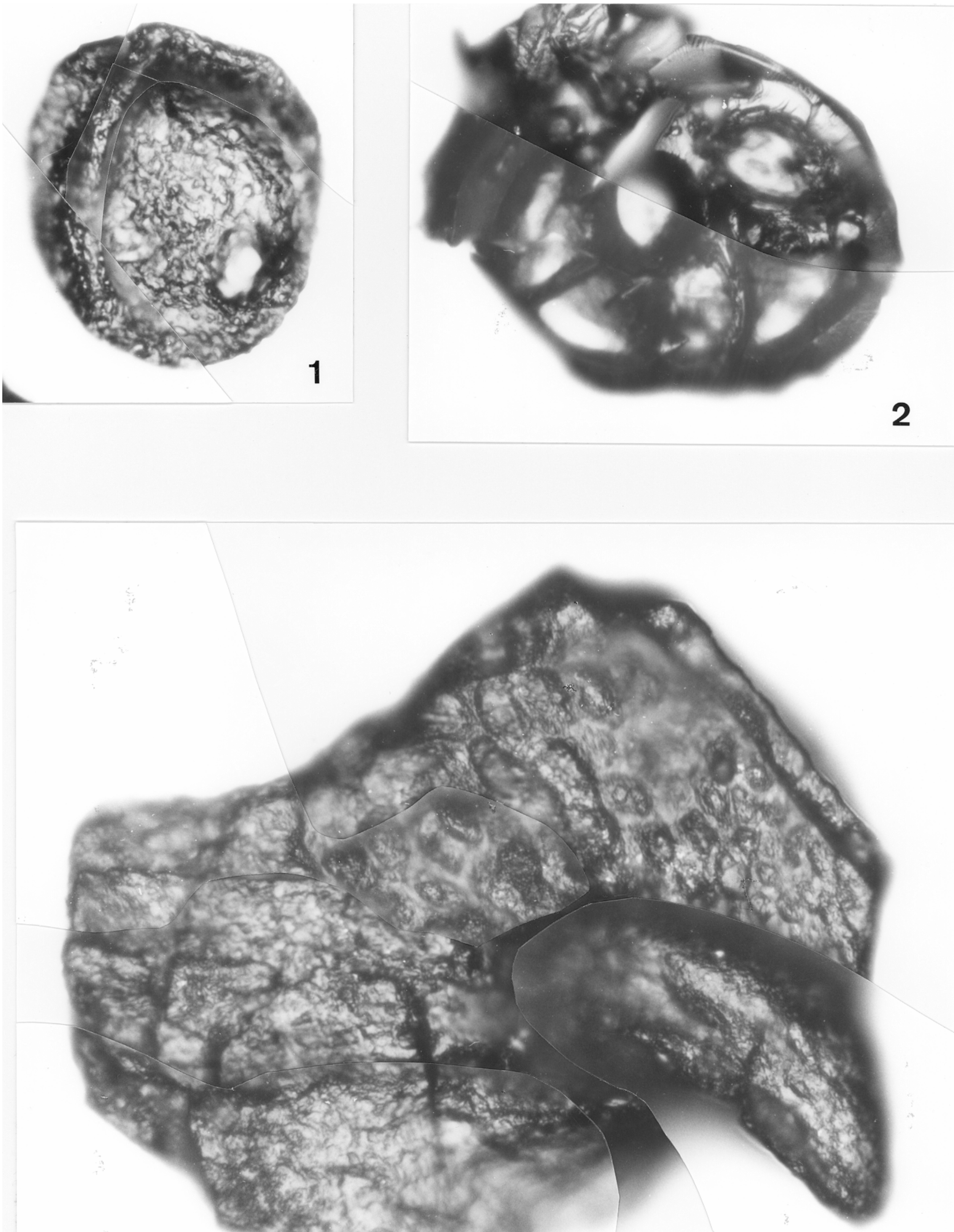


Plate F 2-10

Fig. 1: *Monoletes* indet. (AV 147-2; 38.9/91.0; BK 3004/05, depth 22.2 - 22.4m; late Viséan Bruchberg sandstone; T/R)

Fig. 2: *Densosporites subcrenatus* (WALTZ in LUBER & WALTZ 1938) POTONIÉ & KREMP 1955 (AV 25-3; 37.8/101.3); abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; PU — Upper Carboniferous; Bruchberg sandstone; T/R)

Fig. 3: *Knoxisporites triradiatus* HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 25-3; 32.0/96.0; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; TS — Upper Carboniferous; Bruchberg sandstone; T/R; oblique-equatorial view)

Fig. 4: *Spelaeotriletes* sp. (AV 25-3; 34.9/97.8; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; Viséan Bruchberg sandstone; T/R; frequent)

Fig. 5: *Radiizonates mirabilis* PHILLIPS & CLAYTON 1980 (AV 25.3; 23.4/100.8; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; PC — CM; Bruchberg sandstone; T/R)

Fig. 6: *Knoxisporites stephanephorus* LOVE 1960 (AV 25-3; 36.8/108.1; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; TS — Upper Carboniferous; Bruchberg sandstone; T)

Fig. 7: *Densosporites brevispinosus* HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 25-3; 38.6/103.0; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; PU — Upper Carboniferous; Bruchberg sandstone; T/R)

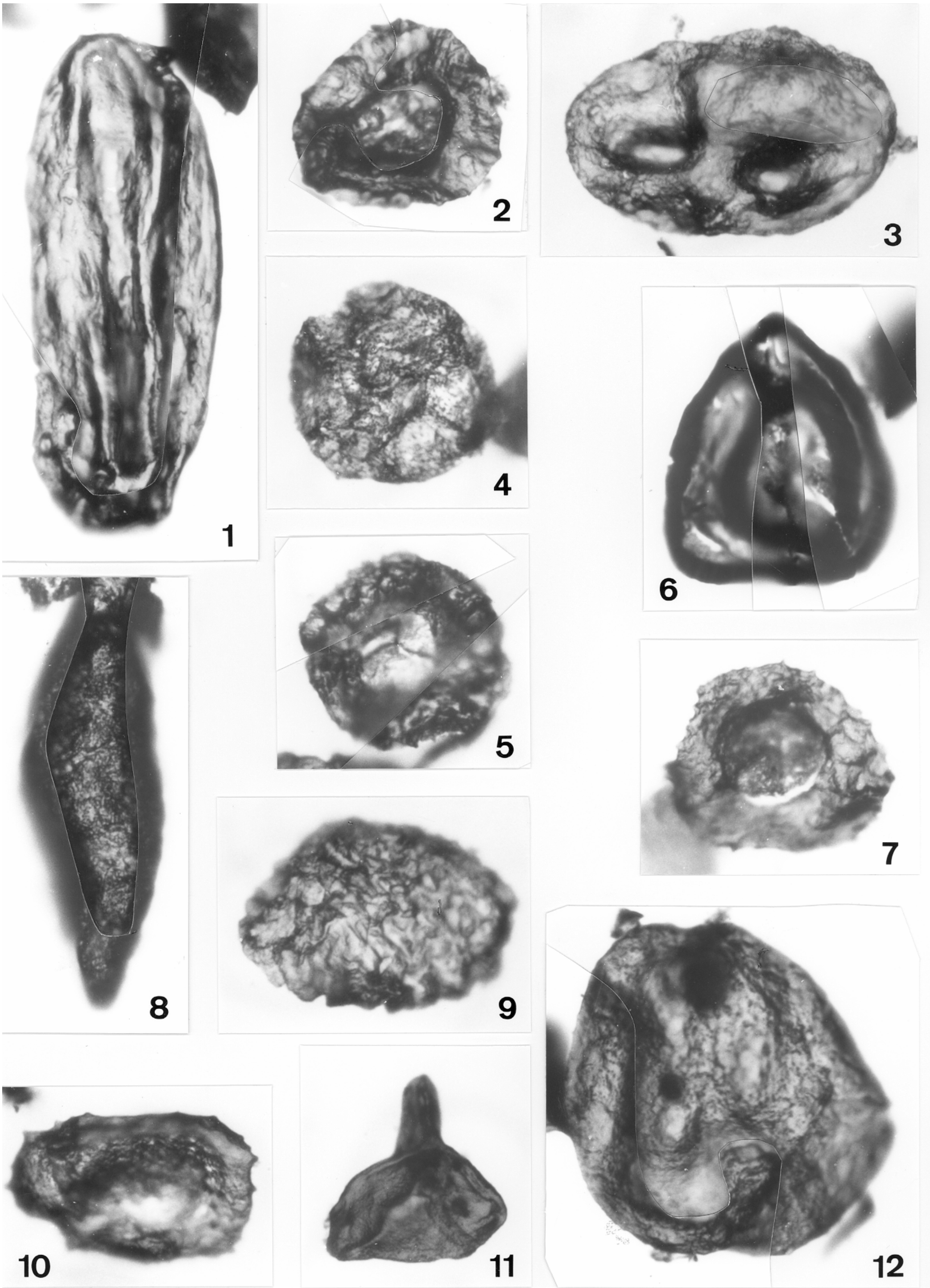
Fig. 8: *Monoletes* indet. (AV 25-3; 29.2/111.8; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; Viséan Bruchberg sandstone; T/R)

Fig. 9: *Convolutispora* sp. (AV 25-4; 32.0/91.5; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; Viséan Bruchberg sandstone; T/R; probably reworked)

Fig. 10: *Densosporites spinifer* HOFFMEISTER, STAPLIN & MALLOY 1955 (AV 25-3; 43.2/96.4; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; PU — Upper Carboniferous; Bruchberg sandstone; T/R)

Fig. 11: Unidentified palynomorph (AV 25-3; 36.9/111.0; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; Viséan Bruchberg sandstone; T/R)

Fig. 12: *Spelaeotriletes* sp. (AV 25-3; 29.8/114.8; abandoned "quartzite-" quarry, ca. 500m south of Dietkirchen; Viséan Bruchberg sandstone; T/R)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F 2.3 Famennian debris flow sediments (AV 57, 67-69, 72-88, 258, 259, 282-283, ?295, 297): Compilation of achieved results and complete fossil list for samples from different locations

On the following pages a compilation of all identified fossils from the analysed Famennian debris flow sediments is listed (tables F 2.1 - F 2.4). A short analysis of these listings is presented in tables D 2.1 and D 2.2.

The identified fossils are listed with their known stratigraphic range and the number of samples they had been recovered from. See the original sample descriptions for more details (e. g. coordinates of the fossils on the slides).

Tab. F 2.1: Synopsis of identified SPORES in Famennian debris flow sediments from different locations:

? *Apiculiretusispora* cf. *brandtii* STREEL 1967 in EDWARDS 1968, RICHARDSON & MCGREGOR 1986 (AV 73)	[Lower Siegenian — lower Eifelian (near base *polygonalis - emsiensis* (ca. di 7.6) — in *velatus - langii* (ca. dm 2.4))]
Acanthotriletes bucerus CHIBRIKOVA (AV 84)	["Early Frasnian" of the Eastern European spore-zonation (OK - zone, ca. dm 17.2 — ds 2.2)]
Ancyrospora cf. *incisa* (NAUMOVA 1953) M. RASKATOVA & OBUKHOVSKAYA (AV 69)	[? latest Givetian — late Frasnian (IM — AS - zone of the Eastern European spore-zonation; ca. equival. to ? *hermanni-cristatus* — upper *Pa. gigas*-zone)]
cf. *Ancyrospora involucra* OWENS 1971 (AV 69)	[Upper Givetian (*optivus-triangularis* (dm ca. 18.7)) — mid. Frasnian (in *ovalis-bulliferus* (ds ca. 4.2))]
Ancyrospora cf. *voronensis* (ARKHANGELSKAYA 1972) ARKHANGELSKAYA 1985 (AV 69)	[at least: middle Frasnian]
Ancyrospora melvillensis OWENS 1971 (AV 87)	[Uppermost Givetian — Frasnian (in *optivus-triangularis* (dm 18.7 —*ovalis-bulliferus* (ds 6.0))]
Ancyrospora sp. (AV 57, AV 87)	
Aneurospora greggsi (MCGREGOR) STREEL 1974 (AV 67, AV 74, AV 75, AV 87, AV 88, AV 283)	[Givetian (in *lemurata-magnificus*, ca. dm 14.5) — Uppermost Famennian: (*lepidophyta-nitidus*-zone)]
Aneurospora cf. *greggsi* (MCGREGOR) STREEL 1974 (AV 57)	[see above]
cf. *Aneurospora greggsi* (MCGREGOR) STREEL 1974 (AV 297)	[see above]
Apiculiretusispora gaspiensis MCGREGOR 1973 (AV 283)	[Upper Emsian — Eifelian (ca. di 17.7 — dm 7.7)]
Apiculiretusispora plicata (ALLEN 1965) STREEL 1967 (AV 87)	[Lower Gedinnian — Lower Eifelian (within *micrornatus - newportensis* (ca. di 1.4 — near top *velatus - langii* (ca. dm 3.0))]
Apiculiretusispora sp. (AV 77)	
Archaeoperisaccus cf. *A. concinnus* NAUMOVA 1953 (AV 258, AV 283, AV 297)	[Frasnian (OG-zone, approx. equivalent to the *ovalis-bulliferus*-zone (ca. ds 1.7 — 6.0))]
Archaeoperisaccus cf. *A. echinatus* RASKATOVA (AV 283)	[Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0)]
Archaeoperisaccus ovalis NAUMOVA 1953 (AV 67, AV 283)	[Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0)]
Archaeoperisaccus sp. (AV 297)	[Frasnian (*ovalis-bulliferus*-zone, ds 1.7 — 6.0)]
Archaeozonotriletes timanicus NAUMOVA 1953 (AV 73, AV 259)	[Middle Givetian — early Frasnian (ca. dm 10.9 — near top *optivus-triangularis* (ca. ds 0.8))]
Archaeozonotriletes variabilis NAUMOVA 1953 (AV 259, AV 297)	[Givetian (within *devonicus-naumovii*, ca. dm 8.9) — Famennian (*lepidophyta-nitidus*, ca. ds 20.0)]
Auroraspora macra SULLIVAN 1968 (AV 75, AV 87)	[Early Famennian — Lower Carboniferous (in *torquata - gracilis* (DK 1996: ca. ds 10.3) — ?PU)]
Brochotriletes cf. *B. foveolatus?* (NAUMOVA 1953) MCGREGOR 1973 (AV 297)	[Pragian (in *polygonalis-emsiensis*, ca. di 8.2) — Emsian (in *douglastownense-eurypterota*, di 19.7)]
cf. *Brochotriletes robustus* (SCOTT & ROUSE) MCGREGOR 1973 (AV 73, AV 75)	[Emsian (ca. *annulatus-sextantii*-zone (ca. di 11.2 — 19.0)]
Bulbosporites bulbosus (OBUKHOVSKAYA) OBUKHOVSKAYA (AV 297)	[Frasnian (MR — AS-zone; ca. equivalent lower to upper *gigas*-zone, ca. ds 4.2 — 5.5)]
Camarozonotriletes obtusus NAUMOVA 1953 (AV 297)	[at least: Frasnian (SD-zone, ca. ds 2.4 — 3.0)]
cf. *Camarozonotriletes sextantii* MCGREGOR & CAMFIELD 1982 (AV 77)	[Emsian (within *polygonalis-emsiensis* (ca. di 10.2) — in *douglastownense-eurypterota* (ca. di 19.7)

Camarozonotriletes sp. (AV 297)	
Contagisporites optivus (CHIBRIKOVA) OWENS 1971 var. *optivus* (AV 84, AV 283)	[Late Givetian — earliest Famennian (in *optivus-triangulatus* (ca. dm 17.8) — near base *torquata-gracilis* (ca. ds 6.9))]
Convolutispora caperata WICANDER & PLAYFORD 1985 (AV 73, AV 88)	[at least: late Frasnian (Lower *Pa. gigas*-zone, at least: ds 4.2 — 5.1)]
Convolutispora cf. *crassitunicata* (OBUKHOVSKAYA) OBUKHOVSKAYA (AV 83, AV 87)	["Middle" Frasnian of the Eastern European spore-zonation (OG - zone, CVe-subzone, ds 4.2 — 5.1)]
Convolutispora sp. (AV 69, AV 83)	
Cristatisporites sp. (AV 77)	
cf. *Cymbosporites proteus* MCGREGOR & CAMFIELD 1982 (AV 77)	[middle Gedinnian — middle Emsian (in *micrornatus-newportensis* (ca. di 2.2) — in *annulatus-sextantii* (ca. di 15.1)]
Cyrtospora cristifera (LUBER) VAN DER ZWAN 1979 (AV 57, AV 283)	[Famennian (*torquata-gracilis*) — Tournaisian (PC)]
cf. *Cyrtospora cristifera* (LUBER) VAN DER ZWAN 1979 (AV 258)	[see above]
Densosporites inaequus (MCGREGOR) MCGREGOR & CAMFIELD 1982 (AV 84)	[Late Eifelian — late Frasnian (*devonicus-naumovii* (ca. dm 4.6) — *ovalis-bulliferus* (ca. ds 3.9))]
Densosporites sp. (AV 75, AV 78, AV 84)	
cf. *Densosporites* sp. (AV 83)	
Diaphanospora reticulata GUENNEL 1963 (AV 57]	[Middle Frasnian (within *ovalis* - *bulliferus* - zone: ca. ds 2.4 — 4.7)]
Dibolisporites echinaceus (EISENACK) RICHARDSON 1965 (AV 283)	[Emsian — middle Frasnian (in *annulatus-sextantii* (ca. di 12.3) — in *ovalis-bulliferus* (ca. ds 4.3))]
Dibolisporites cf. *D. echinaceus* RICHARDSON 1965 (AV 77)	[see above]
Dibolisporites eifelensis (LANNINGER 1968) MCGREGOR 1973 (AV 77)	[Siegenian — lower Eifelian (*polygonalis* - *emsiensis* (di 6.7) — in *velatus* - *langii* (dm 2.0))]
cf. *Dibolisporites microspicatus* PLAYFORD 1978 (AV 77)	[Late Frasnian — Lower Carboniferous]
cf. *Dibolisporites turriculatus* BALME 1988 (AV 297)	[Late Givetian — Frasnian (*optivus* - *triangulatus*, ca. dm 17.2 — *ovalis-bulliferus*-zone, ca. ds 6.0)]
Dictyotriletes cf. *D. emsiensis* (ALLEN 1965) MCGREGOR 1973 in PLAYFORD 1976 (AV 86)	[upper Siegenian — lowermost Eifelian (ca. di 9.0 — dm 1.1)]
Dictyotriletes cf. *D. emsiensis* (ALLEN 1965, MCGREGOR 1973) MCGREGOR & CAMFIELD 1976 (AV 74)	[Pragian — Eifelian (*polygonalis-emsiensis* (di 6.7) — in *velatus-langii* (ca. dm 2.5))]
Dictyotriletes sp. (AV 47, AV 67, AV 69)	[?Famennian — ? Upper Tournaisian]
Diducites poljessicus (KEDO) VAN VEEN 1981 (AV 73, AV 75, AV 87)	[Early Famennian — in Low. Carboniferous (within *torquata* - *gracilis* (DK 1996: ca. ds 6.4) — L. C.)]
Emphanisporites cf. *E. annulatus* MCGREGOR 1961 (AV 297)	[Emsian — Givetian (*annulatus* - *sextantii* (di 11.2) — near base *optivus* - *triangulatus* (dm 17.4))]
cf. *Emphanisporites decoratus* ALLEN 1965 (AV 77)	[Lower Siegenian — lower Eifelian (near base *polygonalis* - *emsiensis* (ca. di 7.6) — *annulatus-sextantii* (di 19.0)]
Emphanisporites rotatus MCGREGOR 1961 (AV 73)	[Devonian — lower Tournaisian]
Geminospora aurita ARKHANGELSKAYA 1972 (AV 297)	[Frasnian (SD — MR-zone, ca. ds 2.4 — 5.1)]
Geminospora extensa (NAUMOVA 1953) GAO (AV 75)	[Givetian (EX-zone, ca. dm 11.7 — dm 17.7)]
Geminospora cf. *G. extensa* (NAUMOVA 1953) GAO (AV 74, AV 84)	[see above]
Geminospora lemurata (BALME 1962) PLAYFORD 1983 (AV 67)	[Middle Givetian — early Famennian *(lemurata-magn.* (dm 11.7) — in *torquata-grac.* (ca. ds 7.5))]
cf. *Geminospora lemurata* (BALME 1962) PLAYFORD 1983 (AV 77)	[see above]
Geminospora micromanifesta (NAUMOVA 1953) ARKHANGELSKAYA (AV 283)	[Givetian — early Frasnian (EX — SD-zones, approx. equival. to DK1996: ca. dm 11.7 — ds 2.7)]
Geminospora notata (NAUMOVA 1953) OBUKHOVSKAYA (AV 67, AV 283)	[Middle Givetian — early Famennian (EX — CZ - zones; ca. dm 11.7 — ca. ds 10.6)]
cf. *Geminospora notata* (NAUMOVA 1953) OBUKHOVSKAYA (AV 297)	[see above]
Geminospora notata (NAUMOVA 1953) OBUKHOVSKAYA var. *microspinosus* TCHIBRIKOVA (AV 57, AV 87)	[Latest Frasnian — early Famennian (GS — CZ-zone; ca. ds 5.5 — ds 10.6)]
Geminospora tuberculata (KEDO) ALLEN 1965 (AV 283)	[Givetian (EX-zone, ca. dm 11.7 — dm 17.7)]
Geminospora cf. *G. tuberculata* (KEDO) ALLEN 1965 (AV 69)	[see above]

Geminospora tuberculata (Kedo 1955) Allen 1965, maybe var. *micrornata* McGregor & Camfield 1982 (AV 83)	[Givetian (EX-zone of the Eastern European spore zonation, ca. dm 11.7 — dm 17.7)]
Geminospora vasjamica (Tchibrikova) Obukhovskaya & Nekriata 1983 (AV 57, AV 67, AV 75, AV 297)	[Early Famennian (VV — CZ - zone; approximately ds 6.1 — ds 10.6)]
Geminospora cf. *G. vasjamica* (Chibrikova) Obukhovskaya & Nekriata (AV 73, AV 83)	[see above]
cf. *Geminospora venusta?* (Naumova 1953) McGregor & Camfield 1982 (AV 297)	[at least: middle Givetian]
Geminospora sp. (AV 57, AV 67, AV 73, AV 297)	
cf. *Grandispora inculta* Allen 1965 (AV 69)	[Upper Eifelian — upper Frasnian (in *devonicus-naumov.* (dm 4.6) — in *ovalis-bullif.* (ds ca. 5.2))]
Grandispora sp. (AV 57)	
cf. *Hymenozonotriletes celeber* Chibrikova (AV 283)	[Middle Givetian (*lemurata-magnificus*, dm 11.7) — middle Frasnian (in *ovalis-bulliferus*, ca. ds 4.2]
Hystricosporites cf. *H. corystus* (Richardson 1965) Riegel 1973 (AV 69)	[uppermost Emsian — uppermost Givetian (uppermost *annulatus-sextantii* (di ca. 18.5— in *optivus-triangulatus* (dm ca. 18.3)]
Hystricosporites sp. (AV 283)	
Kedoesporis evlanensis (Naumova 1953) Obukhovskaya (AV 77)	[Late Frasnian (upper part of *ovalis-bulliferus* (ca. ds 4.2 — 6.0)]
Lophozonotriletes lebedianensis Naumova 1953 (AV 259)	[Famennian (near base *torquata-gracilis*, ca. ds 7.1 — *lepidophyta-nitidus*, ca. ds 20.0)]
cf. *Lophozonotriletes lebedianensis* Naumova 1953 (AV 283)	[see above]
cf. *Lophozonotriletes magnus* Kedo 1974 (AV 83)	[(?Givetian) Famennian — Lower Tournaisian]
Lophozonotriletes media Taugourdeau-Lantz 1967 (AV 78)	[Early — middle Frasnian (in *optivus-triangularis* (ca. ds 0.5) — in *ovalis-bulliferus* (ca. ds 4.7))]
cf. *Lophozonotriletes media* Taugourdeau-Lantz 1967 (AV 259, AV 282)	[see above]
Lophozonotriletes cf. *L. torosus* Naumova 1953 (AV 297)	[at least: Frasnian (OG-zone, approx. equivalent to the *ovalis-bulliferus*-zone (ca. ds 1.7 — 6.0))]
Punctatisporites sp. (AV 57)	
cf. *Retispora* sp. (AV 57)	
Retusotriletes maculatus McGregor & Camfield 1976 (AV 69)	[Gedinnian — Emsian (*micrornatus - newportensis* (di 0.6) — in *annulatus - sextantii* (di 17.4))]
Retusotriletes sp. (AV 77, AV 297)	
cf. *Spinozonotriletes arduinnae* Riegel 1973 (AV 87)	[U. Emsian — lower Eifelian (*douglastownense - eurypt.* (di 19.0) — in *velatus - langii* (dm 2.5))]
Stenozonotriletes sp. (AV 83)	
Verrucosisporites bulliferus (Taugourdeau-Lantz 1967) Richardson & McGregor 1986 (AV 259, AV 283)	[Frasnian (*ovalis-bulliferus* (ds 1.7)) — late Famennian (in *flexuosa-cornuta* (ca. ds 16.5))]
Verrucosisporites cf. *V. bulliferus* (Taugourdeau-Lantz 1967) Richardson & McGregor 1986 (AV 297)	[see above]
cf. *Verrucosisporites bulliferus* (Taugourdeau-Lantz 1967) Richardson & McGregor 1986 (AV 282)	[see above]
Verrucosisporites evlanensis (Naumova) Obukhovskaya (AV 87)	[Uppermost Frasnian — lowermost Famennian (DE-VV-zones, ca. ds 4.2 — ds 8.1)]
Verrucosisporites premnus Richardson 1965 (AV 87)	[Middle Eifelian — Givetian (*devonicus-naumovii* (dm 3.8) — *optivus-triangularis* (ca. ds 0.5)]
Verrucosisporites sp. (AV 67, AV 283)	

Tab. F 2.2: Synopsis of identified ACRITARCHS AND PRASINOPHYCEAN ALGAE (cysts) in Famennian debris flow sediments from different locations:

Ammonidium ? *alloiteaui* (DEUNFF 1955) MARTIN 1981 (AV 83)	[Devonian]
cf. *Ammonidium* ? *alloiteaui* (DEUNFF 1955) MARTIN 1981 (AV 77)	[see above]
Ammonidium cf. *A. sprucegrovense* (STAPLIN 1961) LISTER 1970 (AV 75)	[Middle Frasnian — Early Famennian (ca. ds 1.7 — ca. 11.3)]
Ammonidium cf. *A. waldronensis* (TAPPAN & LOEBLICH 1971) DORNING 1981 (AV 83)	[Middle — upper Silurian (Wenlockian — lower Ludlowian)]
Ammonidium grosjeani (STOCKMANS & WILLIERE 1969) MARTIN 1981 (AV 77)	[Frasnian (ca. ds 0)— middle Famennian (ca. ds 15.6)]
Ammonidium cf. *hamatum* WICANDER 1974 (AV 87)	[Famennian]
Ammonidium sp. (AV 73, AV 83)	
Baltisphaeridium sp. (AV 77, AV 83)	
Comasphaeridium caesariatum WICANDER 1974 (AV 77)	[Famennian]
Comasphaeridium muscosum WICANDER & PLAYFORD 1985 (AV 75, AV 297)	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
cf. *Comasphaeridium muscosum* WICANDER & PLAYFORD 1985 (AV 77)	[see above]
Cymatiosphaera cf. *C. ambotrocha* WICANDER & LOEBLICH 1977 (AV 297)	[Upper Frasnian — Lower Famennian]
cf. *Cymatiosphaera chelina* WICANDER & LOEBLICH 1977 (AV 57)	[Upper Frasnian — lower Famennian]
Cymatiosphaera labyrinthica WICANDER 1974 (AV 88)	[Famennian]
Cymatiosphaera cf. *C. labyrinthica* WICANDER 1974 (AV 67)	[see above]
Cymatiosphaera limbatisphaera WICANDER & LOEBLICH 1977 (AV 75, AV 77)	[Uppermost Givetian — Famennian]
Cymatiosphaera multisepta DEUNFF 1955 (AV 283)	[Emsian — Givetian]
Cymatiosphaera nebulosa (DEUNFF 1954) DEFLANDRE 1954 (AV 83)	[Silurian — early Famennian]
Cymatiosphaera cf. *nebulosa* (DEUNFF 1954) DEFLANDRE 1954 (AV 74)	[see above]
cf. *Cymatiosphaera octoplana* DOWNIE 1959 (AV 297)	[Silurian (upper Llandoverian — lower Ludlowian)]
Cymatiosphaera cf. *perimembrana* STAPLIN 1961 (AV 84)	[(?Mid. Dev.) Frasnian — ?lowermost Carbonif.)]
Cymatiosphaera sp. (AV 72, AV 75)	
Dictyotidium cavernosulum PLAYFORD 1977 (AV 83, AV 84)	[Emsian]
cf. *Dictyotidium cavernosulum* PLAYFORD 1977 (AV 83)	[see above]
Dictyotidium sp. (AV 83, AV 283)	
cf. *Duvernaysphaera krauseli* (STOCKMANS & WILLIERE) STOCKMANS & WILLIERE 1962 (AV 83)	[at least: lower Famennian]
Elektroriskos dolos WICANDER & LOEBLICH 1977 (AV 75)	[Late Frasnian — middle Famennian (ca. ds 5.4 — ca. ds 16.4)]
Estiastra sp. (AV 83)	
Estriastra rugosa WICANDER 1974 (AV 258)	[Famennian]
Exochoderm triangulata WICANDER & WOOD 1981 (AV 282, AV 283)	[Givetian]
Gorgonisphaeridium absitum WICANDER 1974 (AV 73)	[Famennian]
Gorgonisphaeridium cf. *G. absitum* WICANDER 1974 (AV 75, AV 77, AV 83)	[see above]
Gorgonisphaeridium cf. *G. andrewsi* (STOCKMANS & WILLIERE 1962) MARTIN 1984 nov. comb. (AV 57)	[Uppermost Frasnian (upper *Palmatolepis gigas* — lowermost Famennian (lower *Pa. triangularis*-zone)]
Gorgonisphaeridium echinodermum (STOCKMANS & WILLIÉRE 1963) EISENACK, CRAMER & DIEZ 1979 (AV 297)	[Silurian (— ? Lower Devonian)]
Gorgonisphaeridium evexispinosum WICANDER 1974 (AV 74, AV 77)	[Frasnian — Viséan]
Gorgonisphaeridium cf. *G. evexispinosum* WICANDER 1974 (AV 74)	[see above]
Gorgonisphaeridium plerispinosum WICANDER 1974 (AV 69, AV 74, AV 75, AV 83)	[upper Frasnian — Famennian; — ? Tournaisian]
Gorgonisphaeridium telum WICANDER & PLAYFORD 1985 (AV 57, AV 75, AV 83, AV 297)	[up to now only known from: late Frasnian (lower *Palmatolepis gigas* - zone, at least: ds 4.2 — 5.1)]
Gorgonisphaeridium cf. *G. telum* WICANDER & PLAYFORD 1985 (AV 73)	[see above]
cf. *Gorgonisphaeridium telum* WICANDER & PLAYFORD 1985 (AV 69)	[see above]

Gorgonisphaeridium sp. (AV 73-3, 41.3/98.4, AV 83-2, 25.0/105.5)	
Leiofusa estrecha CRAMER 1964 (AV 283)	[Silurian]
Leiofusa exilata DORNING 1981 (AV 283)	[Upper Silurian (lower Ludlowian)]
Leiofusa cf. *L. exilata* DORNING 1981 (AV 69)	[see above]
Leiofusa pumilia DEUNFF 1966 (AV 283, AV 283)	["Upper Devonian of Tunisia"]
Leiofusa pyrena WICANDER & WOOD 1981 (AV 69)	[Givetian]
Leiofusa cf. *L. pyrena* WICANDER & WOOD 1981 (AV 69)	[see above]
Leiofusa sp. (AV 76, AV 282, AV 283)	
Lophosphaeridium galeatum (HILL 1974) LE HERISSE 1989 (AV 297)	[Silurian (upper Llandoverian — Wenlockian)]
Lophosphaeridium segregum PLAYFORD 1981 (AV 72, AV 73, AV 75, AV 77, AV 84)	[Frasnian — Visean]
Lophosphaeridium sp. (AV 73, AV 74, AV 77, AV 83, AV 283)	
Maranhites stockmansi MARTIN 1981 (AV 75)	[Late Frasnian (? *Pa. gigas*-zone) — early Famennian (? *Pa. crepida*-zone)]
Maranhites sp. (AV 75)	
Micrhystridium coronatum STOCKMANS & WILLÉRE 1963 (AV 283)	[Frasnian — early Famennian (ca. ds 15.6)]
Micrhystridium erugatum WICANDER 1974 (AV 86)	[Famennian]
Micrhystridium sp. (AV 69)	
Multiplicisphaeridium rakoe (STOCKMANS & WILLIERE 1969) DIEZ & CRAMER 1977 (AV 69)	[Early Famennian (*torquata-gracilis,* ca. ds 6.0 — in *flexuosa cornuta*, ca. ds 16.5)]
cf. *Muraticavea enteichia* WICANDER 1974 (AV 75)	[Famennian]
Navifusa bacillum (DEUNFF 1955) PLAYFORD 1977 (AV 69, AV 78, AV 84, AV 86, AV 88, AV 259, AV 282)	[late Pragian — Lower Carboniferous (Tournaisian)]
Navifusa bacillum crescentis COMBAZ, LANGE & PANSART 1967 [but compare PLAYFORD 1977: 29 for discussion of *N. bacillum*] (AV 78, AV 259, AV 259)	[at least: Frasnian (of Lybia)]
Onondagaella asymmetrica (DEUNFF 1954) CRAMER 1966 (AV 77, AV 258, AV 282, AV 283)	[? Upper Silurian (Ludlowian) — Lower Devonian]
cf. *Palacanthus ledanoisii* (DEUNFF 1957) PLAYFORD 1977 (AV 78)	[Emsian — Frasnian]
Polyedrixium pharaonis DEUNFF 1961 (AV 69, AV 282)	[Devonian]
cf. *Polyedrixium pharaonis* DEUNFF 1961 (AV 297)	[see above]
Pterospermella cf. *P. radiata* WICANDER 1974 (AV 282)	[Famennian]
Pterospermella tenellula PLAYFORD 1981 (AV 67, AV 69)	[Frasnian — Early Famennian]
Pterospermella sp. (AV 67, AV 283)	
Puteoscortum williereae MARTIN 1981 (AV 83)	[Early Famennian (*Palm. triangularis*-zone — ?)]
Solisphaeridium astrum WICANDER 1974 (AV 86)	[Famennian]
Solisphaeridium spinoglobosum (STAPLIN 1961) WICANDER 1974 (AV 77)	[? Silurian — Devonian (mostly reported from Upper Devonian deposits)]
Stellinium cf. *S. comptum* WICANDER & LOEBLICH 1977 (AV 75)	[Givetian — early Famennian]
cf. *Stellinium micropolygonale* (STOCKMANS & WILLIÉRE) PLAYFORD 1977 (AV 283)	[Upper Emsian — Tournaisian]
Tapajonites sp. I in MARTIN 1984, pl. 7, fig. 9 (AV 67)	[Early Famennian]
Tasmanites sp. in WICANDER 1974, pl. 19, fig. 11 (AV 67, AV 75, AV 77)	[at least: Famennian]
Tasmanites sp. (AV 84, AV 86)	
Unellium cf. *U. elongatum* WICANDER 1974 (AV 75)	[Famennian — Lower Mississippian]
cf. *Unellium* cf. *U. piriforme* RAUSCHER 1965 (AV 69)	[? Lower Devonian — Famennian]
Veryhachium downiei STOCKMANS & WILLIERE 1962 (AV 87)	[Upper Silurian — Devonian]
Veryhachium reductum DEUNFF 1958 (AV 282)	[Silurian — ?Emsian]
Veryhachium sp. (AV 69-1, 40.5/111.6, (AV 297)	
Villosacapsula sp. (AV 69, AV 73, AV 86, AV 258)	
Visbysphaera cf. *V.* n. sp. A MARTIN 1982 (AV 69)	[Late Frasnian (ca. *Pa. gigas*-zone, ca. ds 4.2 — 6.0)]
cf. *Visbysphaera* n. sp. A MARTIN 1982 (AV 282)	[see above]
Winwaleusia ranulaeforma MARTIN 1984 (AV 75, AV 282)	[Late Frasnian (? *Pa. gigas*-zone, ca. ds 4.2) — early Famennian (? *Pa. crepida*-zone, ca. ds 10.6)]
cf. *Winwaleusia ranulaeforma* MARTIN 1984 (AV 76)	[see above]
Winwaleusia sp. (AV 283)	

Tab. F 2.3: Synopsis of identified CHITINOZOANS in Famennian debris flow sediments from different locations:

Ancyrochitina cf. *A. aequoris* URBAN & KLINE 1970 (AV 282)	[upper Middle Devonian (probably Givetian)]
Cyathochitina ? *infundibuliformis* TAUGOURDEAU & JEKHOWSKY 1960 in MARTIN 1982 (AV 258, AV 283)	[Devonian]
Cyathochitina ? cf. *C.*? *infundibuliformis* TAUGOURDEAU & JEKHOWSKY 1960 in MARTIN 1982 (AV 258)	[Devonian]
Desmochitina cf. *D. aranea* URBAN 1972 (AV 69)	[Upper Middle Devonian (lower Givetian)]
Desmochitina EISENACK 1931 sp. (AV 83, AV 282)	[at least: Middle Devonian]
cf. *Margachitina* EISENACK 1968 sp. (AV 86)	[? Upper Silurian — ? lower Lochkovian]
Sphaerochitina cf. *S. sphaerocephala* (EISENACK) EISENACK 1955 in MARTIN 1982, page 12, pl. 3 (AV 259)	[Silurian (Wenlockian) — Upper Devonian]
Chitinozoa indet. (AV 84, AV 86)	[probably reworked Silurian species]

Tab. F 2.4: Synopsis of identified SCOLECODONTS in Famennian debris flow sediments from different locations:

Scolecodont, indet. (AV 282, AV 283)

F 3 Drill core descriptions, for drill sites directly north of Limburg

Information is given in the following order:

LEGEND to the drill site descriptions
BK 2010 / 036 (mainly debris flow, Famennian)
BK 2010 / 128 (mainly pyroclastic deposits, Lower - Middle Devonian)
BK 2010 / 130 (mainly debris flow, Famennian)
BK 2010 / 132 (mainly debris flow, Famennian)
BK 2010 / 137 (mainly debris flow, Famennian)
BK 2010 / 138 (mainly Bruchberg sandstone formation; late Viséan)
BK 2010 / 139 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 01A (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 04 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 05 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 07 (mainly Bruchberg sandstone formation; late Viséan)
BK 3005 / 01 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 09 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 10 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 13 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 14 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 15 (mainly Bruchberg sandstone formation; late Viséan)
BK 3004 / 17 (mainly Bruchberg sandstone formation; late Viséan)

See chapter C 12 for a map with drill site locations and a geological cross section with a synopsis of obtained results.

Drill site: near Limburg. Preparatory drillings for the planning of a tunnel for the new railway-line Cologne-Frankfurt /M.
Apparent thickness of Palaeozoic sediments: vertical drill core thickness.
Thickness when bedding rotated to zero dip: model thickness normal to bedding.
Calculation:
a) dip < 45°: "true" thickness = cos (dip X°) x (core-length of interest)
b) dip > 45°: "true" thickness = sin (dip Y°) x (core-length of interest)
Lateral extension of the sedimentary facies: by rotating the bedding to zero dip we obtain an additional information about the minimum lateral extension of the sedimentary facies. But a problem arises: either a) we conclude the facies remained laterally steady for some time, or b) small scale lateral variations are not detectable (i. e. the documented depositional place remained not immobile, but has "moved" laterally through time).
Calculation:
a) dip < 45°: lateral extension = sin (dip X°) x (core-length of interest)
b) dip > 45°: lateral extension = cos (dip Y°) x (core-length of interest)

Dip-variation: X - Y° within the whole drill core. Where possible, dip data obtained from the core and presented herein. Dip-directions not obtainable since no oriented core samples had been taken. Mostly only cleavage-data obtainable; for easier modelling it is assumed, that the cleavage (s) lies subparallel to bedding (ss). This is in gross accordance with observations at outcrops nearby.

model mean: Dip-values used for the creation of the model graphic log (where bedding is rotated to zero dip).

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data	→	Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment

Preservation:
1 - good; core nearly complete
2 - good; core partly shattered
3 - medium; bleaching & disaggregation along fractures
4 - mixed; partly good, partly oxidized/disaggregated within the matrix
5 - insufficient; oxidation and disaggregation prevails

Core colour:
O - brown
G - grey
B - black
Y - yellowish
R - reddish
E - greenish
l - light
m - medium
d - dark

AV - samples:
AV - André Vogt
grey shading shows sample range.

Maceration:
grey point when treatment with hydroflouric acid.

Fossils:
fossils found after treatment with HF
acritarchs:
spores:
chitinozoans:
scolecodonts:

TAI:
Thermal Alteration Index
(determined on spore-colour)

Short description:
of the sedimentary inventory.
Cl - clay
Si - silt
S - sand
G - gravel
X - stone
Capital letters define major, small letters minor, components in ascending order of importance.
f - fine, m - medium, c - coarse

Graphic visualization of data obtained during close core observation.
Presentation of data starts always with the beginning of Palaeozoic sediments.

Light-dark changes between different laminae/layers at µm to cm-scale (cyclic sequences).

Graphic visualization of calculated data obtained by rotation of the bedding-surfaces to zero dip. Presentation only for Palaeozoic sediments.

Comments directly related to the original drill core graphic log.

(This is due to the larger space available for comments along this log.)

Fault
Fault zone
Traces of bedding
Lithology A intercalated by B
Debris flow, coarse grained
Sand with pelite clasts
Sand
Silt, clayey
Clay, silty
Flinty slate
Pyroclastic deposits, partly reworked

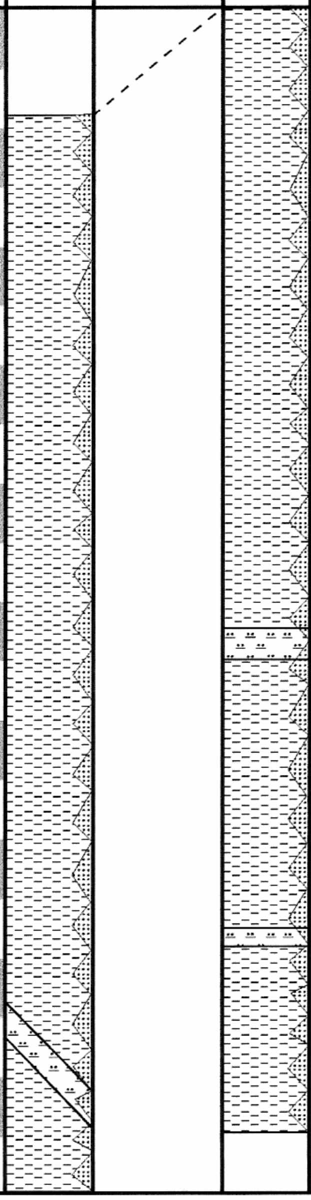
LEGEND to the drill site descriptions

Drill site: BK 2010 / 036
Initiator: Deutsche Bahn AG
Date: 17.09. - 23.09.1993
Location: E 3434781.75 N 5584536.40
Height: 167.52 m a.s.l.
Depth: 35 m
Apparent thickness of Palaeozoic sediments: 33.2 m
Thickness when bedding rotated to zero dip: 18.9 m
Lateral extension of the sedimentary facies: 14.8 m

Dip-variation: 45 - 70° (assumed: s subparallel ss)	model mean:
1.8 m - 18.7 m: s ~ 45°	45°
- 26.9 m: s ~ 60 - 70° - 35.0 m: s ~ 70°	65°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]
	YO B IG O					Fill (G, s, si) Fill (G: tar) Fill (G, s) Fill ? (G, si, s & sandstone-components)	
3 4 5	lO mO G					Cl, si with fs-lenses & -flasers	5
2 3 4	lG mG dG	58 59					10 15
	EG	60				Si, fs	
	lG mG dG	61				Cl, si with fs-lenses & -flasers	
1 2	dG	62					

Graphic log: raw data → Graphic log: bedding rotated to zero dip



Sedimentation processes & interpretation of the palaeoenvironment

Tar Fill Fill (tar fragments) Fill Fill (or drift ?)	Artificial fills

Deposition of clay/silt from suspension punctuated by sudden incursions of silt/sand by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay-silt sediment pile along a slope. Carriage of large volumes of these sediments onto the deeper sea floor, deposition when a reduction in slope caused deceleration. Most striking sedimentary features: plastic deformation prior to tectonic deformation, ungraded and mostly disorganised fabric, although original bedding features are sometimes still observable.
Finegrained DEBRIS FLOW.
AGE: Early Famennian (with redeposited sediments of the middle-late Frasnian, Givetian and Emsian).

Larger siltstone component within the debris flow.

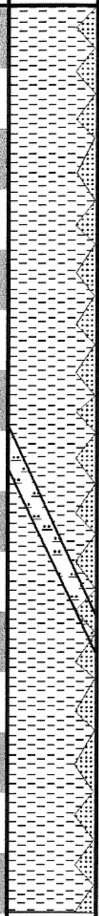
Finegrained DEBRIS FLOW.

Drill site: BK 2010 / 036
Initiator: Deutsche Bahn AG
Date: 17.09. - 23.09.1993
Location: E 3434781.75 N 5584536.40
Height: 167.52 m a.s.l.
Depth: 35 m
Apparent thickness of Palaeozoic sediments: 33.2 m
Thickness when bedding rotated to zero dip: 18.9 m
Lateral extension of the sedimentary facies: 14.8 m

Dip-variation: 45 - 70°
(assumed: s subparallel ss)

	model mean:
1.8 m - 18.7 m: s ~ 45°	45°
- 26.9 m: s ~ 60 - 70°	65°
- 35.0 m: s ~ 70°	

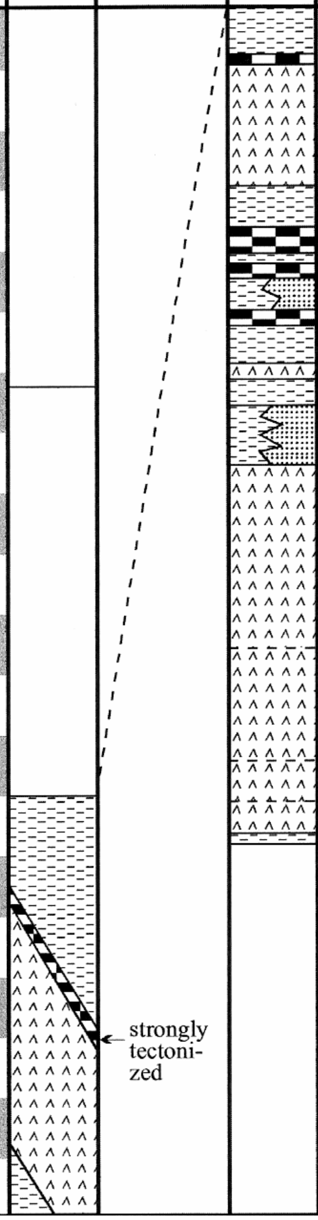
Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data →	Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
1 2 (3)	dG B	63, 64, 65, 66, 67, 68, 69	● (67), ● (69)	✿⊗ (67), ✿⊗ (69)	4-5 (67), 4-5 (69)	Cl, si with fs-lenses & -flasers	25			Debris flow with finegrained components. (Originally deposition of clay from suspension, often punctuated by sudden incursions of silt, finesand and -partly- greywacke probably by turbidity currents of waning strength.) AGE: Early Famennian (with redeposited sediments of the middle-late Frasnian, Givetian and Emsian) (Greywacke clasts plastic deformed, i. e. not yet lithefied at the time of redeposition)
	G					Si, fs		+ greywacke clasts		Larger siltstone component within the debris flow.
	dG B					Cl, si with fs-lenses & -flasers	30, 35			Finegrained DEBRIS FLOW.



Drill site: BK 2010 / 128 Initiator: Deutsche Bahn AG Date: 27.06. - 29.06.1994 Location: E 3434736.33 N 5584730.37 Height: 167.30 m a.s.l. Depth: 40.40 m Apparent thickness of Palaeozoic sediments: 27.4 m Thickness when bedding rotated to zero dip: 13.7 m Lateral extension of the sedimentary facies: 23.7 m	**Dip-variation: ~ 60°** (assumed: s subparallel ss) 40.3 - 40.4 m: s ~ ss ~ 60°	**model mean:** 60°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]
	O					Fill (Si, cl, s, organic matter)	
	O G					Fill (basalt gravel, concrete pelites)	
	GE lG					Fill (slates: Cl, si, g)	5
	O					Fill (G, S, cl, si)	
	lG					Fill (concrete)	
4 5	YO					Si, cl g (flinty slates)	
	OE OR					Cl, si g (pelites)	10
	OY OR					Si, cl; g (flinty slates, pelites)	
	OY					Cl, si	
4	G					Cl, siliceous slates	15
5	OY OR					Si (pyroclastics) laminated / flaggy layering < 2 cm	
4						Cl, si	

Graphic log: raw data → **Graphic log: bedding rotated to zero dip**



Sedimentation processes & interpretation of the palaeoenvironment

Artificial fills (material used for filling ditches or hollows in the ground, esp. in the vicinity of fundaments for the plant at this site)

? Tertiary sediments (probably dislocated; due to bad preservation no reconstruction of the palaeoenvironment possible)

Deposition of clay from suspension, punctuated by incursions of silt by currents. Basinal marine environment.

The enhanced silica content is maybe produced by primary siliceous oozes, deposited under low-energy conditions. The oozes became temporarily protected from coarser sediment influx by the relief build up by the volcanic sediments.

Eruption of magma into, or through, seawater. Fragmentation of magma by submarine volcanic activity; it comprises fragments of juvenile lava, crystals and lithic fragments. No distinction between fall or flow deposit possible due to palagonitization and weathering.
PYROCLASTIC DEPOSIT of a keratophyric magma. Age: Emsian or Givetian (?Famennian).

Deposition of clay from suspension, punctuated by incursions of silt by currents. Basinal marine environment.

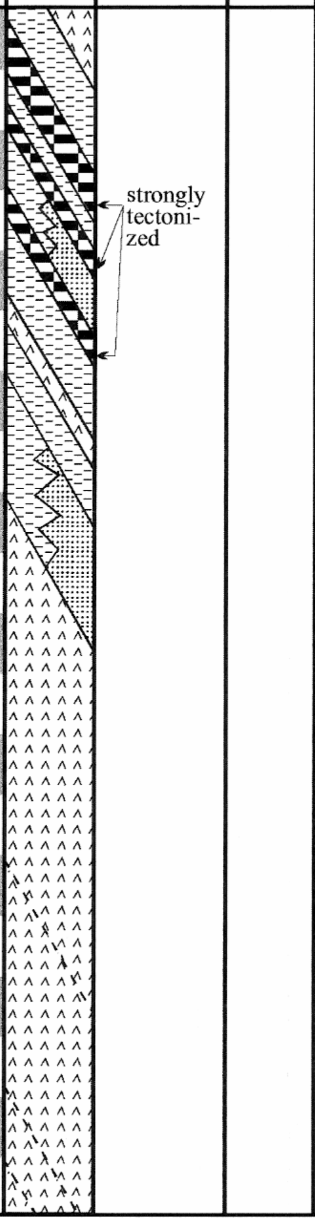
Drill site: BK 2010 / 128
Initiator: Deutsche Bahn AG
Date: 27.06. - 29.06.1994
Location: E 3434736.33 N 5584730.37
Height: 167.30 m a.s.l.
Depth: 40.40 m
Apparent thickness of Palaeozoic sediments: 27.4 m
Thickness when bedding rotated to zero dip: 13.7 m
Lateral extension of the sedimentary facies: 23.7 m

Dip-variation: ~ 60°
(assumed: s subparallel ss)
40.3 - 40.4 m: s ~ ss ~ 60°

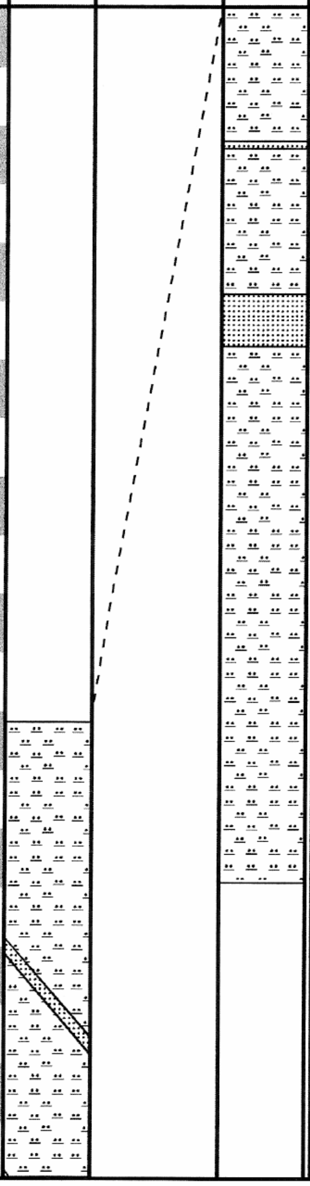
model mean: 60°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Sedimentation processes & interpretation of the palaeoenvironment
4 5	GY					Cl, partly siliceous slates		Deposition of primary siliceous oozes, protected from coarser sediment influx, under low-energy conditions.
	OY					Cl, si		Deposition of clay from suspension, punctuated by incursions of silt by currents.
	G					Cl, siliceous slates		Deposition of primary siliceous oozes ... (s. above)
	OR					Cl, si, intercalated by fS-layers		Deposition of clay from suspension, punctuated by sudden (?turbiditic, seismic. induced) incursions of silt and finesand. Basinal marine environment.
	dG					Cl, partly siliceous slates		Deposition of primary siliceous oozes ... (s. above)
	OR					Cl, si		Deposition of clay from suspension, punctuated by incursions of silt by currents. Basinal marine environment.
4						Si (pyroclast.)	25	PYROCLASTIC DEPOSIT (keratophyric magma)
5	O					Cl, si		Deposition of clay from suspension, punctuated by incursions of silt by currents. Basinal marine environment.
						Cl, si, intercalated by fS-layers		Deposition of clay from suspension, punctuated by sudden (?turbiditic, seismically induced) incursions of silt and finesand. Basinal marine environment.
4 (5)	O G					Cl, si (pyroclastics)	30	Eruption of magma into, or through, seawater. Fragmentation of magma by submarine volcanic activity; it comprises fragments of juvenile lava, crystals and lithic fragments. No distinction between fall or flow deposit possible due to palagonitization and weathering. PYROCLASTIC DEPOSIT of a keratophyric magma. Age: Emsian or Givetian (?Famennian).
	IO G					Si, cl (pyroclastics)	35	? Grading (decreasing grain size) ? due to decreasing strength of the volcanic eruption (? single event)
	G O R					Si (pyroclast.) laminat./flaggy layering < 2 cm		
	G R	71				fS (pyroclast.) - 40.4 m		

Graphic log: raw data → Graphic log: bedding rotated to zero dip



Drill site: BK 2010 / 130 Initiator: Deutsche Bahn AG Date: 20.06. - 23.06.1994 Location: E 3434809.35 N 5584655.27 Height: 166.36 m a.s.l. Depth: 35.50 m Apparent thickness of Palaeozoic sediments: 23.2 m Thickness when bedding rotated to zero dip: 14.9 m Lateral extension of the sedimentary facies: 17.8 m	**Dip-variation: ~ 50°** (assumed: s subparallel ss)	**model mean:** 50°

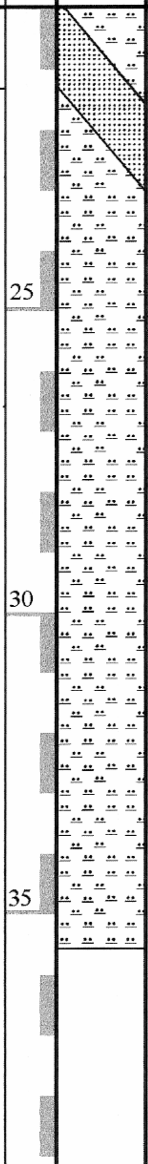
Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data → Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment	
	B G					Fill (m-c G, x basalt fragments)			Tar surface above artificial fill	
	l-m O					Si, f-mG (Sandstones, flinty slates, sandy slates (flaggy layered))			Gravelly channel bar deposit	Quaternary sediments Old terraces of the river Lahn: stream flow deposits
	lO GO					Si, fs (dense)			Deposition from suspension with episodic decelerating flows	
	mO					Si, fG, fs, x	5		Gravelly channel bar deposit ? masked by finer sediment laid down during falling river stage	
	YO RO					Si (dense)			Deposition from suspension with episodic decelerating flows	
	G-B					X, G, si (fragments of flinty slates)			Gravelly channel bar deposits. Varying grain sizes due to varying energy regimes within the river, maybe with lateral migration of bedform features (falling/rising river stage).	
	YO					Si, fs, fg				
	G-B					X, G, si (fragments of flinty slates)				
	YO					Si, f-mg, s, x				
	O					f-mG, cS, si	10			
	YO RO					Si, fs, g (reworked fragments of pelites)			Flood plain deposits ? With subaerially dried mud-chips which became reworked during flooding periods ?	
4 5	YO					Si, fs, cl flaser-like to streaked texture	15		Deposition of clay from suspension punctuated by sudden incursions of silt by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay-silt sediment pile along a slope. Carriage of large volumes of these sediments onto the deeper sea floor, deposition when a reduction in slope caused deceleration. Most striking sedimentary features: plastic deformation prior to tectonic deformation, ungraded and mostly disorganised fabric, although original bedding features are sometimes still observable. DEBRIS FLOW. Age: probably early Famennian (compare BK 2010/132).	
						fS, si				
						Si, fs, cl flaser-like to streaked texture				

Drill site: BK 2010 / 130
Initiator: Deutsche Bahn AG
Date: 20.06. - 23.06.1994
Location: E 3434809.35 N 5584655.27
Height: 166.36 m a.s.l.
Depth: 35.50 m
Apparent thickness of Palaeozoic sediments: 23.2 m
Thickness when bedding rotated to zero dip: 14.9 m
Lateral extension of the sedimentary facies: 17.8 m

Dip-variation: ~ 50°
(assumed: s subparallel ss)

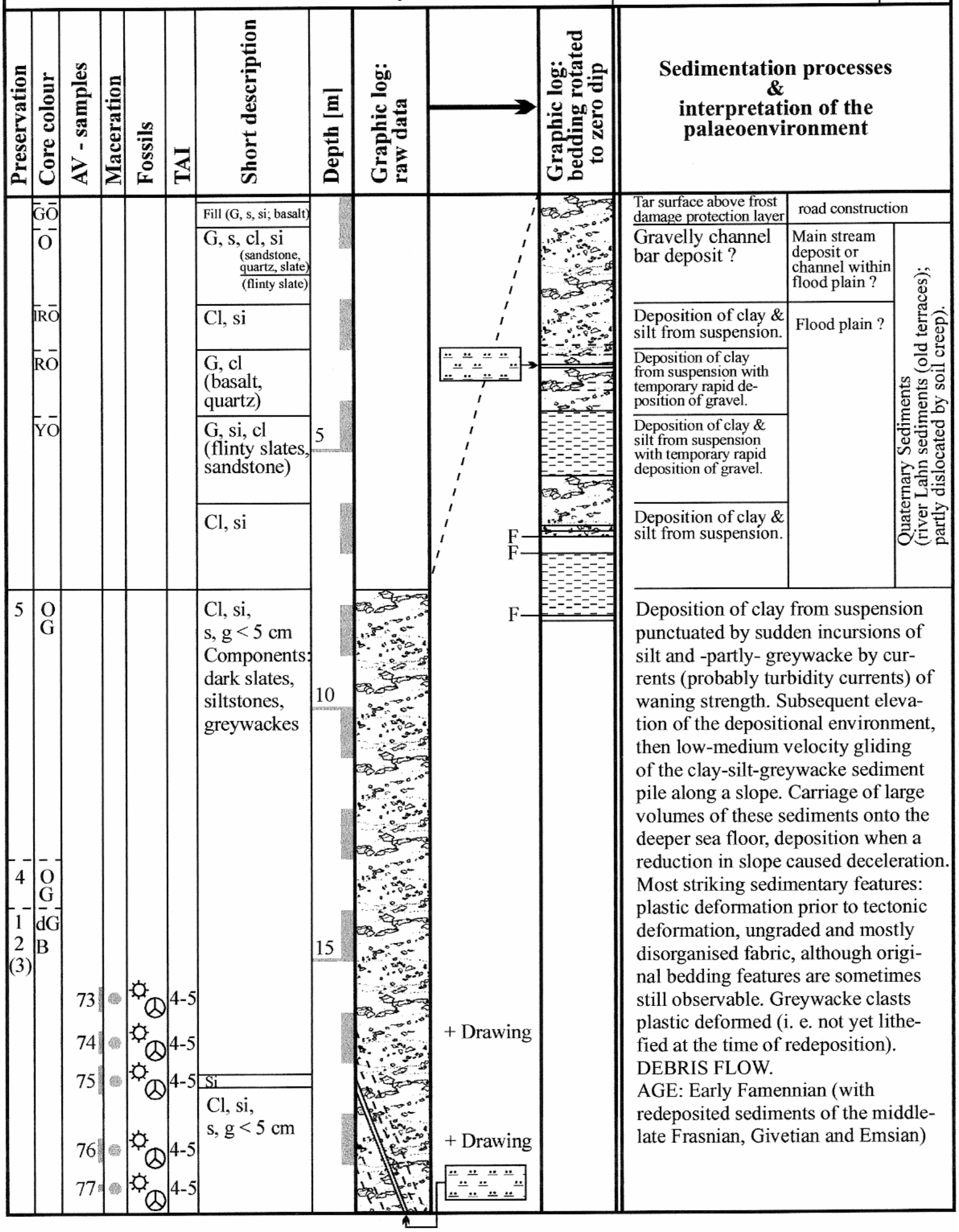
model mean: 50°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data	→	Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
4	YO					fS, si very thin - thin bedded					Large sandstone component (deposits of distal turbidity currents?) of unknown age within the debris flow.
						Si, s					Debris flow with silt-, partly sand-, sized components.
	GO dG					Si, cl, fs flaser-like parly layered texture	25				Debris flow with finegrained components. (Originally deposition of clay from suspension, often punctuated by sudden incursions of silt and finesand (layered texture) by currents (probably turbidity currents) of waning strength.)
						Si, fs, cl flaser-like texture	30				
							35				
		72	●	☮	4-5						(Spores of middle-late Frasnian age; interpreted as components of reworked pelites.)



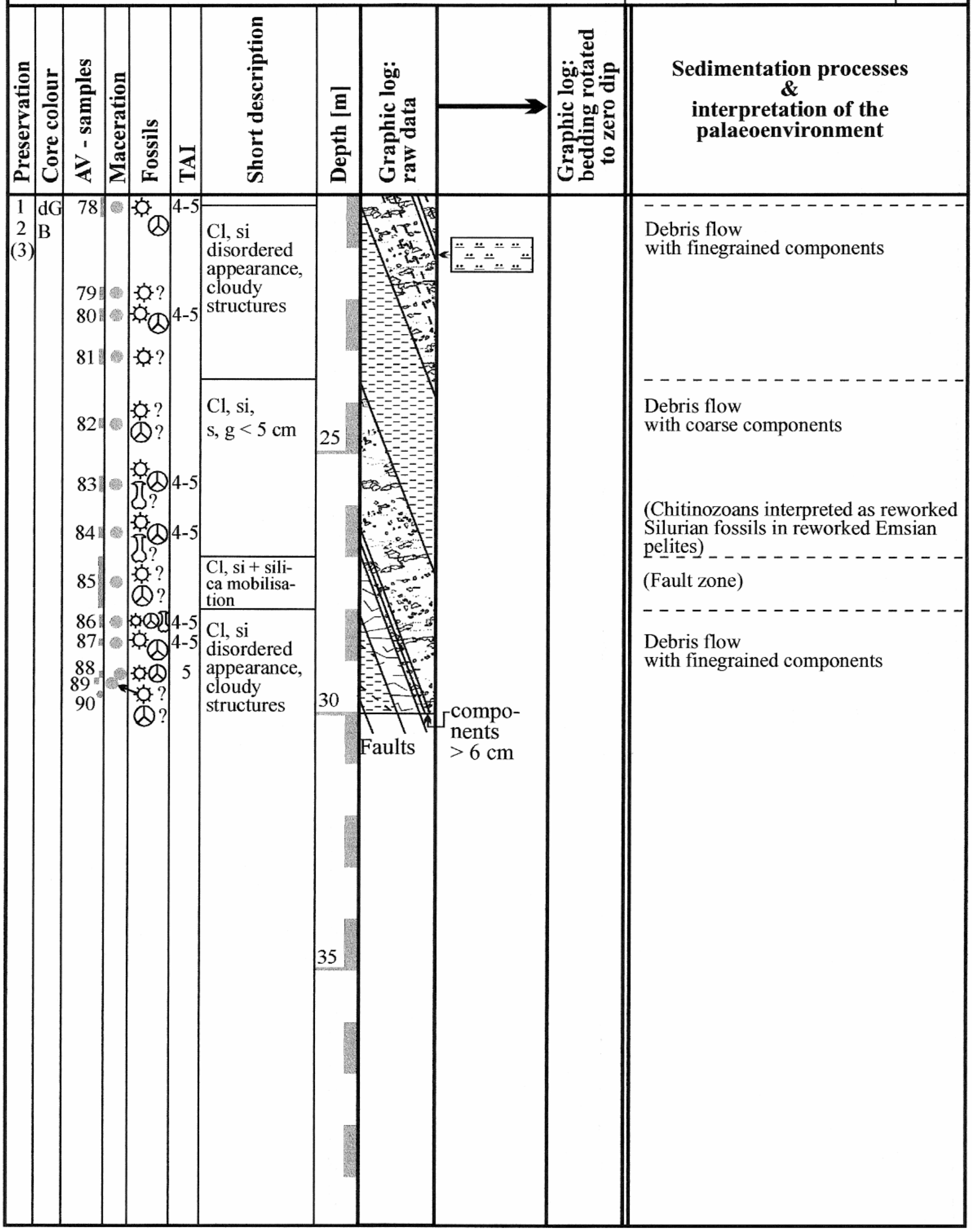
Drill site: BK 2010 / 132
Initiator: Deutsche Bahn AG
Date: 26.07. - 04.08.1994
Location: E 3434954.91 N 5584540.64
Height: 166.77 m a.s.l.
Depth: 30.0 m
Apparent thickness of Palaeozoic sediments: 22.3 m
Thickness when bedding rotated to zero dip: 8.2 m
Lateral extension of the sedimentary facies: 20.4 m

Dip-variation: 40 - 80° (assumed: s subparallel ss)	**model mean:**
11.6 - 13.3m: s ~ 60°-80°	70°
15.0 - 20.5m: s ~ 70°-80° 17.0m: s ~ 60°-70° 16.3 - 16.7m: ss ~ 68° 18.4 - 18.8m: ss ~ 70° 20.05 - 20.3m: ss ~ 65° 21.8 - 22.0m: s ~ 70°	70°
26.4 - 26.6m: ss ~ 70° 28.1 - 28.3m: s ~ 55° 28.6 - 28.7m: ss ~ 40° 29.2 - 29.3m: ss ~ 60°	40°



Drill site: BK 2010 / 132
Initiator: Deutsche Bahn AG
Date: 26.07. - 04.08.1994
Location: E 3434954.91 N 5584540.64
Height: 166.77 m a.s.l.
Depth: 30.0 m
Apparent thickness of Palaeozoic sediments: 22.3 m
Thickness when bedding rotated to zero dip: 8.2 m
Lateral extension of the sedimentary facies: 20.4 m

Dip-variation: 40 - 80° (assumed: s subparallel ss)	**model mean:**
11.6 - 13.3m: s ~ 60°-80°	70°
15.0 - 20.5m: s ~ 70°-80° 17.0m: s ~ 60°-70° 16.3 - 16.7m: ss ~ 68° 18.4 - 18.8m: ss ~ 70° 20.05 - 20.3m: ss ~ 65° 21.8 - 22.0m: s ~ 70°	70°
26.4 - 26.6m: ss ~ 70° 28.1 - 28.3m: s ~ 55° 28.6 - 28.7m: ss ~ 40° 29.2 - 29.3m: ss ~ 60°	40°



Drill site: BK 2010 / 137
Initiator: Deutsche Bahn AG
Date: 09.08. - 22.08.1995
Location: E 3434940.51 N 5584564.49
Height: 167.76 m a.s.l.
Depth: 35.2 m
Apparent thickness of Palaeozoic sediments: 34.1 m
Thickness when bedding rotated to zero dip: 19.6 m
Lateral extension of the sedimentary facies: 16.1 m

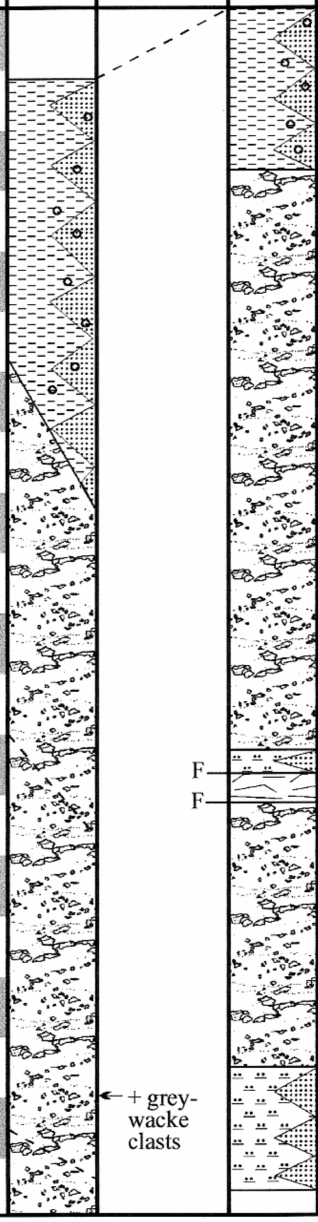
Dip-variation: 40 - 60°
(assumed: s subparallel ss)
5.8 - 12.0 m: s ~ 60°
12.0 - 22.3 m: s ~ 40 - 60°
28.0 - 31.5 m: s ~ 45 - 60°
31.5 - 35.2 m: s ~ 50 - 60°

Oriented core samples taken at 18.35m - 19.6 m; one reading for dip-direction & dip obtained:
18.4 - 18.5 m:
s parallel ss = 077°/39°

model mean: 55°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Sedimentation processes & interpretation of the palaeoenvironment
	GO					G, s, si, x		Top-soil & soil-creep deposits — Quaternary sediments
	GO RO					Si, g, s, x (quartz & flinty slates)		River Lahn deposits (old terrace) ? — Quaternary sediments
5	G GO					Cl, si, g, fs, x (weathered slate with fs-flasers & single g-size clasts)	5	Debris flow with, mostly, finegrained components, weathered.
3 4		93 94 95 96 97 98 99 100 101 102 103 104 105 106 107				Si, Cl, g, s, x Components: dark slate, siltstone, partly greywacke.	10 15	Deposition of clay from suspension punctuated by sudden incursions of silt and -partly- greywacke by currents (probably turbidity currents) of waning strength. Subsequent elevation of the depositional environment, then low-medium velocity gliding of the clay-silt-greywacke sediment pile along a slope. Carriage of large volumes of these sediments onto the deeper sea floor, deposition when a reduction in slope caused deceleration. Most striking sedimentary features: plastic deformation prior to tectonic deformation, ungraded and mostly disorganised fabric, although original bedding features are sometimes still observable. Greywacke clasts plastic deformed (i. e. not yet lithefied at the time of redeposition). DEBRIS FLOW. AGE: probably early Famennian (with redeposited sediments of the middle-late Frasnian, Givetian and Emsian).

Graphic log: raw data → Graphic log: bedding rotated to zero dip



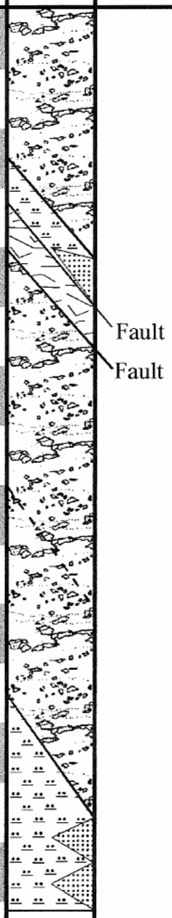
Drill site: BK 2010 / 137
Initiator: Deutsche Bahn AG
Date: 09.08. - 22.08.1995
Location: E 3434940.51 N 5584564.49
Height: 167.76 m a.s.l.
Depth: 35.2 m
Apparent thickness of Palaeozoic sediments: 34.1 m
Thickness when bedding rotated to zero dip: 19.6 m
Lateral extension of the sedimentary facies: 16.1 m

Dip-variation: 40 - 60°
(assumed: s subparallel ss)
5.8 - 12.0 m: s ~ 60°
12.0 - 22.3 m: s ~ 40 - 60°
28.0 - 31.5 m: s ~ 45 - 60°
31.5 - 35.2 m: s ~ 50 - 60°

Oriented core samples taken at 18.35m - 19.6 m; one reading for dip-direction & dip obtained:
18.4 - 18.5 m:
s parallel ss = 077°/39°

model mean: 55°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data	→ Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
	G GO	108 109 110				Si, Cl, g, s, x Components: dark slate, siltstone, partly greywacke.				Debris flow with coarse components.
	lG mG	111				Si, cl, fs				Debris flow with finegrained components.
						Core loss				Fault zone
	G GO	112 113 114 115				Cl, si, g, s, x Components: dark slate, siltstone, partly greywacke.	25 30			Debris flow with coarse components.
	G					Si, cl, fs	35			Debris flow with finegrained components.



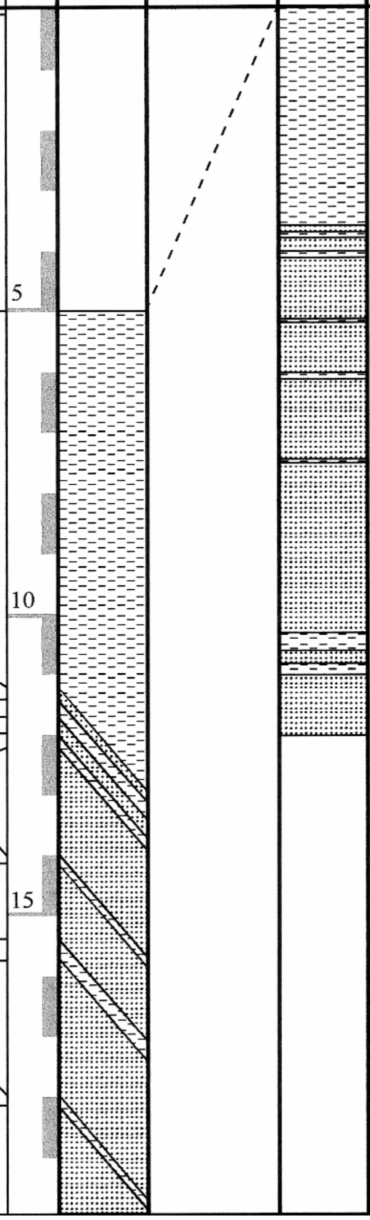
Drill site: BK 2010 / 138
Initiator: Deutsche Bahn AG
Date: 01.11. - 10.11.1995
Location: E 3434961.50 N 5584484.57
Height: 163.07 m a.s.l.
Depth: 26.0 m
Apparent thickness of Palaeozoic sediments: 21.0 m
Thickness when bedding rotated to zero dip: 12.0 m
Lateral extension of the sedimentary facies: 17.2 m

Dip-variation: 55°
(assumed: s subparallel ss)
18.1 - 20.1 m:ss ~ 55°

model mean: 55°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description
4 5	G O					X, g, s (dominated by subrounded quartzitic sandstone)
						Cl, si
	G RO					
	lG					fS, si
	G/O					Cl, si
	lG					fS, si
	G/O					Cl, si
	lG					fS, si
	G/O					Cl, si
	lG					fS, si
	G/O					Cl, si
	lG					fS, si
	G/O					Cl, si
	lG					fS, si

Depth [m] | **Graphic log: raw data** → **Graphic log: bedding rotated to zero dip**



Sedimentation processes & interpretation of the palaeoenvironment

Weathered Bruchberg sandstone and soil creep deposits, maybe with dislocated material of river Lahn sediments (old terraces). — Quaternary deposits

Deposition of clay from suspension punctuated by sudden incursions of silt by currents (maybe turbidity currents) of waning strength. Basinal background sedimentation of the Bruchberg sandstone formation (late Viséan)?

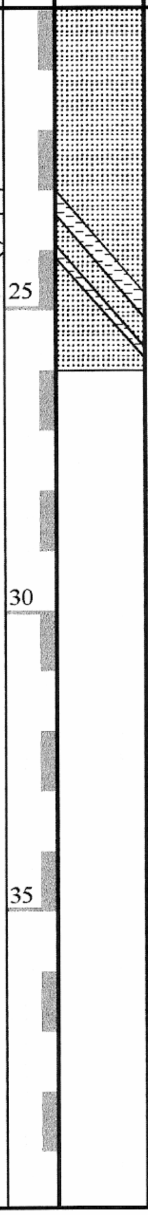
Deposition of massive, sometimes graded, fine- to medium grained sand. Resulting from rapid deposition from suspension with little or nor bed transport (probably turbidity current, "BOUMA (1962) A" sequence).
With intercalations of:
Layers of clay to finesilt. Resulting from suspension in quiet water or from slow currents with dilute suspensions (probably turbidity current, "BOUMA (1962) E (D)" sequence).
Bruchberg sandstone formation: late Viséan.

Drill site: BK 2010 / 138
Initiator: Deutsche Bahn AG
Date: 01.11. - 10.11.1995
Location: E 3434961.50 N 5584484.57
Height: 163.07 m a.s.l.
Depth: 26.0 m
Apparent thickness of Palaeozoic sediments: 21.0 m
Thickness when bedding rotated to zero dip: 12.0 m
Lateral extension of the sedimentary facies: 17.2 m

Dip-variation: 55°
(assumed: s subparallel ss)
18.1 - 20.1 m:ss ~ 55°

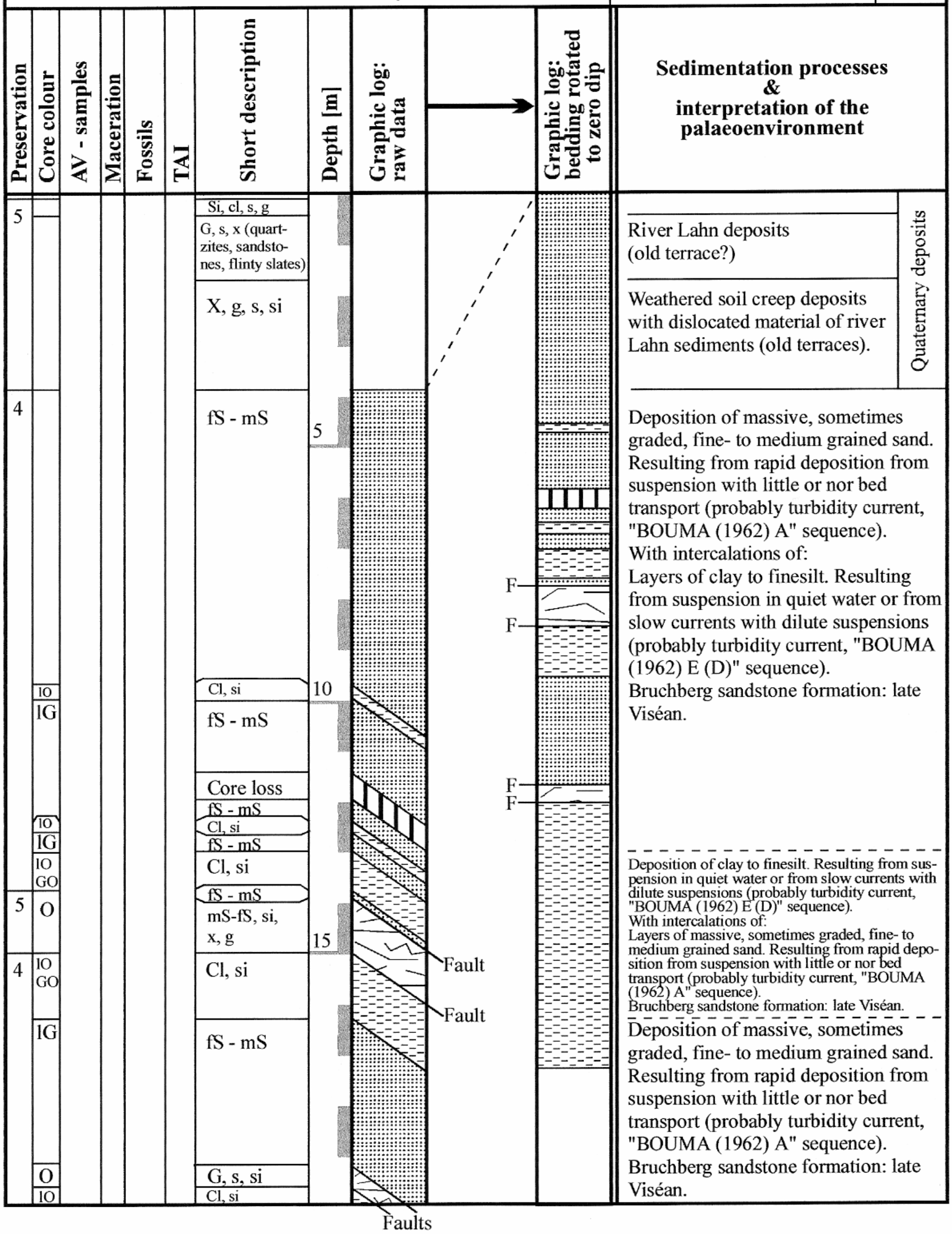
model mean: 55°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data	→	Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
4 5	lG	40				fS, si					Deposition of massive, sometimes graded, fine- to medium grained sand. Resulting from rapid deposition from suspension with little or nor bed transport (probably turbidity current, "BOUMA (1962) A" sequence). With intercalations of: Layers of clay to finesilt. Resulting from suspension in quiet water or from slow currents with dilute suspensions (probably turbidity current, "BOUMA (1962) E (D)" sequence). Bruchberg sandstone formation: late Viséan.
	G/O					Cl, si					
	lG					fS, si					
	G/O					Cl, si					
	lG					fS, si	25				
							30				
							35				



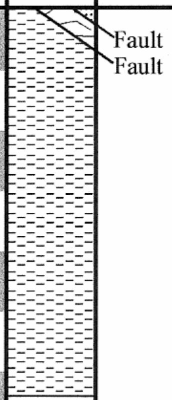
Drill site: BK 2010 / 139
Initiator: Deutsche Bahn AG
Date: 27.11. - 11.12.1995
Location: E 3434961.38 N 5584497.17
Height: 165.18 m a.s.l.
Depth: 26.40 m
Apparent thickness of Palaeozoic sediments: 22.5 m
Thickness when bedding rotated to zero dip: 17.2 m
Lateral extension of the sedimentary facies: 14.5 m

Dip-variation: 30 - 60° (assumed: s subparallel ss)	**model mean:**
18.3 m: ss ~ 30° 21.8 m: s ~ 50° 23.8 m: s ~ 40° 24.1 m: s ~ 35° 24.7 m: s ~ 48° 25.3 m: s ~ 43° 26.1 m: s ~ 60°	40°



Drill site: BK 2010 / 139
Initiator: Deutsche Bahn AG
Date: 27.11. - 11.12.1995
Location: E 3434961.38 N 5584497.17
Height: 165.18 m a.s.l.
Depth: 26.40 m
Apparent thickness of Palaeozoic sediments: 22.5 m
Thickness when bedding rotated to zero dip: 17.2 m
Lateral extension of the sedimentary facies: 14.5 m

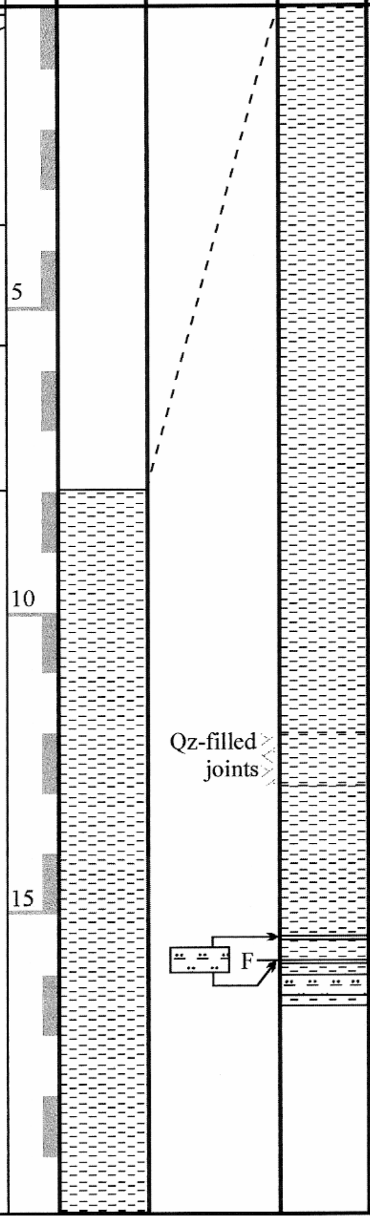
Dip-variation: 30 - 60° (assumed: s subparallel ss)	model mean:
18.3 m: ss ~ 30° 21.8 m: s ~ 50° 23.8 m: s ~ 40° 24.1 m: s ~ 35° 24.7 m: s ~ 48° 25.3 m: s ~ 43° 26.1 m: s ~ 60°	40°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data → Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
4	IO - GO	116, 117				Cl, si	25, 30, 35		Deposition of clay from suspension punctuated by sudden incursions of silt by currents (maybe turbidity currents) of waning strength. Basinal background sedimentation of the Bruchberg sandstone formation (late Viséan).

Drill site: BK 3004 / 01A
Initiator: Deutsche Bahn AG
Date: 10.1995
Location: E 3434997.69 N 5584433.60
Height: 146.30 m a.s.l.
Depth: 41.0 m
Apparent thickness of Palaeozoic sediments: 33.0 m
Thickness when bedding rotated to zero dip: 16.5 m
Lateral extension of the sedimentary facies: 28.6 m

Dip-variation: 45 - 65°	model mean:
(assumed: s subparallel ss) 33.9m: s ~ 65° 34.5m: s ~ 65° 36.5m: s ~ 45° 37.5m: s ~ 50° 38.1m: s ~ 45° 39.6m: s ~ 65° 40.0m: s ~ 65°	60°

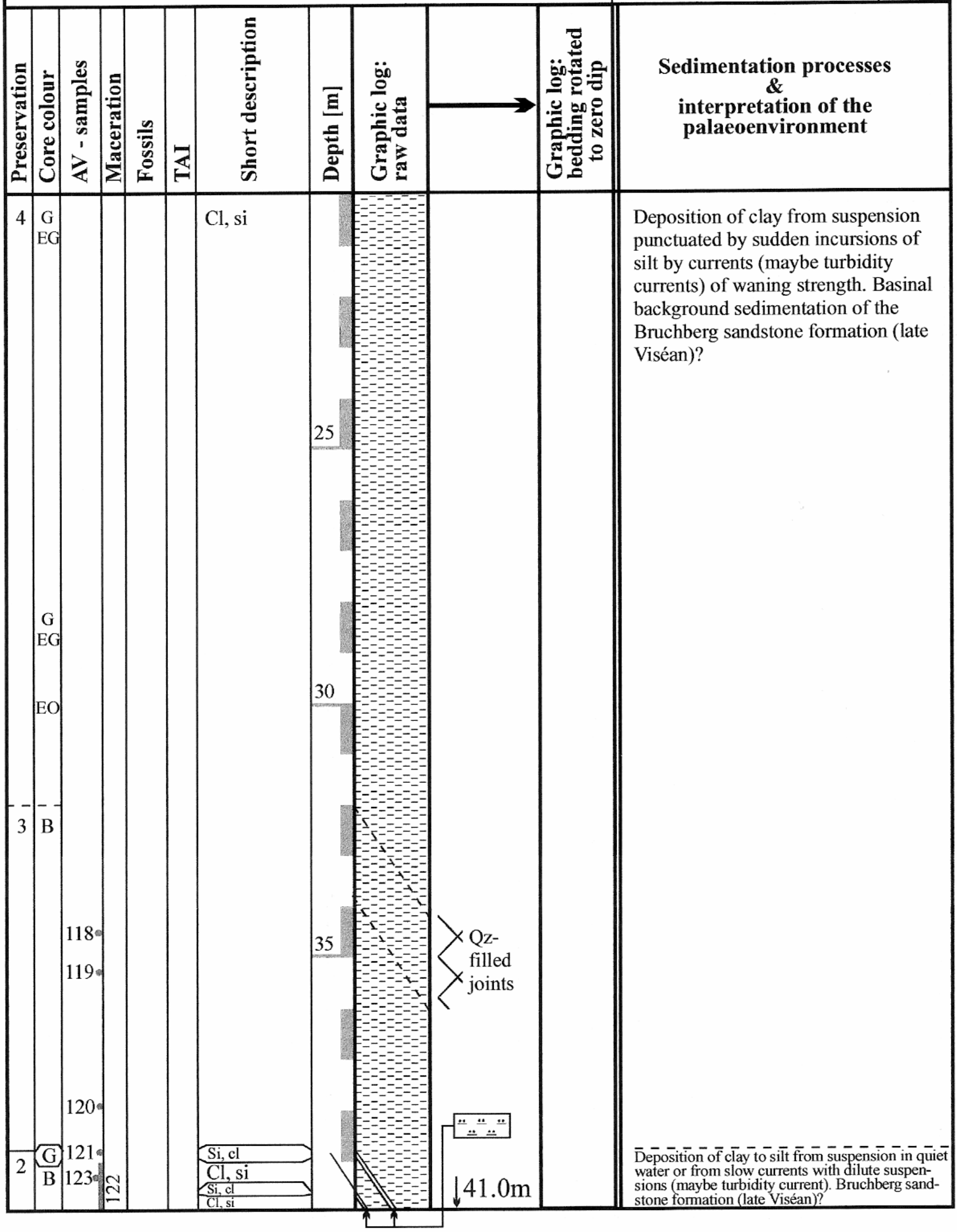
Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data → Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
4 5	BO O					Cl, s Cl, fs			Weathered soil creep deposits (and/or deposits of minor land-slides?). Lower parts maybe weathered palaeozoic slates (indeterminable). — Quaternary deposits
						Si, cl	5		
	O EO O YO					Si,s, g; x (angular quartzitic sandstone)			
	G EG YO O G EG					Cl, si	10 15	Qz-filled joints; F	Deposition of clay from suspension punctuated by sudden incursions of silt by currents (maybe turbidity currents) of waning strength. Basinal background sedimentation of the Bruchberg sandstone formation (late Viséan)?



Drill site: BK 3004 / 01A
Initiator: Deutsche Bahn AG
Date: 10.1995
Location: E 3434997.69 N 5584433.60
Height: 146.30 m a.s.l.
Depth: 41.0 m
Apparent thickness of Palaeozoic sediments: 33.0 m
Thickness when bedding rotated to zero dip: 16.5 m
Lateral extension of the sedimentary facies: 28.6 m

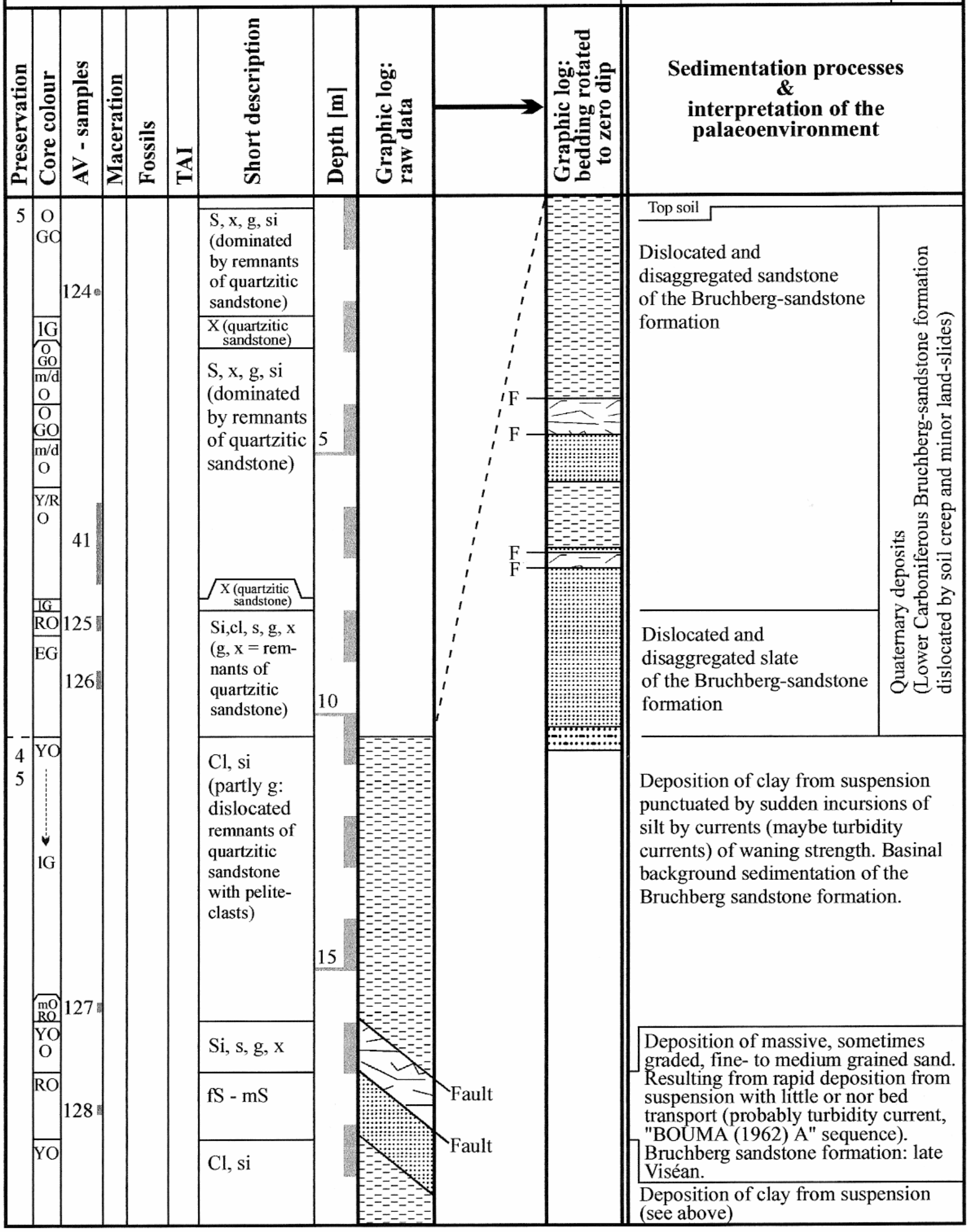
Dip-variation: 45 - 65°
(assumed: s subparallel ss)
33.9m: s ~ 65°
34.5m: s ~ 65°
36.5m: s ~ 45°
37.5m: s ~ 50°
38.1m: s ~ 45°
39.6m: s ~ 65°
40.0m: s ~ 65°

model mean: 60°



Drill site: BK 3004 / 04
Initiator: Deutsche Bahn AG
Date: 10.1995
Location: E 3435032.85 N 5584400.29
Height: 134.1 m a.s.l.
Depth: 25.6 m
Apparent thickness of Palaeozoic sediments: 15.1 m
Thickness when bedding rotated to zero dip: 10.7 m
Lateral extension of the sedimentary facies: 10.7 m

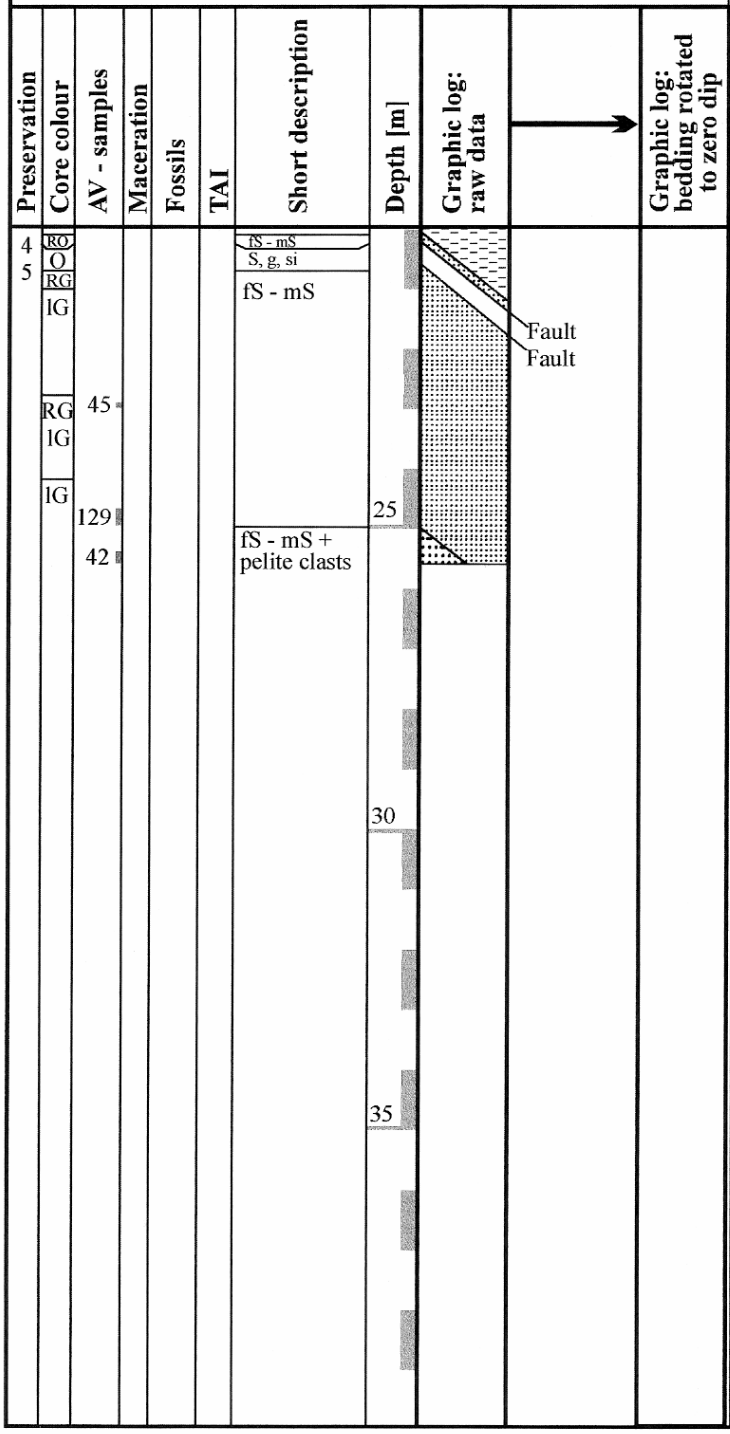
Dip-variation: ca. 45° (assumed: s subparallel ss)	**model mean:**
21.6m: s ~ 45° 23.2m: s ~ 45° 23.9m: s ~ 45° 24.5m: s//ss ~ 45°	45°



Drill site: BK 3004 / 04
Initiator: Deutsche Bahn AG
Date: 10.1995
Location: E 3435032.85 N 5584400.29
Height: 134.1 m a.s.l.
Depth: 25.6 m
Apparent thickness of Palaeozoic sediments: 15.1 m
Thickness when bedding rotated to zero dip: 10.7 m
Lateral extension of the sedimentary facies: 10.7 m

Dip-variation: ca. 45°
(assumed: s subparallel ss)
21.6m: s ~ 45°
23.2m: s ~ 45°
23.9m: s ~ 45°
24.5m: s//ss ~ 45°

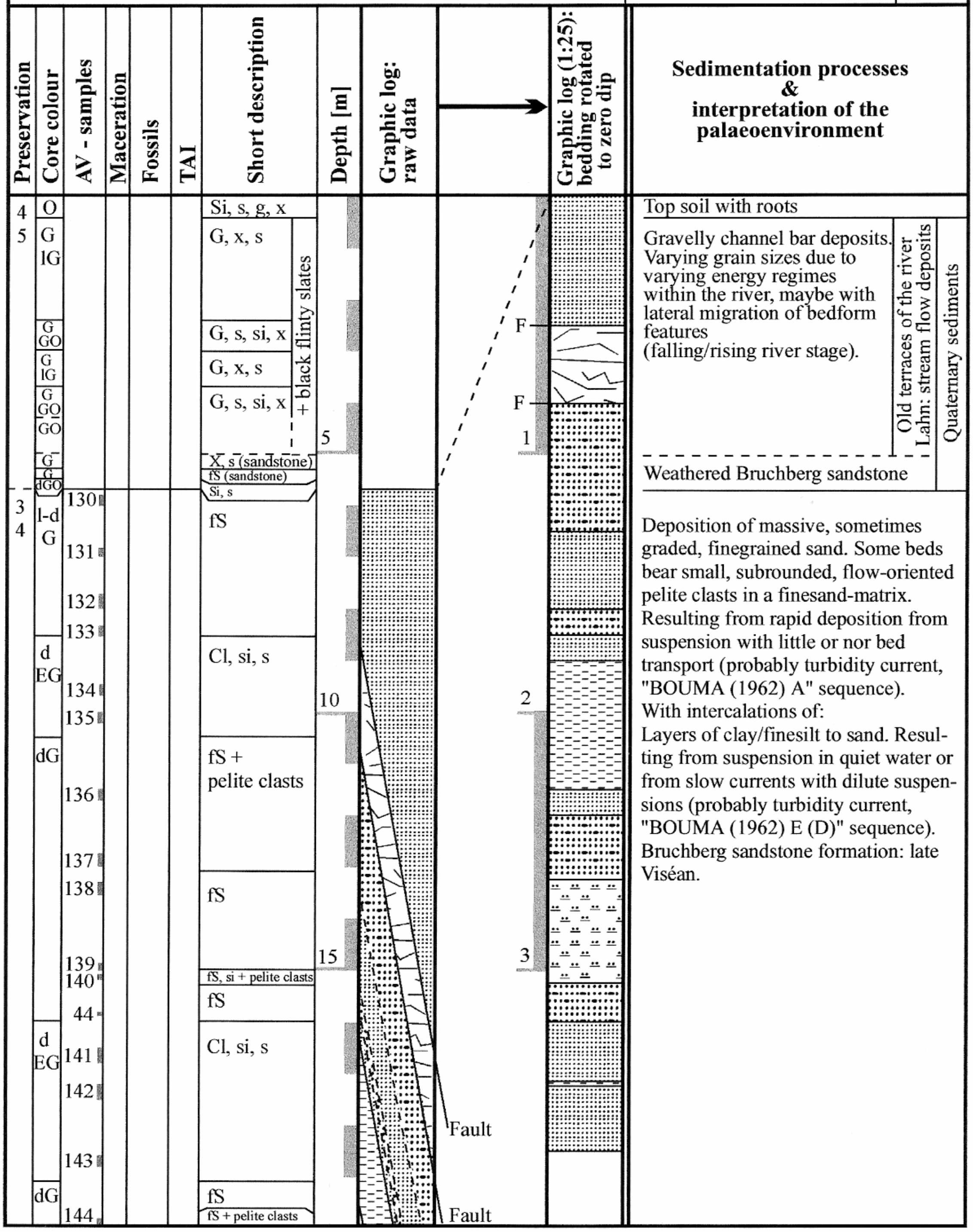
model mean: 45°



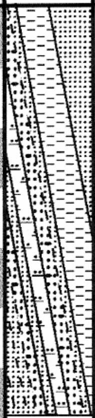
Sedimentation processes & interpretation of the palaeoenvironment

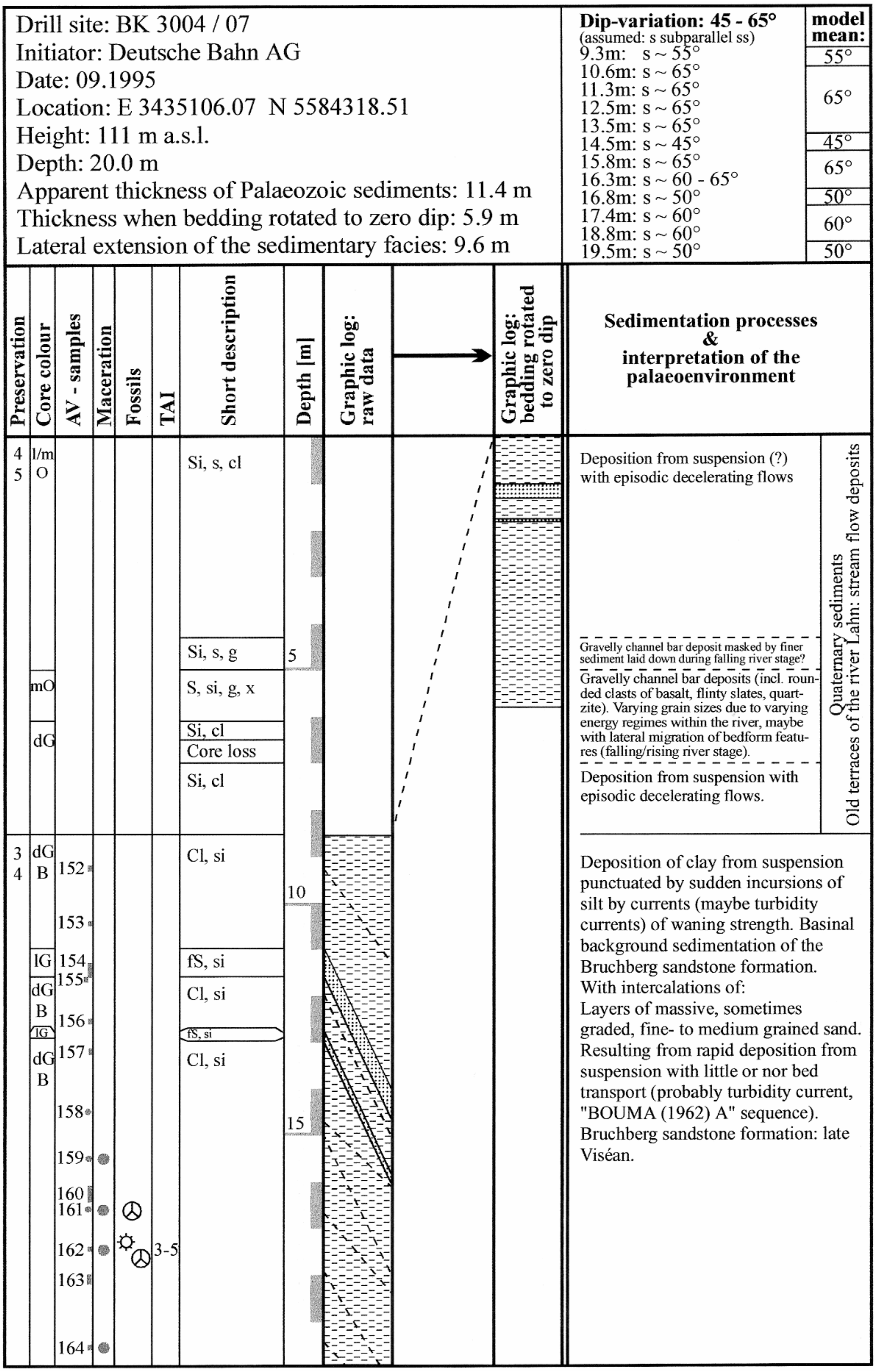
Deposition of massive, sometimes graded, fine- to medium grained sand. Resulting from rapid deposition from suspension with little or nor bed transport (probably turbidity current, "BOUMA (1962) A" sequence). Bruchberg sandstone formation: late Viséan.

Drill site: BK 3004 / 05 Initiator: Deutsche Bahn AG Date: 10.1995 Location: E 3435071.54 N 5584363.16 Height: 118 m a.s.l. Depth: 26.8 m Apparent thickness of Palaeozoic sediments: 21.1m Thickness when bedding rotated to zero dip: 3.7m Lateral extension of the sedimentary facies: 20.8m	**Dip-variation: ca. 80°** (assumed: s subparallel ss) 11.5 - 13.0m: ss ~ 80-90° 16.5 - 18.8m: ss ~ 80° 21.3 - 21.45m: ss ~ 80° 22.2 - 22.4m: ss ~ 80° 23.7 - 24.0m: ss ~ 80° 25.0 - 25.4m: ss ~ 80°	**model mean:** 80°



Drill site: BK 3004 / 05 Initiator: Deutsche Bahn AG Date: 10.1995 Location: E 3435071.54 N 5584363.16 Height: 118 m a.s.l. Depth: 26.8 m Apparent thickness of Palaeozoic sediments: 21.1m Thickness when bedding rotated to zero dip: 3.7m Lateral extension of the sedimentary facies: 20.8m	**Dip-variation: ca. 80°** (assumed: s subparallel ss) 11.5 - 13.0m: ss ~ 80-90° 16.5 - 18.8m: ss ~ 80° 21.3 - 21.45m: ss ~ 80° 22.2 - 22.4m: ss ~ 80° 23.7 - 24.0m: ss ~ 80° 25.0 - 25.4m: ss ~ 80°	**model mean:** 80°

Preservation	**Core colour**	**AV - samples**	**Maceration**	**Fossils**	**TAI**	**Short description**	**Depth [m]**	**Graphic log: raw data**	→	**Graphic log: bedding rotated to zero dip**	**Sedimentation processes & interpretation of the palaeoenvironment**
2 3	dG					fS + pelite clasts					Deposition of massive, sometimes graded, finegrained sand. Some beds bear small, subrounded, flow-oriented pelite clasts in a finesand-matrix. Resulting from rapid deposition from suspension with little or nor bed transport (probably turbidity current, "BOUMA (1962) A" sequence). With intercalations of: Layers of clay/finesilt to sand. Resulting from suspension in quiet water or from slow currents with dilute suspensions (probably turbidity current, "BOUMA (1962) E (D)" sequence). Bruchberg sandstone formation: late Viséan.
		145 146				Cl, si					
		147			3-4	Si, cl					
		148				fS + pelite clasts					
		149				fS	25				
		150				fS, cl					
		151				fS					
							30				
							35				

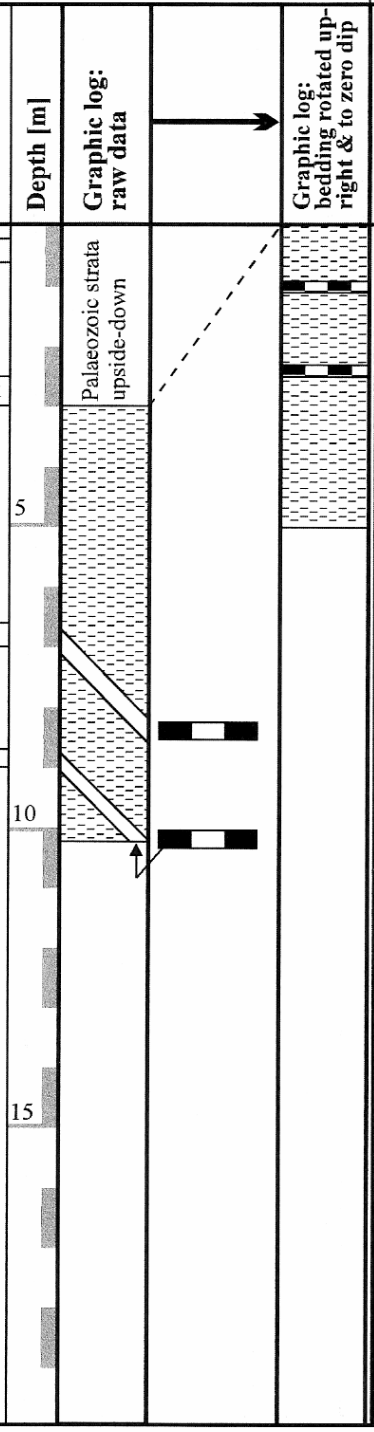

Drill site: BK 3004 / 07
Initiator: Deutsche Bahn AG
Date: 09.1995
Location: E 3435106.07 N 5584318.51
Height: 111 m a.s.l.
Depth: 20.0 m
Apparent thickness of Palaeozoic sediments: 11.4 m
Thickness when bedding rotated to zero dip: 5.9 m
Lateral extension of the sedimentary facies: 9.6 m
Dip-variation: 45 - 65°
(assumed: s subparallel ss)
9.3m: s ~ 55°
10.6m: s ~ 65°
11.3m: s ~ 65°
12.5m: s ~ 65°
13.5m: s ~ 65°
14.5m: s ~ 45°
15.8m: s ~ 65°
16.3m: s ~ 60 - 65°
16.8m: s ~ 50°
17.4m: s ~ 60°
18.8m: s ~ 60°
19.5m: s ~ 50°
model mean:
55°
65°
45°
65°
50°
60°
50°
Preservation
Core colour
AV - samples
Maceration
Fossils
TAI
Short description
Depth [m]
Graphic log: raw data
Graphic log: bedding rotated to zero dip
Sedimentation processes & interpretation of the palaeoenvironment
4
5
l/m O
mO
dG
Si, s, cl
Si, s, g
S, si, g, x
Si, cl
Core loss
Si, cl
5
Deposition from suspension (?) with episodic decelerating flows
Gravelly channel bar deposit masked by finer sediment laid down during falling river stage?
Gravelly channel bar deposits (incl. rounded clasts of basalt, flinty slates, quartzite). Varying grain sizes due to varying energy regimes within the river, maybe with lateral migration of bedform features (falling/rising river stage).
Deposition from suspension with episodic decelerating flows.
Quaternary sediments
Old terraces of the river Lahn: stream flow deposits
3
4
dG B
lG
dG B
lG
dG B
152
153
154
155
156
157
158
159
160
161
162
163
164
3-5
Cl, si
fS, si
Cl, si
fS, si
Cl, si
10
15
Deposition of clay from suspension punctuated by sudden incursions of silt by currents (maybe turbidity currents) of waning strength. Basinal background sedimentation of the Bruchberg sandstone formation.
With intercalations of:
Layers of massive, sometimes graded, fine- to medium grained sand. Resulting from rapid deposition from suspension with little or nor bed transport (probably turbidity current, "BOUMA (1962) A" sequence).
Bruchberg sandstone formation: late Viséan.

Drill site: BK 3005 / 01
Initiator: Deutsche Bahn AG
Date: 26.05. - 30.05.1994
Location: E 3435255.81 N 5584081.75
Height: 156.22 m a.s.l.
Depth: 10.2 m
Apparent thickness of Palaeozoic sediments: 7.2 m
Thickness when bedding rotated to zero dip: 5.1 m
Lateral extension of the sedimentary facies: 5.1 m

Dip-variation: 45°
(assumed: s subparallel ss)
6.9 m: ss ~ 45°
strata upside-down

model mean: 45°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description
5	B / GB					Tar
						G
	O					Si, cl, s, g
						Si, cl, s, g, x
3 / 4	G / BO					Cl, si
	BO dO					
	B dG	226				
3	B-O	227	●		4-5	Cl
	B / G / RO					Cl, si
	B-O	228				Cl
	B / G	229				Cl, si
		230				



Sedimentation processes & interpretation of the palaeoenvironment

Quaternary deposits:

Fill (Tar on top of basalt-gravel)

Weathered Bruchberg sandstone and soil creep deposits, maybe with dislocated material of river Lahn sediments (old terraces).

Deposition of clay from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt by currents (maybe turbidity currents) of waning strength; often in detectable cyclic sequences (see chapter C 8.2, light-dark changes between different laminae/layers at µm to cm-scale).

Cherty appearance, partly flinty slate*.

Cherty appearance, partly flinty slate*.

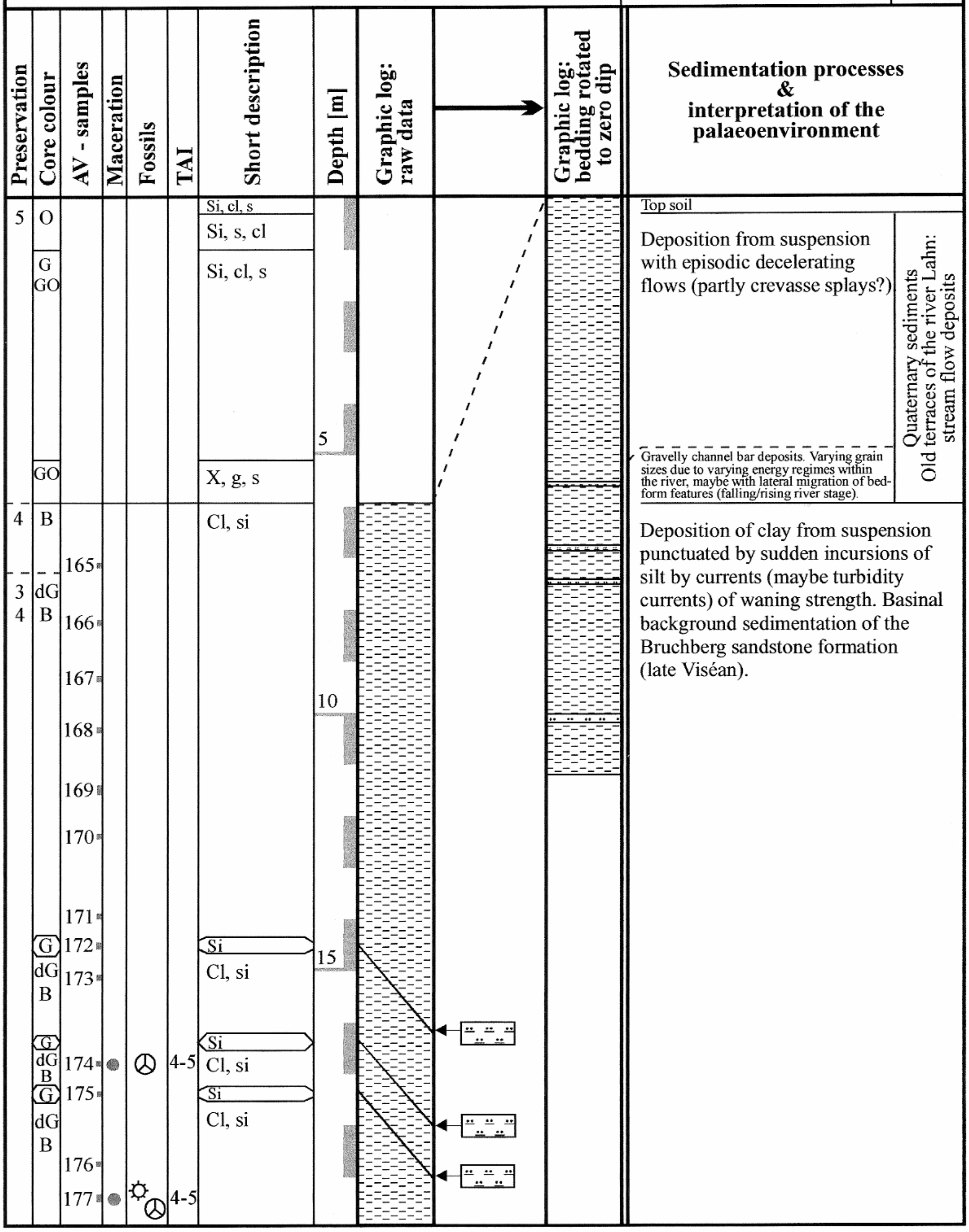
Basinal background sedimentation (the palynofacies is dominated by acritarchs) of the Bruchberg sandstone formation: Late Viséan.

(* The thin platy layers which appear cherty are probably thin finesilt intercalations which became separated during diagenesis, compaction and orogenesis. An alternative origin as products of deposition of primary siliceous oozes seems less probable, since internal sedimentary structures (lamination) as well as single detrital clasts are sometimes observable. Silica precipitation seems to require weakly alkaline conditions, but the precise controls and processes are poorly understood.)

Drill site: BK 3004 / 09
Initiator: Deutsche Bahn AG
Date: 09.1995
Location: E 3435132.91 N 5584264.14
Height: 111 m a.s.l.
Depth: 23.3 m
Apparent thickness of Palaeozoic sediments: 17.4 m
Thickness when bedding rotated to zero dip: 11.2 m
Lateral extension of the sedimentary facies: 13.3 m

Dip-variation: 45 - 50°
(assumed: s subparallel ss)
7.10 - 7.20m: s ~ 80°
11.40 - 11.60m: s ~ 70°
12.35 - 12.45m: s ~ 75°
14.45 - 14.60m: s ~ 60°
ss ~ 50°
17.35 - 17.45m: s ~ 65°
ss ~ 45°
18.70 - 18.80m: s ~ 65°

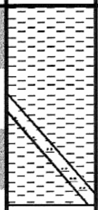
model mean: 50°



Drill site: BK 3004 / 09
Initiator: Deutsche Bahn AG
Date: 09.1995
Location: E 3435132.91 N 5584264.14
Height: 111 m a.s.l.
Depth: 23.3 m
Apparent thickness of Palaeozoic sediments: 17.4 m
Thickness when bedding rotated to zero dip: 11.2 m
Lateral extension of the sedimentary facies: 13.3 m

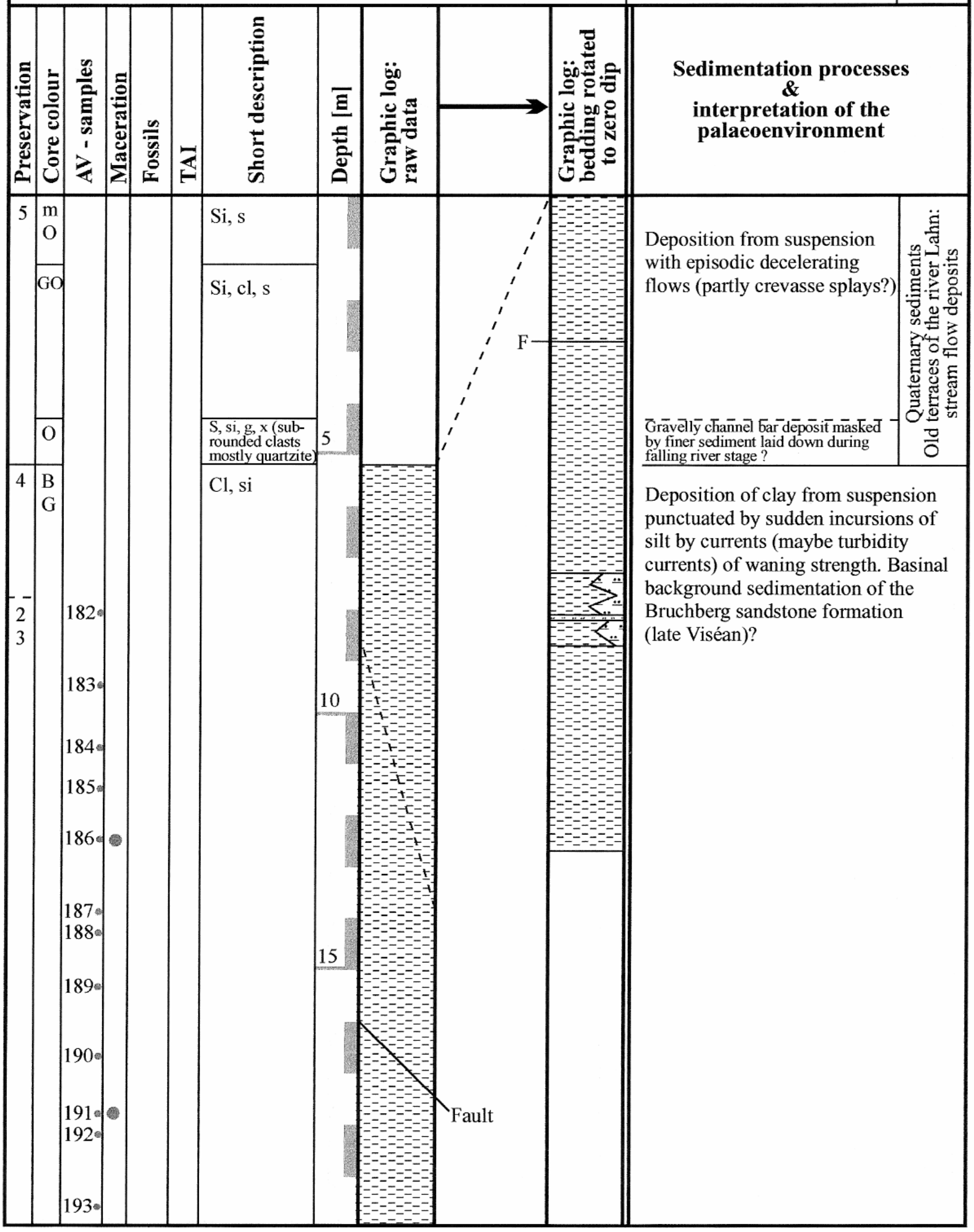
Dip-variation: 45 - 50°
(assumed: s subparallel ss)
7.10 - 7.20m: s ~ 80°
11.40 - 11.60m: s ~ 70°
12.35 - 12.45m: s ~ 75°
14.45 - 14.60m: s ~ 60°
ss ~ 50°
17.35 - 17.45m: s ~ 65°
ss ~ 45°
18.70 - 18.80m: s ~ 65°

model mean: 50°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data	→	Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
3 4	dG B	178				Cl, si					Deposition of clay from suspension punctuated by sudden incursions of silt by currents (maybe turbidity currents) of waning strength. Basinal background sedimentation of the Bruchberg sandstone formation (late Viséan).
	G	179	●	☼ ☮		Si, cl					
	dG B	180				Cl, si + pyrite aggregates up to 1.5 cm					
		181	●			Cl, si					
							25				
							30				
							35				

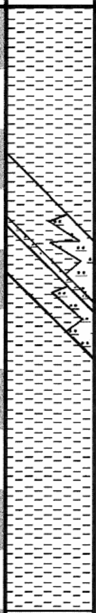
Drill site: BK 3004 / 10
Initiator: Deutsche Bahn AG
Date: 09.1995
Location: E 3435142.67 N 5584268.75
Height: 111 m a.s.l.
Depth: 30.0 m
Apparent thickness of Palaeozoic sediments: 24.8 m
Thickness when bedding rotated to zero dip: 12.7 m
Lateral extension of the sedimentary facies: 20.3 m

Dip-variation: 45 - 80° (assumed: s subparallel ss)	**model mean:**
10.7m: s ~ 80° 13.9m: s ~ 75° 15.3m: s ~ 75°	75°
16.7m: s//ss ~ 40° 20.3m: s//ss ~ 45° 24.2m: s//ss ~ 50° 28.1m: s//ss ~ 45°	45°



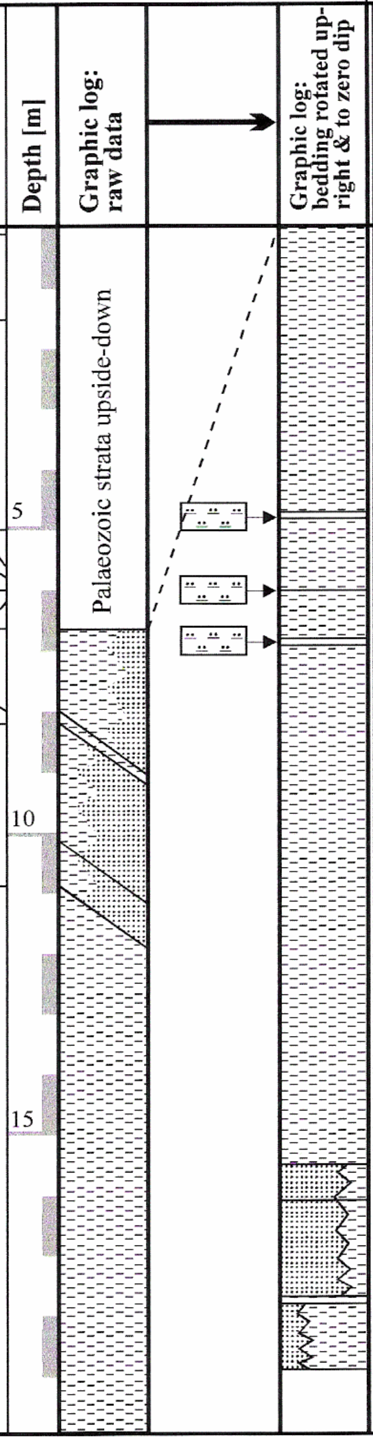
Drill site: BK 3004 / 10
Initiator: Deutsche Bahn AG
Date: 09.1995
Location: E 3435142.67 N 5584268.75
Height: 111 m a.s.l.
Depth: 30.0 m
Apparent thickness of Palaeozoic sediments: 24.8 m
Thickness when bedding rotated to zero dip: 12.7 m
Lateral extension of the sedimentary facies: 20.3 m

Dip-variation: 45 - 80° (assumed: s subparallel ss)	model mean:
10.7m: s ~ 80° 13.9m: s ~ 75° 15.3m: s ~ 75°	75°
16.7m: s//ss ~ 40° 20.3m: s//ss ~ 45° 24.2m: s//ss ~ 50° 28.1m: s//ss ~ 45°	45°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]	Graphic log: raw data	→	Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
2 3	B G	194 195				Cl, si					Deposition of clay from suspension punctuated by sudden incursions of silt by currents (maybe turbidity currents) of waning strength. Basinal background sedimentation of the Bruchberg sandstone formation?
	B IG	196				Cl, Si					Deposition of clay and silt from suspension in quiet water or from slow currents with dilute suspensions (probably distal turbidity current, "BOUMA (1962) E (D)" sequence). Bruchberg sandstone formation (late Viséan)?
	IG	197	●			Si					
	B IG	198				Cl, Si					
	B G	199 200 201				Cl, si	25				Deposition of clay from suspension punctuated by sudden incursions of silt by currents (maybe turbidity currents) of waning strength. Basinal background sedimentation of the Bruchberg sandstone formation (late Viséan)?
3	B	202 203	●				30				Slates appear fissile, probably due to alteration by tertiary fluids.
							35				

Drill site: BK 3004 / 13 Initiator: Deutsche Bahn AG Date: 30.01. - 09.02.1996 Location: E 3435208.64 N 5584174.73 Height: 129.99 m a.s.l. Depth: 30.0 m Apparent thickness of Palaeozoic sediments: 23.3 m Thickness when bedding rotated to zero dip: 18.9 m Lateral extension of the sedimentary facies: 13.7 m	**Dip-variation: 30 - 45°** (assumed: s subparallel ss) 18.5m: ss ~ 42° 20.8m: ss ~ 38° 21.8m: ss ~ 40° 22.4m: ss ~ 35° 23.8m: ss ~ 30° 24.4m: ss ~ 35° 25.7m: ss ~ 35° 26.3m: ss ~ 30° 28.3m: ss ~ 45° 29.3m: ss ~ 30° strata upside down	**model mean:** 36°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description
5	O, lO					Si, cl, s
	O, G					G, x, si, s (mostly quartzitic sandstone)
	O, GO					m-cS, g, x
	O-G, lG					G, x, si, s
	O					fS (q. sandstone)
	O, GO					Si, cl, s, g
						m-cS, g, x
4	GO, lG					Cl, si intercalated by fS-layers
	mG, GE					Cl, si
	lG, GO					fS, intercalated by Cl, si-layers
	lG, YO, GO, YO, dO, dGO, lG, lGO, YO, O					Cl, si
2 3	BG					



Sedimentation processes & interpretation of the palaeoenvironment

Quaternary deposits:

Top soil

Weathered loess ?

Weathered Bruchberg sandstone and soil creep deposits, maybe with dislocated material of river Lahn sediments (old terraces).

Drill-generated "sediment"

Weathered Bruchberg sandstone

Drill-generated "sediment"

Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt, often in detectable cyclic sequences (see chapter C 8.2, AV 204); partly thick, but short-termed, turbiditic deposition of finesand piles.

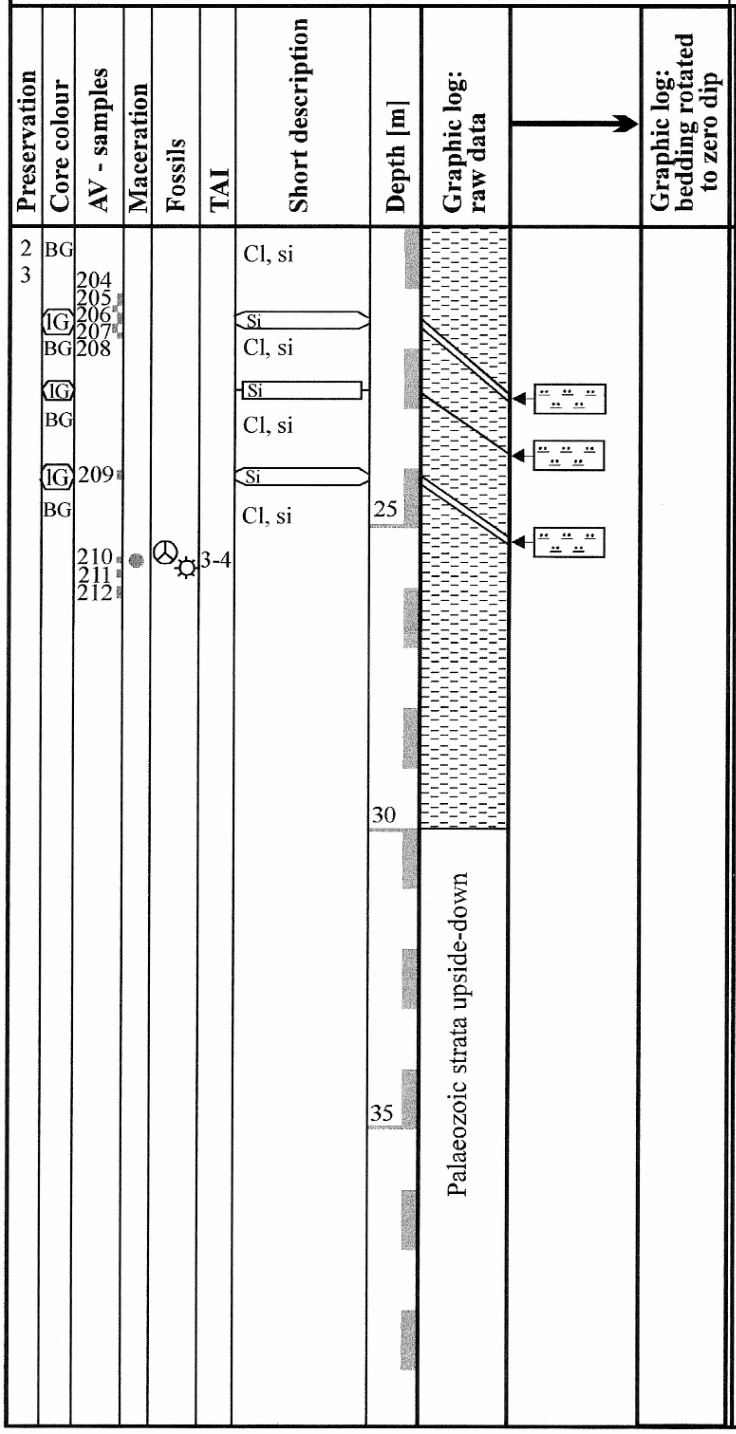
In sample AV 210 (compare appendix F 2.1) a basinal and fully marine background biofacies with acritarchs and radiolarians is preserved; also present are spores. They indicate a shallow-marine, near-shore palynofacies before redeposition and their relatively good preservation a rapid, single-event, transport.

The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbity currents along submarine canyons into the Rhenish Basin. Bruchberg sandstone formation: late Viséan.

Drill site: BK 3004 / 13
Initiator: Deutsche Bahn AG
Date: 30.01. - 09.02.1996
Location: E 3435208.64 N 5584174.73
Height: 129.99 m a.s.l.
Depth: 30.0 m
Apparent thickness of Palaeozoic sediments: 23.3 m
Thickness when bedding rotated to zero dip: 18.9 m
Lateral extension of the sedimentary facies: 13.7 m

Dip-variation: 30 - 45°
(assumed: s subparallel ss)
18.5m: ss ~ 42°
20.8m: ss ~ 38°
21.8m: ss ~ 40°
22.4m: ss ~ 35°
23.8m: ss ~ 30°
24.4m: ss ~ 35°
25.7m: ss ~ 35°
26.3m: ss ~ 30°
28.3m: ss ~ 45°
29.3m: ss ~ 30°
strata upside down

model mean: 36°

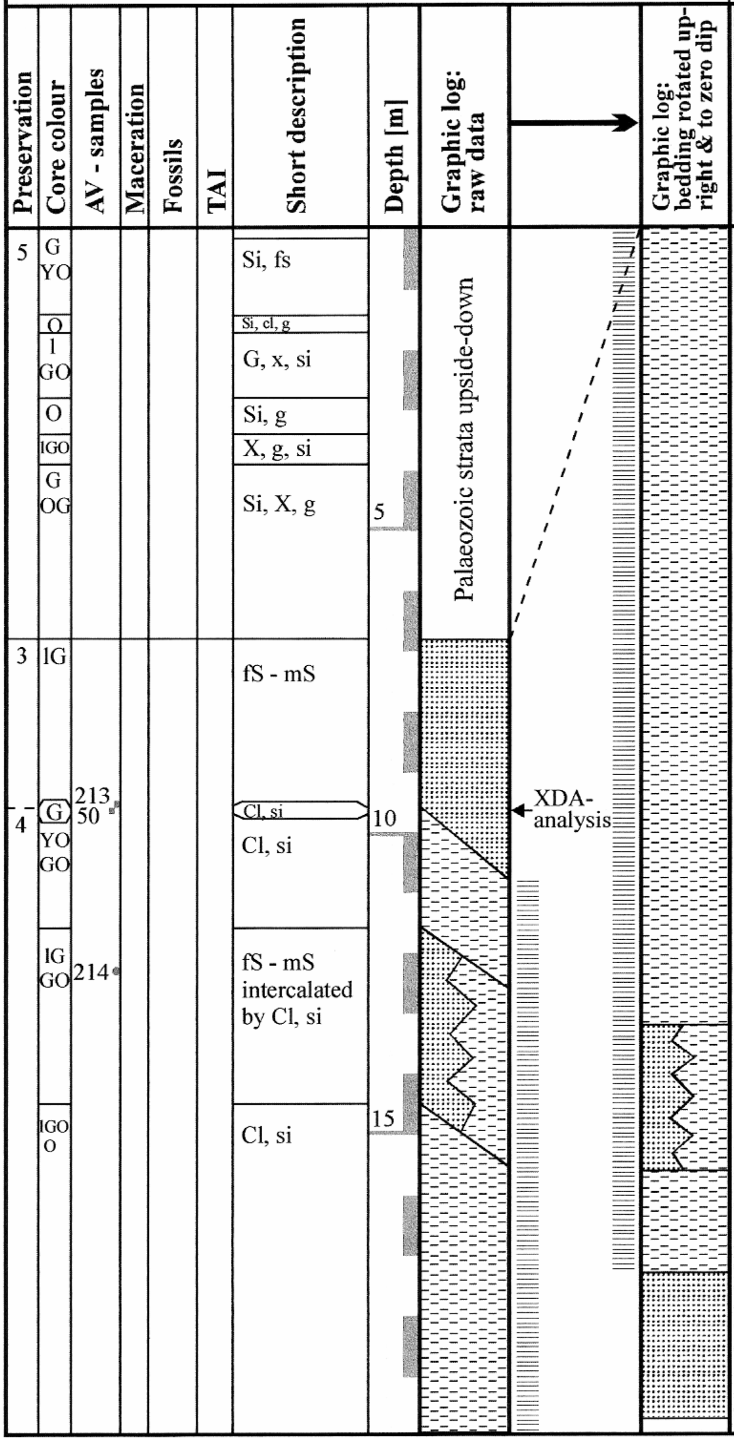


Sedimentation processes & interpretation of the palaeoenvironment

Deposition of clay to silt from suspension in quiet water or from slow currents with dilute suspensions (probably turbidity current, "BOUMA (1962) E (D)" sequence).
Bruchberg sandstone formation: late Viséan.

Drill site: BK 3004 / 14
Initiator: Deutsche Bahn AG
Date: 16.01. - 29.01.1996
Location: E 3435202.60 N 5584165.78
Height: 127.89 m a.s.l.
Depth: 30.50 m
Apparent thickness of Palaeozoic sediments: 23.7 m
Thickness when bedding rotated to zero dip: 19.7 m
Lateral extension of the sedimentary facies: 13.3 m

Dip-variation: 30 - 40° (assumed: s subparallel ss)	model mean:
7.7 m: ss ~ 40° 21.7 m: ss ~ 35° 22.5 m: ss ~ 30° 25.9 m: ss ~ 30° 26.3 m: ss ~ 30° 27.4 m: ss ~ 35° 28.5 m: ss ~ 35° 29.4 m: ss ~ 35° 30.5 m: ss ~ 35° strata upside down	34°



Sedimentation processes & interpretation of the palaeoenvironment

Top soil

Weathered loess ?

Weathered Bruchberg sandstone and soil creep deposits, maybe with dislocated material of river Lahn sediments (old terraces).

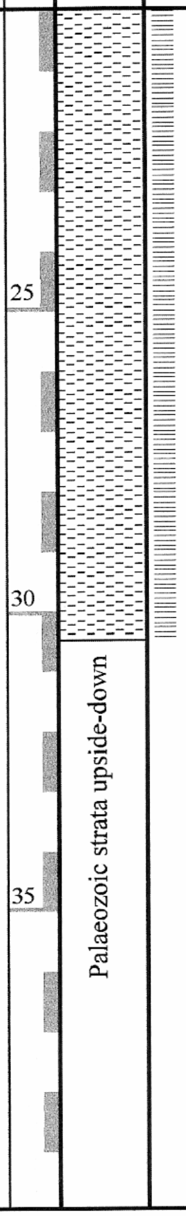
Quaternary deposits

Deposition of mud from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt, often in detectable cyclic sequences (see chapter C 8.2, light-dark changes between different laminae/ layers at µm to cm-scale); partly thick, but short-termed, turbiditic deposition of fine/medium-sand piles.
Results of the XDA-analysis for the clay-minerals of sample AV 50: the clay-fraction is dominated by kaolinite and illite. Kaolinite was probably generated by the weathering of silicates under non-alcaline conditions. Illite was probably derived by alteration of other clay minerals during diagenesis; succeeded by crystal growth (see chapter C 7, fig. C 7.2).
The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel. Thirdly, these sediments were transported together by turbity currents along submarine canyons into the Rhenish Basin.
Bruchberg sandstone formation: late Viséan.

Drill site: BK 3004 / 14
Initiator: Deutsche Bahn AG
Date: 16.01. - 29.01.1996
Location: E 3435202.60 N 5584165.78
Height: 127.89 m a.s.l.
Depth: 30.50 m
Apparent thickness of Palaeozoic sediments: 23.7 m
Thickness when bedding rotated to zero dip: 19.7 m
Lateral extension of the sedimentary facies: 13.3 m

Dip-variation: 30 - 40°
(assumed: s subparallel ss)
7.7 m: ss ~ 40°
21.7 m: ss ~ 35°
22.5 m: ss ~ 30°
25.9 m: ss ~ 30°
26.3 m: ss ~ 30°
27.4 m: ss ~ 35°
28.5 m: ss ~ 35°
29.4 m: ss ~ 35°
30.5 m: ss ~ 35°
strata upside down

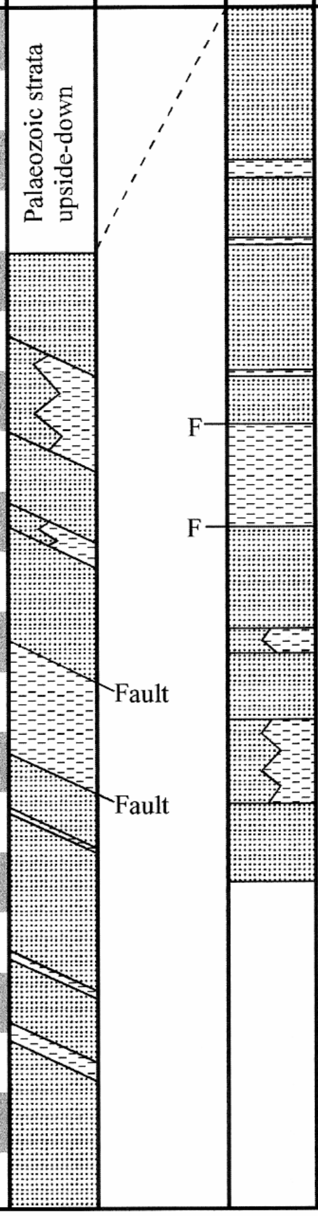
model mean: 34°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m] / Graphic log: raw data → Graphic log: bedding rotated to zero dip	Sedimentation processes & interpretation of the palaeoenvironment
4	IGO O					Cl, si		Deposition of clay to silt from suspension in quiet water or from slow currents, often in detectable cyclic sequences (see chapter C 8.2, light-dark changes between different laminae/layers at µm to cm-scale), with dilute suspensions (probably turbidity current, "BOUMA (1962) E (D)" sequence). Bruchberg sandstone formation: late Viséan.
2 3	BG	215 216 217 218 219	● ● ●					

Drill site: BK 3004 / 15 Initiator: Deutsche Bahn AG Date: 12.12.95 - 08.01.1996 Location: E 3435241.25 N 5584128.20 Height: 142.01 m a.s.l. Depth: 20.0 m Apparent thickness of Palaeozoic sediments: 16.0 m Thickness when bedding rotated to zero dip: 14.5 m Lateral extension of the sedimentary facies: 6.8 m	**Dip-variation: 15 - 30°** (assumed: s subparallel ss) 5.4 m: s ~ 30° [12.8 m: s ~ 15°, near fault zone] 14.9 m: s ~ 30° 17.4 m: s ~ 25° strata upside down	**model mean:** 25°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]
5	dO					Si, cl	
	O EG EO					Si, cl, g	
	O G					X, g, s, si (mostly quartzitic sandstone)	
3 4	G lG					fS - mS	5
	O dO G					fS - mS intercalated by Cl, si	
	G YG					fS - mS	
	O dG					fS intercalated by Cl, si	
	lG OG					fS - mS	10
5	O GO					Cl, si	
3 4	lG					fS	
	dO	220				Cl, si	
	lG					fS	15
	dG	221	●	☮		Cl, si	
	lG					fS	
	dG	222	●			Cl, si	
	m G lG					fS - mS	

Graphic log: raw data → **Graphic log: bedding rotated upright & to zero dip**



Sedimentation processes & interpretation of the palaeoenvironment

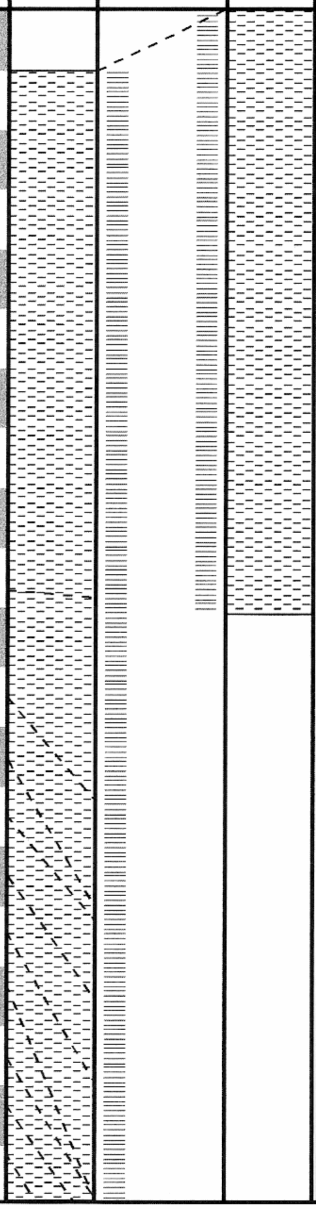
Quaternary deposits: Weathered Bruchberg sandstone and soil creep deposits, maybe with dislocated material of river Lahn sediments (old terraces).

Deposition of clay from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt by currents (maybe turbidity currents) of waning strength; often in detectable cyclic sequences (see chapter C 8.2, light-dark changes between different laminae/layers at µm to cm-scale). Intercalated are partly thick, but short-termed, sometimes graded, fine/medium-sand piles. Resulting from rapid deposition from suspension with little or nor bed transport (probably turbidity current, "BOUMA (1962) A" sequence).
The depositional history of the sandstones is threefold. Firstly, erosion of material from the Old Red Continent, isostatically uplifted after the Caledonian orogeny, took place. Secondly, the eroded rocks were transported, reworked under shallow marine conditions and deposited as unconsolidated pelites, psammites and gravel (spores are preserved in sample AV221, which indicate a shallow-marine, near-shore palynofacies before redeposition and their relatively good preservation a rapid, single-event, transport; compare BK 3004 / 13). Thirdly, these sediments were transported together by turbity currents along submarine canyons into the Rhenish Basin.
Bruchberg sandstone formation: late Viséan.

Drill site: BK 3004 / 17 Initiator: Deutsche Bahn AG Date: 09.01. - 16.01.1996 Location: E 3435281.38 N 5584068.72 Height: 158.47 m a.s.l. Depth: 20.0 m Apparent thickness of Palaeozoic sediments: 19.0 m Thickness when bedding rotated to zero dip: 10.1 m Lateral extension of the sedimentary facies: 16.1 m	**Dip-variation: 50 - 68°** (assumed: s subparallel ss) [9.7 m: ss ~ 5°, only 0.3m] 11.5 m: ss ~ 50° 12.5 m: ss ~ 60° 13.5 m: ss ~ 50° 14.5 m: ss ~ 55° 15.5 m: ss ~ 60° 16.4 m: ss ~ 68° 17.6 m: ss ~ 58° 18.4 m: ss ~ 55° 19.2 m: ss ~ 60° strata probably upside-down	**model mean:** 58°

Preservation	Core colour	AV - samples	Maceration	Fossils	TAI	Short description	Depth [m]
5	O					Si, cl, s	
	G-O					X, g, s, si	
4 5	GO					Cl, si	
							5
3 4	GB						10
		223	●				
4	G OG						
							15
3 4	GB (partly GO)	224					
		225	●	☮			

Graphic log: raw data → **Graphic log: bedding rotated up-right & to zero dip**



Sedimentation processes & interpretation of the palaeoenvironment

Quaternary deposits: dislocated material (Bunter Sandstone, Tertiary quartzite) of river Lahn sediments (old terraces).

Deposition of clay from suspension, punctuated by sudden distal turbiditic incursions of rapidly deposited finesilt to silt by currents (maybe turbidity currents) of waning strength; often in detectable cyclic sequences (see chapter C 8.2, light-dark changes between different laminae/layers at µm to cm-scale).
Basinal background sedimentation of the Bruchberg sandstone formation: Late Viséan.

F 4 Cyclic sequences: raw data

Light / dark - cycles for sample AV 204

(overturned (upside down) core sample from drill site BK 3004/13, depth 21.1-21.3m)

Observed sedimentary types and colour changes:

sediment type 1: black - blackgray; clay

sediment type 2: blackgray; clay, finesilty

sediment type 3: darkgray; clay, medium to coarse silty

sediment type 4: gray; medium to coarse silt, clayey

sediment type 5: lightgray; coarse silt (- ?fine sandy)

Additional remarks:

layer no. 032: thickness laterally varying from 200 - 800 µm
layer no. 046: transition from sediment-type 1 to 2
layer no. 063: thickness laterally varying from 200 - 1000 µm
layer no. 085: thickness laterally varying from 100 - 550 µm
layer no. 115: transition from sediment-type 2 to 3
layer no. 120: transition from sediment-type 3 to 4; + slump-folds
layer no. 178: + layered pyrite patches
layer no. 187: + layered pyrite patches
layer no. 192: transition from sediment-type 2 to 3
layer no. 226: transition from sediment-type 2 to 3
layer no. 229: transition from sediment-type 2 to 3
layer no. 233: + ?bioturbation: max. vertical thickness ca. 1cm (looks like trace of "*Zoophycos*")
layer no. 251: + erosional bases
layer no. 272: + erosional bases

Tab. F 4.1: Details for each counted micro-layer; sample AV 204: from base (layer 001) to top (corrected for former upside down orientation):

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
001	> 300	3	5
002	700	10	1
003	400	14	5
004	150	15.5	1
005	100	16.5	5
006	600	22.5	3
007	100	23.5	5
008	2000	43.5	3
009	400	47.5	2
010	3800	85.5	3
011	600	91.5	2
012	5000	141.5	3
013	1000	151.5	2
014	700	158.5	4
015	2600	184.5	3
016	100	185.5	2
017	50	186	4
018	2500	211	3
019	1400	225	1
020	100	226	4
021	100	227	3
022	100	228	4
023	100	229	3
024	100	230	4
025	400	234	3
026	100	235	4
027	2000	255	3
028	400	259	4
029	1700	276	3
030	300	279	4
031	3000	309	3
032	200	311	4
033	2000	331	3
034	800	339	4
035	2200	361	3
036	300	364	4
037	1000	374	3
038	200	376	4
039	1800	394	3
040	100	395	4
041	100	396	3
042	100	397	4
043	2000	417	3
044	200	419	4
045	3500	454	3
046	400	458	2
047	2500	483	3
048	300	486	4
049	6000	546	3
050	100	547	4
051	3100	578	3
052	100	579	4
053	1000	589	3
054	50	589.5	4
055	1400	603.5	3
056	50	604	4
057	1100	615	3
058	700	622	4
059	1500	637	3
060	50	637.5	1
061	1300	650.5	3
062	800	658.5	1
063	200	660.5	5

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
064	300	663.5	2
065	200	665.5	4
066	50	666	2
067	100	667	4
068	150	668.5	2
069	350	672	4
070	300	675	3
071	400	679	4
072	300	682	3
073	100	683	4
074	400	687	3
075	2900	716	4
076	150	717.5	3
077	500	722.5	4
078	50	723	3
079	100	724	4
080	100	725	3
081	50	725.5	4
082	400	729.5	3
083	50	730	4
084	100	731	3
085	100	732	4
086	50	732.5	3
087	600	738.5	4
088	150	740	3
089	150	741.5	4
090	50	742	3
091	300	745	4
092	50	745.5	3
093	150	747	4
094	500	752	3
095	150	753.5	4
096	800	761.5	3

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
097	1800	779.5	4
098	150	781	3
099	1100	792	4
100	500	797	3
101	400	801	4
102	100	802	5
103	400	806	4
104	100	807	5
105	800	815	3
106	700	822	4
107	600	828	3
108	500	833	4
109	600	839	3
110	2500	864	4
111	250	866.5	3
112	300	869.5	4
113	1300	882.5	3
114	400	886.5	4
115	600	892.5	3
116	700	899.5	4
117	100	900.5	3
118	1000	910.5	4
119	200	912.5	3
120	5800	970.5	3+4
121	700	977.5	4
122	500	982.5	3
123	800	990.5	4
124	1100	1001.5	3
125	400	1005.5	4
126	700	1012.5	3
127	350	1016	4
128	2800	1044	3
129	2600	1070	4

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
130	200	1072	1
131	600	1078	2
132	300	1081	1
133	750	1088.5	2
134	450	1093	1
135	1100	1104	3
136	200	1106	4
137	1000	1116	3
138	1100	1127	1
139	200	1129	5
140	200	1131	2
141	150	1132.5	4
142	50	1133	3
143	150	1134.5	4
144	1500	1149.5	3
145	100	1150.5	4
146	500	1155.5	3
147	150	1167	4
148	1200	1179	3
149	200	1181	4
150	150	1182.5	3
151	50	1183	4
152	300	1186	3
153	50	1186.5	4
154	400	1190.5	3
155	150	1192	4
156	200	1194	3
157	100	1195	4
158	300	1198	3
159	100	1199	4
160	250	1201.5	3
161	100	1202.5	4
162	150	1204	3

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
163	100	1205	4
164	200	1207	3
165	200	1209	4
166	500	1214	3
167	100	1215	4
168	500	1220	3
169	200	1222	4
170	1000	1232	3
171	1000	1242	4
172	1400	1256	3
173	100	1257	4
174	200	1259	3
175	50	1259.5	4
176	300	1262.5	3
177	100	1263.5	4
178	200	1265.5	3
179	100	1266.5	4
180	300	1269.5	2
181	200	1271.5	4
182	400	1275.5	3
183	100	1276.5	4
184	250	1279	3
185	100	1280	4
186	1300	1293	3
187	200	1295	3
188	400	1299	3
189	100	1300	4
190	600	1306	3
191	300	1309	4
192	300	1312	2
193	200	1314	4
194	100	1315	2
195	100	1316	4

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
196	400	1320	3
197	100	1321	4
198	600	1327	3
199	100	1328	4
200	200	1330	3
201	100	1331	4
202	300	1334	3
203	50	1334.5	2
204	400	1338.5	3
205	200	1340.5	1
206	100	1341.5	4
207	500	1346.5	3
208	100	1347.5	4
209	2400	1371.5	3
210	200	1373.5	1
211	50	1374	4
212	200	1376	3
213	50	1376.5	4
214	100	1377.5	3
215	150	1379	4
216	400	1383	3
217	100	1384	4
218	700	1391	3
219	100	1392	4
220	300	1395	3
221	200	1397	4
222	100	1398	3
223	200	1400	4
224	100	1401	3
225	200	1403	4
226	700	1410	2
227	400	1414	4
228	1400	1428	3

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
229	200	1430	2
230	1500	1445	3
231	100	1446	4
232	1000	1456	3
233	100	1457	4
234	150	1458.5	3
235	200	1460.5	4
236	1400	1474.5	3
237	100	1475.5	4
238	500	1480.5	3
239	250	1483	4
240	100	1484	3
241	200	1486	4
242	50	1486.5	3
243	200	1488.5	4
244	200	1490.5	3
245	50	1491	4
246	100	1492	3
247	50	1492.5	4
248	600	1498.5	3
249	100	1499.5	4
250	600	1505.5	3
251	300	1508.5	4
252	50	1509	3
253	100	1510	4
254	50	1510.5	3
255	200	1512.5	4
256	300	1515.5	3
257	200	1517.5	4
258	50	1518	3
259	100	1519	4
260	200	1521	3
261	200	1523	4

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
262	100	1524	3
263	200	1526	4
264	400	1530	3
265	100	1531	4
266	1000	1541	3
267	350	1544.5	4
268	50	1545	3
269	100	1546	4
270	50	1546.5	3
271	150	1548	4
272	500	1553	5
273	150	1554.5	3
274	100	1555.5	4
275	250	1558	3
276	300	1561	4
277	200	1563	3
278	100	1564	4
279	250	1566.5	3
280	50	1567	4
281	100	1568	3
282	50	1568.5	4
283	300	1571.5	3
284	100	1572.5	4
285	200	1574.5	3
286	200	1576.5	4
287	50	1577	2
288	450	1581.5	3
289	100	1582.5	4
290	600	1588.5	3
291	300	1591.5	4
292	1100	1602.5	3
293	200	1604.5	4
294	200	1606.5	3

Layer	Thickness µm	Total thickness x 0.1 mm	Type of sediment
295	100	1607.5	4
296	2700	1634.5	3
297	100	1635.5	4
298	400	1639.5	3
299	100	1640.5	4
300	500	1645.5	3
301	200	1647.5	4
302	1100	1658.5	3
303	100	1659.5	4
304	200	1661.5	3
305	100	1662.5	4
306	700	1669.5	3
307	500	1674.5	4
308	100	1675.5	2
309	1300	1688.5	3
310	100	1689.5	4
311	200	1691.5	3
312	200	1693.5	4
313	1600	1709.5	3
314	100	1710.5	2
315	2700	1737.5	3
316	100	1738.5	2
317	2700	1765.5	3
318	500	1770.5	1
319	700	1777.5	3
320	100	1778.5	1
321	50	1779	4
322	700	1786	1
323	200	1788	3
324	300	1791	1
325	400	1795	3
326	> 1000	1805	1

Tab. F 4.2: Light flinty slates. Details for each counted layer; from base (layer 001) to top:

Layer	Total thickness (cm)	Layer thickness (cm)
001	4	4
002	8	4
003	9	1
004	12	3
005	19	7
006	53	34
007	59	6
008	81	22
009	86	5
010	99	13
011	106	7
012	107	1
013	126	19
014	141	15
015	144	3
016	147	3
017	151	4
018	157	6
019	170	13
020	174	4
021	180	6
022	193	13
023	202	9
024	207	5
025	209	2
026	219	10
027	233	14
028	247	14
029	261	14
030	262	1
031	268	6
032	269	1
033	271	2
034	274	3
035	278	4
036	288	10
037	295	7
038	309	14
039	310	1
040	312	2
041	320	8
042	324	4
043	329	5
044	333	4
045	340	7
046	345	5
047	349	4
048	357	8
049	360	3
050	363	3
051	368	5
052	374	6
053	378	4
054	389	11
055	405	16
056	416	11
057	419	3
058	422	3
059	423	1
060	426	3
061	434	8
062	442	8
063	444	2
064	449	5
065	452	3
066	456	4
067	459	3
068	464	5
069	474	10
070	484	10
071	490	6
072	500	10
073	508	8
074	522	14
075	523	1
076	525	2
077	526	1
078	530	4
079	535	5
080	540	5
081	547	7
082	562	15
083	566	4
084	576	10
085	589	13
086	593	4
087	596	3
088	620	24
089	623	3
090	626	3
091	630	4
092	635	5

Layer	Total thickness (cm)	Layer thickness (cm)
093	643	8
094	646	3
095	659	13
096	670	11
097	677	7
098	680	3
099	684	4
100	697	13
101	703	6
102	705	2
103	715	10
104	721	6
105	728	7
106	736	8
107	739	3
108	743	4
109	750	7
110	762	12
111	766	4
112	769	3
113	774	5
114	784	10
115	791	7
116	794	3
117	796	2
118	798	2
119	800	2
120	803	3
121	804	1
122	815	11
123	820	5
124	827	7
125	829	2
126	838	9
127	848	10
128	861	13
129	867	6
130	872	5
131	879	7
132	882	3
133	886	4
134	889	3
135	900	11
136	906	6
137	909	3
138	914	5
139	933	19
140	947	14

Layer	Total thickness (cm)	Layer thickness (cm)
141	954	7
142	958	4
143	962	4
144	982	20
145	986	4
146	993	7
147	1010	17
148	1014	4
149	1018	4
150	1022	4
151	1023	1
152	1027	4
153	1031	4
154	1038	7
155	1046	8
156	1054	8
157	1063	9
158	1067	4
159	1073	6
160	1078	5
161	1081	3
162	1090	9
163	1100	10
164	1105	5
165	1108	3
166	1111	3
167	1126	15
168	1151	25
169	1157	6
170	1164	7
171	1169	5
172	1179	10
173	1184	5
174	1186	2
175	1191	5
176	1196	5
177	1201	5
178	1208	7
179	1216	8
180	1224	8
181	1227	3
182	1229	2
183	1237	8
184	1239	2
185	1248	9

F 5 Fractal analysis: raw data

Tab. F 5.1: Detailed results obtained during fractal analysis in order to determine the fractal dimensions of the discontinuity networks for samples Aardeck A - D and Oberhofer Mühle AV 1.

	Aardeck A					**Aardeck B**				
R [m]	0.064	0.016	0.008	0.004	0.002	0.064	0.016	0.008	0.004	0.002
1/R	15.625	62.5	125	250	500	15.625	62.5	125	250	500
ln (1/R)	2.7489	4.1352	4.8283	5.5215	6.2146	2.7489	4.1352	4.8283	5.5215	6.2146
N (R)	1	16	64	256	879	1	16	64	248	815
ln N (R)	0	2.773	4.159	5.545	6.779	0	2.773	4.159	5.513	6.703
R_{real} [m]	0.64	0.16	0.08	0.04	0.02	0.64	0.16	0.08	0.04	0.02
ξ [m]	0.133					0.133				
r^2	0.99					0.99				
D_{dn}	**1.97**					**1.95**				

	Aardeck C					**Aardeck D**				
R [m]	0.064	0.016	0.008	0.004	0.002	0.064	0.016	0.008	0.004	0.002
1/R	15.625	62.5	125	250	500	15.625	62.5	125	250	500
ln (1/R)	2.7489	4.1352	4.8283	5.5215	6.2146	2.7489	4.1352	4.8283	5.5215	6.2146
N (R)	1	16	64	254	928	1	16	64	252	800
ln N (R)	0	2.773	4.159	5.537	6.833	0	2.773	4.159	5.529	6.685
R_{real} [m]	0.92	0.23	0.115	0.0575	0.0288	0.92	0.23	0.115	0.0575	0.0288
ξ [m]	0.153					anisotropy: 0.537 / 0.153				
r^2	0.99					0.99				
D_{dn}	**1.98**					**1.95**				

	Oberhofer Mühle AV 1					**Legend**
R [m]	0.064	0.016	0.008	0.004	0.002	R = unit square size of the counting grid
1/R	15.625	62.5	125	250	500	R_{real} = real size of the unit square
ln (1/R)	2.7489	4.1352	4.8283	5.5215	6.2146	ξ = largest observed length on which the network is non-uniform
N (R)	1	16	64	256	851	
ln N (R)	0	2.773	4.159	5.545	6.746	r^2 = correlation coefficient
R_{real} [m]	0.06	0.015	0.0075	0.0038	0.0019	D_{dn} = fractal dimension of the discontinuity network
ξ [m]	anisotropy: 0.014 / 0.007					
r^2	0.99					the outer square size of the counting grid was always 64 mm
D_{dn}	**1.96**					

Tab. F 5.2: Detailed results obtained during fractal analysis in order to determine the fractal dimension of the fracture density and block density for sample Aardeck A.

	Aardeck A									
	fracture density					**block density**				
R [m]	0.064	0.016	0.008	0.004	0.002	0.064	0.016	0.008	0.004	0.002
R*	1	0.25	0.125	0.0625	0.0313	1	0.25	0.125	0.063	0.0313
1/R*	1	4	8	16	32	1	4	8	16	32
ln (1/R*)	0	1.3863	2.0794	2.7726	3.4657	0	1.3863	2.0794	2.7726	3.4657
N (R)		257	372	675	1197		283	457	900	2034
N* (R)	1	11.69	41.33	112.5	299.25	1	12.29	311.18	490.25	845.5
ln N* (R)	0	2.4587	3.7216	4.7229	5.7013	0	2.5088	3.7269	4.8565	5.8284
r^2	0.99					0.99				
D	**D_{fd} = 2.70**					**D_{bd} = 2.73**				
N_1 (R)				21	599					18
N_2 (R)				91	245				35	613
N_3 (R)			3	111	32				107	203
N_4 (R)			6	28	3			3	72	40
N_5 (R)			20	3				7	34	4
N_6 (R)			15	2				12	5	1
N_7 (R)			14					17	3	
N_8 (R)			3					11		
N_9 (R)			3					10		
N_{10} (R)								3		
N_{11} (R)								1		
N_{12} (R)		1								
N_{13} (R)		3								
N_{14} (R)		3					1			
N_{15} (R)		1					6			
N_{16} (R)		1								
N_{17} (R)		2					2			
N_{18} (R)		1					2			
N_{19} (R)		1								
N_{20} (R)		2					1			
N_{21} (R)							1			
N_{22} (R)		1					1			
N_{23} (R)							2			
N_{24} (R)										
N_{25} (R)										
N_{26} (R)										
N_{27} (R)										
N_{28} (R)										
N_{29} (R)										
N_{30} (R)										

Tab. F 5.3: Detailed results obtained during fractal analysis in order to determine the fractal dimension of the fracture density and block density for sample Aardeck B.

	Aardeck B									
	fracture density					**block density**				
R [m]	0.064	0.016	0.008	0.004	0.002	0.064	0.016	0.008	0.004	0.002
R*	1	0.25	0.125	0.0625	0.0313	1	0.25	0.125	0.063	0.0313
1/R*	1	4	8	16	32	1	4	8	16	32
ln (1/R*)	0	1.3863	2.0794	2.7726	3.4657	0	1.3863	2.0794	2.7726	3.4657
N (R)		211	325	562	1053		231	389	804	1826
N* (R)	1	11.73	40.625	112.4	351	1	12.15	38.9	114.9	365.2
ln N* (R)	0	2.4621	3.7045	4.7221	5.8608	0	2.4974	3.6609	4.7441	5.9004
r^2	0.99					0.99				
D	**D_{fd} = 2.72**					**D_{bd} = 2.72**				
N_1 (R)				35	591				1	21
N_2 (R)			2	132	210				35	606
N_3 (R)			1	65	14			2	134	160
N_4 (R)			17	12				1	65	27
N_5 (R)			19	4				17	8	1
N_6 (R)			15					23	4	
N_7 (R)			7					10	1	
N_8 (R)		1	2					6		
N_9 (R)							1	2		
N_{10} (R)		3					1	2		
N_{11} (R)										
N_{12} (R)		1					1			
N_{13} (R)		3					2			
N_{14} (R)		5					2			
N_{15} (R)							4			
N_{16} (R)							2			
N_{17} (R)		2					1			
N_{18} (R)		1					1			
N_{19} (R)							1			
N_{20} (R)										
N_{21} (R)										
N_{22} (R)										
N_{23} (R)										
N_{24} (R)										
N_{25} (R)										
N_{26} (R)										
N_{27} (R)										
N_{28} (R)										
N_{29} (R)										
N_{30} (R)										

Tab. F 5.4: Detailed results obtained during fractal analysis in order to determine the fractal dimension of the fracture density and block density for sample Aardeck C.

	Aardeck C									
	fracture density					**block density**				
R [m]	0.064	0.016	0.008	0.004	0.002	0.064	0.016	0.008	0.004	0.002
R*	1	0.25	0.125	0.0625	0.0313	1	0.25	0.125	0.063	0.0313
1/R*	1	4	8	16	32	1	4	8	16	32
ln (1/R*)	0	1.3863	2.0794	2.7726	3.4657	0	1.3863	2.0794	2.7726	3.4657
N (R)		264	444	761	1407		309	529	1011	2283
N* (R)	1	12.568	40.364	126.83	351.75	1	12.36	40.692	126.38	456.6
ln N* (R)	0	2.5312	3.6979	4.8428	5.8629	0	2.5145	3.7060	4.8393	6.1238
r^2	0.99					0.99				
D	**D_{fd} = 2.73**					**D_{bd} = 2.77**				
N_1 (R)				11	505					18
N_2 (R)				70	369				13	532
N_3 (R)				99	52				77	317
N_4 (R)			2	60	2			1	94	55
N_5 (R)			10	11				1	51	6
N_6 (R)			14	3				10	12	
N_7 (R)			15					12	5	
N_8 (R)			17					16	2	
N_9 (R)			2					7		
N_{10} (R)			1					8		
N_{11} (R)			3					5		
N_{12} (R)								2		
N_{13} (R)		1						2		
N_{14} (R)		3								
N_{15} (R)		2					1			
N_{16} (R)		3					3			
N_{17} (R)		1					2			
N_{18} (R)		2					3			
N_{19} (R)		2					1			
N_{20} (R)		1								
N_{21} (R)		1					1			
N_{22} (R)							1			
N_{23} (R)							2			
N_{24} (R)										
N_{25} (R)							2			
N_{26} (R)										
N_{27} (R)										
N_{28} (R)										
N_{29} (R)										
N_{30} (R)										

Tab. F 5.5: Detailed results obtained during fractal analysis in order to determine the fractal dimension of the fracture density and block density for sample Aardeck D.

	Aardeck D									
	fracture density					**block density**				
R [m]	0.064	0.016	0.008	0.004	0.002	0.064	0.016	0.008	0.004	0.002
R*	1	0.25	0.125	0.0625	0.0313	1	0.25	0.125	0.063	0.0313
1/R*	1	4	8	16	32	1	4	8	16	32
ln (1/R*)	0	1.3863	2.0794	2.7726	3.4657	0	1.3863	2.0794	2.7726	3.4657
N (R)		172	297	541	1015		197	360	773	1746
N* (R)	1	10.753	29.7	90.167	253.75	1	10.943	27.692	128.83	349.2
ln N* (R)	0	2.3752	3.3911	4.5017	5.5363	0	2.3927	3.3211	4.8585	5.8556
r^2	0.99					0.99				
D	**D_{fd} = 2.62**					**D_{bd} = 2.70**				
N_1 (R)				65	595				2	44
N_2 (R)			4	105	196				69	583
N_3 (R)			14	65	8			5	112	157
N_4 (R)			12	15	1			13	51	15
N_5 (R)		1	15	1				13	15	1
N_6 (R)		1	13	1			1	15	3	
N_7 (R)		1	4					13		
N_8 (R)		1	1				2	2		
N_9 (R)							1	2		
N_{10} (R)		4	1							
N_{11} (R)		1					2			
N_{12} (R)		2					2			
N_{13} (R)		2					1	1		
N_{14} (R)		1					3			
N_{15} (R)		1					2			
N_{16} (R)		1								
N_{17} (R)							1			
N_{18} (R)							1			
N_{19} (R)										
N_{20} (R)										
N_{21} (R)										
N_{22} (R)										
N_{23} (R)										
N_{24} (R)										
N_{25} (R)										
N_{26} (R)										
N_{27} (R)										
N_{28} (R)										
N_{29} (R)										
N_{30} (R)										

Tab. F 5.6: Detailed results obtained during fractal analysis in order to determine the fractal dimension of the fracture density and block density for sample Oberhofer Mühle AV 1.

	Oberhofer Mühle AV 1									
	fracture density					**block density**				
R [m]	0.064	0.016	0.008	0.004	0.002	0.064	0.016	0.008	0.004	0.002
R*	1	0.25	0.125	0.0625	0.0313	1	0.25	0.125	0.063	0.0313
1/R*	1	4	8	16	32	1	4	8	16	32
ln (1/R*)	0	1.3863	2.0794	2.7726	3.4657	0	1.3863	2.0794	2.7726	3.4657
N (R)	222	325	485	788	1376	258	387	589	1061	2181
N* (R)	1	12.04	34.643	112.57	344	1	12.9	36.813	132.63	436.2
ln N* (R)	0	2.4882	3.5451	4.7236	5.8406	0	2.5572	3.6059	4.8876	6.0781
r^2	0.99					0.99				
D	**D_{fd} = 2.70**					**D_{bd} = 2.76**				
N_1 (R)				19	426					20
N_2 (R)				73	337				26	449
N_3 (R)			1	74	76				67	279
N_4 (R)			3	63	12			1	73	89
N_5 (R)			7	16				1	45	14
N_6 (R)			8	8				6	28	
N_7 (R)			12	3				4	13	
N_8 (R)			14					13	4	
N_9 (R)			10					10		
N_{10} (R)			3					14		
N_{11} (R)			3					8		
N_{12} (R)			2					2		
N_{13} (R)		1						2		
N_{14} (R)			1					2		
N_{15} (R)							1			
N_{16} (R)		3						1		
N_{17} (R)										
N_{18} (R)		2					1			
N_{19} (R)		1								
N_{20} (R)		2					1			
N_{21} (R)		1								
N_{22} (R)							4			
N_{23} (R)		2								
N_{24} (R)		1					1			
N_{25} (R)		1								
N_{26} (R)		1					2			
N_{27} (R)		1					2			
N_{28} (R)							1			
N_{29} (R)							2			
N_{30} (R)							1			

F 6
Sample descriptions

Tab. F 6.1: Sample descriptions. The remarks contribute to the following topics in the given order (if known): lithology; location; stratigraphic correlation; name of the geological map 1 : 25000 (available at: Hessisches Landesamt für Bodenforschung, Leberberg 9, D-65193 Wiesbaden).

Sample	Gauss-Kruger-Coordinates		Remarks
AV	Easting	Northing	
1	3440820	5587970	Bedded black flinty slate; north of Oberhofer Mühle near Hofen; Lower Carboniferous; GK 5515 Weilburg
2	3440820	5587960	Dark slate with intercalations of cherty nodules and flinty slates; north of Oberhofer Mühle near Hofen; uppermost Emsian - lowermost Eifelian; GK 5515 Weilburg
3	3440830	5587940	Dark slate with minor coarsesilt - finesand intercalations (small pseudonodules); north of Oberhofer Mühle near Hofen; Upper Emsian; GK 5515 Weilburg
4	3444690	5593100	Breccia of dark flinty slates (Kieselschieferbrekzie); Kahlhau; Lower Carboniferous; GK 5515 Weilburg
5	3437850	5587325	Blackish - violet slate; Lower Carboniferous; temporary outcrop within Steeden; GK 5514 Hadamar
6	3437850	5587325	Blackish - violet slate; temporary outcrop within Steeden; Lower Carboniferous; GK 5514 Hadamar
7	3440820	5587960	Dark slate with intercalations of cherty nodules and flinty slates (less weathered than AV 2); north of Oberhofer Mühle near Hofen; uppermost Emsian - lowermost Eifelian; GK 5515 Weilburg
8	3440830	5587940	Dark slate (less weathered than AV 3) with minor coarsesilt - finesand intercalations (small pseudonodules); north of Oberhofer Mühle near Hofen; Upper Emsian; GK 5515 Weilburg
9	3431510	5580210	Dark slate; outcrop opposite of Aardecker Mühle; Earliest Eifelian; GK 5614 Limburg
10	3444660	5593260	*Posidonia* - slate: dark, blackblue, bluegrey to grey slate, partly flaser bedding; Kahlhau; Lower Carboniferous; GK 5515 Weilburg
11	3444660	5593260	*Posidonia* - slate: dark, blackblue, bluegrey to grey slate, partly flaser bedding; Kahlhau; Lower Carboniferous; GK 5515 Weilburg
12	3442640	5590580	Medium to thick bedded, fine-grained, micaceous, greygreen sandstone, partly intercalated with flaser-like, micaceous sandy slates; north of Christianshütte; Lower Emsian; GK 5515 Weilburg
13	3442640	5590580	Medium to thick bedded, fine-grained, micaceous, greygreen sandstone, partly intercalated with flaser-like, micaceous sandy slates; north of Christianshütte; Lower Emsian; GK 5515 Weilburg
14	3442540	5590690	Dark slate; outcrop (quarry) at street to Christianshütte; Lower Devonian; GK 5515 Weilburg
15	3442540	5590690	Dark slate; outcrop (quarry) at street to Christianshütte; Lower Devonian; GK 5515 Weilburg

16	3442260	5590260	Light-yellowbrown, sandy to quartzose, partly laminated slate with intercalations of lightgrey quartzose layers; ca. 1.5m uphill from the street to Christianshütte; Upper Devonian; GK 5515 Weilburg
17	3442260	5590260	Light-yellowbrown, sandy to quartzose, partly laminated slate with intercalations of lightgrey quartzose layers; ca. 4m north of AV 16; Upper Devonian; GK 5515 Weilburg
18	3442390	5590860	Black to darkbluegrey slate, partly with minor intercalations of quartzose (silt-finesand) beds; south of former railway station Schupbach; Lower Emsian; GK 5515 Weilburg
19	3442390	5590900	Dark (weathered: reddish/yellowish) slate with silt-finesand pseudonodules, partly intruded by diabas; south of former railway station Schupbach; Emsian; GK 5515 Weilburg
20	3442380	5590880	Black flinty slate (pseudonodules to layers) with intercalations of dark slate; south of former railway station Schupbach; Upper Emsian; GK 5515 Weilburg
21	3442380	5590880	Dark slate (compare AV 19) ca. 1m north of AV 20; south of former railway station Schupbach; Emsian; GK 5515 Weilburg
22	3440700	5587950	Dark slate; north of Oberhofer Mühle near Hofen; Emsian; GK 5515 Weilburg
23	3440690	5588030	Dark slate; north of Oberhofer Mühle near Hofen; Lower Carboniferous; GK 5515 Weilburg
24	3440580	5587880	Sandstone beds within dark slate; east of Hofen; Emsian; GK 5515 Weilburg
25	3435250	5584620	Bruchberg sandstone; abandoned "quartzite"- quarry south of Dietkirchen; Lower Carboniferous; GK 5614 Limburg
26	3437850	5587200	Reddish, greyblack and greenish slates with intercalations of up to ca. 20 cm thick grey, dense cherty nodules and limestone nodules of sometimes more than 1 m lateral extension (compare K 3 (app. 2)); within Steeden; Upper Devonian; GK 5514 Hadamar
27	3435250	5584620	Bruchberg sandstone; abandoned "quartzite"- quarry south of Dietkirchen; Lower Carboniferous; GK 5614 Limburg
28	3435250	5584620	Bruchberg sandstone; abandoned "quartzite"- quarry south of Dietkirchen; Lower Carboniferous; GK 5614 Limburg
29	3435250	5584620	Bruchberg sandstone; abandoned "quartzite"- quarry south of Dietkirchen; Lower Carboniferous; GK 5614 Limburg
30	3444690	5593100	Breccia of dark flinty slates (Kieselschieferbrekzie); Kahlhau; Lower Carboniferous; GK 5515 Weilburg
31	ca. 29°29'	ca. 52°4'	Fine-conglomeratic sandstone (from the collection of the Institut für Geologie & Paläontologie in Marburg); abandoned slate quarry at the Blue Lake between Gommern and Pretzien (southeast of Magdeburg); Lower Carboniferous; GK 3936 Schönebeck / GK 3937 Leitzkau
32	ca. 29°29'	ca. 52°4'	Dark slate (from the collection of the Institut für Geologie & Paläontologie in Marburg); abandoned slate quarry at the Blue Lake between Gommern and Pretzien (southeast of Magdeburg); Lower Carboniferous; GK 3936 Schönebeck / GK 3937 Leitzkau
33	ca. 29°29'	ca. 52°4'	Coarse-conglomeratic sandstone (from the collection of the Institut für Geologie & Paläontologie in Marburg); abandoned slate quarry at the Blue Lake between Gommern and Pretzien (SE of Magdeburg); Lower Carboniferous; GK 3936 Schönebeck / GK 3937 Leitzkau

34	ca. 29°29'	ca. 52°4'	Sandstone (from the collection of the Institut für Geologie & Paläontologie in Marburg); abandoned slate quarry at the Blue Lake between Gommern and Pretzien (southeast of Magdeburg); Lower Carboniferous; GK 3936 Schönebeck / GK 3937 Leitzkau
35	maybe 3474500	maybe 5623500	Sandstone (from the collection of the Institut für Geologie & Paläontologie in Marburg, leg. teacher GEIGER 1913 ("Silur-Quarzit"); "Ochsenberg near Lohra"; ? Emsian; GK 5217 Gladenbach
36	3476100	5604200	Sandstone (from the collection of the Institut für Geologie & Paläontologie in Marburg, leg. STOPPEL May 1955); within Gießen; Emsian; GK 5417 Wetzlar
37	3470650	5617580	Bruchberg sandstone; Niedernberge southwest of Weipoltshausen; Lower Carboniferous; GK 5317 Rodheim-Bieber
38	3470650	5617580	Bruchberg sandstone; Niedernberge southwest of Weipoltshausen; Lower Carboniferous; GK 5317 Rodheim-Bieber
39	3435250	5584620	Bruchberg sandstone (weathered, reddish impregnated); abandoned "quartzite"- quarry (sample from near the top) south of Dietkirchen; Lower Carboniferous; GK 5614 Limburg
40	3434962	5584485	Bruchberg sandstone formation (sandstone and dark slate); BK 2010/138 (21.4 - 21.55m, see appendix 13 for details); northeast of Limburg; Viséan; GK 5614 Limburg
41-42	3435033	5584400	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/04 (41: 5.9 - 7.5m, 42: 25.4 - 25.6m, see appendix 13 for details); northeast of Limburg; Viséan; GK 5614 Limburg
43-44	3435072	5584363	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/05 (43: 0.5 - 0.6m, 44: 15.8 - 15.9m, see appendix 13 for details); northeast of Limburg; Viséan; GK 5614 Limburg
45	3435033	5584400	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/04 (22.9 - 23.0m, see appendix 13 for details); northeast of Limburg; Viséan; GK 5614 Limburg
46	3477950	5601630	Sandstone; Lindener Mark south of Giessen; Lower Devonian; GK 5418 Giessen
47	3440680	5588020	Dark slate; north of Oberhofer Mühle near Hofen; Lower Carboniferous; GK 5515 Weilburg
48	3440890	5588170	Dark (brownish-greenish) slate; north of Oberhofer Mühle near Hofen; Lower Carboniferous (?); GK 5515 Weilburg
49	3434580	5583860	Dark slate; Greifenberg near Limburg (Commerzienrat CAHENSLY - Hain); Lower Carboniferous; GK 5614 Limburg
50	3435203	5584166	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/14 (9.6 - 9.7, see appendix 13 for details); northeast of Limburg; Viséan; GK 5614 Limburg
51	3446050	5591970	Dark greenish tuff-bearing silty slate: silt-components derived from reworked pyroclastic deposits (from the collection of the Institut für Geologie & Paläontologie in Marburg, leg. MUNK 1981, formerly interpreted as "tuffitic Givet-slate of the normal basinal facies"); at forest track near river Lahn; ?Middle Devonian; GK 5515 Weilburg
52	3444500	5602250	Black flinty slate; Flachsberg near Dillhausen; Lower Carboniferous; GK 5415 Merenberg
53	3444510	5602250	Breccia of dark flinty slates (Kieselschieferbrekzie); Flachsberg near Dillhausen; Lower Carboniferous; GK 5415 Merenberg

54-57	3434634	5584305	Debris flow; BK 2010/028 (see appendix 13 for details; 54: 4.0 - 4.2m (dark slate-"breccia" with components up to 8 cm), 55: 7.5 - 7.7m (grey cherty slate with numerous joints), 56: 11.0 - 11.3m (greybrown to darkgrey weathered slate), 57: 12.3 - 12.6m (greybrown to darkgrey weathered slate)); northeast of Limburg; early Famennian; GK 5614 Limburg
58-69	3434782	5584536	Finegrained debris flow; BK 2010/036 (see appendix 13 for details; 58: 9.0 - 9.2m, 59: 15.5 - 15.6m, 60: 16.7 - 17.3m, 61: 18.3 - 18.6m, 62: 19.7 - 19.95m, 63: 20.15 - 20.35m, 64: 21.05 - 21.35m, 65: 22.5 - 22.65m, 66: 23.0 - 23.25m, 67: 24.3 - 24.55m, 68: 25.55 - 25.75m, 69: 26.65 - 26.9m); northeast of Limburg; early Famennian; GK 5614 Limburg
70	3433505	5585501	Dark slate with silty and cherty pseudonodules; BK 2010/112 (32.8 - 33.0m); northeast of Limburg; Lower Carboniferous; GK 5514 Hadamar
71a+b	3434736	5584730	Pyroclastic deposit of a keratophyric magma; BK 2010/128 (see appendix 13 for details; 71a: 39.4 - 39.55m, 71b: 40.3 - 40.4m); northeast of Limburg; Emsian or Givetian (? Famennian); GK 5614 Limburg
72	3434809	5584655	Finegrained debris flow; BK 2010/130 (35.1m); northeast of Limburg; early Famennian; GK 5614 Limburg
73-90	3434955	5584541	Debris flow; BK 2010/132 (see appendix 13 for details; 73: 15.5 - 15.95m, 74: 16.3 - 16.7m, 75: 17.05 - 17.6m, 76: 18.4 - 18.8m, 77: 19.4 - 19.5m, 78: 20.05 - 20.3m, 79: 21.8 - 22.0m, 80: 22.2 - 22.4m, 81: 23.0 - 23.2m, 82: 24.3 - 24.5m, 83: 25.4 - 25.75m, 84: 26.4 - 26.6m, 85: 27.0 - 28.0m, 86: 28.1 - 28.3m, 87: 28.6 - 28.7m, 88: 29.2 - 29.3m, 89: 29.3 - 29.4m, 90: 29.7m); northeast of Limburg; early Famennian; GK 5614 Limburg
91-92	3433643	5585488	Dark slate; BK 2010/136 (91: 46.5m, 92: 51.8m); north of Limburg; Devonian; GK 5614 Limburg
93-115	3434941	5584564	Debris flow; BK 2010/137 (see appendix 13 for details; 93: 6.5 - 6.7m, 94: 7.55 - 7.75m, 95: 8.15 - 8.35m, 96: 9.4 - 9.55m, 97: 10.75 - 10.95m, 98: 11.7 - 11.9m, 99: 12.5 - 12.9m, 100: 13.4 - 13.6m, 101: 14.5 - 14.7m, 102: 15.75 - 15.9m, 103: 16.3 - 16.55m, 104: 17.0 - 17.3m, 105: 18.1 - 18.25m, 106: 18.9 - 19.0m, 107: 19.7 - 20.0m, 108: 20.4 - 20.6m, 109: 21.4 - 21.6m, 110: 22.0 - 22.2m, 111: 22.6 - 22.8m, 112: 24.35 - 24.65m, 113: 25.0 - 25.2m, 114: 25.4m, 115: 27.7 - 27.9m); northeast of Limburg; early Famennian; GK 5614 Limburg
116, -a, 117	3434961	5584497	Bruchberg sandstone formation (sandstone and dark slate); BK 2010/139 (see appendix 13 for details; 116: 20.0 - 20.1m, 116a: 24.5 - 24.75m, 117: 28.2 - 28.6m); northeast of Limburg; Viséan; GK 5614 Limburg
118-123	3434998	5584434	Dark silty slate (basinal background sediment of the Bruchberg sandstone formation); BK 3004/01A (see appendix 13 for details; 118: 34.5m, 119: 35.3m, 120: 37.9m, 121: 38.8m, 122: 39.0 - 41.0m, 123: 39.3m); northeast of Limburg; Viséan; GK 5614 Limburg
124-129	3435033	5584400	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/04 (see appendix 13 for details; 124: 1.8m, 125: 8.1 - 8.4m, 126: 9.2 - 9.5m, 127: 15.6 - 15.8m, 128: 17.6 - 17.8m, 129: 24.7 - 25.0m); northeast of Limburg; Viséan; GK 5614 Limburg

130-151	3435072	5584363	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/05 (see appendix 13 for details; 130: 5.8 - 6.0m, 131: 6.85 - 7.0m, 132: 7.75 - 8.0m, 133: 8.35 - 8.55m, 134: 9.5 -9.7m, 135: 10.0 - 10.2m, 136: 11.5 - 11.7m, 137: 12.75 - 13.0m, 138: 13.3 - 13.55m, 139: 14.9 - 15.0m, 140: 15.1 - 15.2m, 141: 16.5 - 16.8m, 142: 17.2 - 17.5m, 143: 18.6 - 18.8m, 144: 19.8 - 20.0m, 145: 20.7 - 21.0m, 146: 21.3 - 21.45m, 147: 22.2 - 22.4m, 148: 23.7 - 24.0m, 149: 24.6 - 24.8m, 150: 25.0 - 25.4m, 151: 26.5 - 26.7m); northeast of Limburg; Viséan; GK 5614 Limburg
152-164	3435106	5584319	Dark silty slate (basinal background sediment of the Bruchberg sandstone formation); BK 3004/07 (see appendix 13 for details; 152: 9.2 -9.3m, 153: 10.4 - 10.5m, 154: 11.3 -11.6m, 155: 11.6 - 11.7m, 156: 12.5 - 12.6m, 157: 13.15 -13.25m, 158: 14.5m, 159: 15.5m, 160: 16.1 - 16.4m, 161: 16.6m, 162: 17.4 - 17.5m, 163: 18.0 - 18.2m, 164: 19.5 - 19.6m); northeast of Limburg; Viséan; GK 5614 Limburg
165-181	3435133	5584264	Dark silty slate (basinal background sediment of the Bruchberg sandstone formation); BK 3004/09 (see appendix 13 for details; 165: 7.1 - 7.2m, 166: 8.2 - 8.3m, 167: 9.3 - 9.4m, 168: 10.3 - 10.4m, 169: 11.4 - 11.6m, 170: 12.35 - 12.45m, 171: 13.9 - 14.0m, 172: 14.45 - 14.6m, 173: 15.1 - 15.2m, 174: 16.75 - 16.85m, 175: 17.35 - 17.45m, 176: 18.7 - 18.8m, 177: 19.35 - 19.5m, 178: 20.5 - 20.6m, 179: 21.35 - 21.45m, 180: 22.3 - 22.4m, 181: 23.2 - 23.3m); northeast of Limburg; Viséan; GK 5614 Limburg
182-203	3435143	5584269	Dark silty slate (basinal background sediment of the Bruchberg sandstone formation); BK 3004/10 (see appendix 13 for details; 182: 8.1m, 183: 9.5m, 184: 10.7m, 185: 11.5m, 186: 12.5m, 187: 13.9m, 188: 14.3m, 189: 15.3m, 190: 16.7m, 191: 17.8m, 192: 18.2m, 193: 19.6m, 194: 20.3m, 195: 21.6m, 196: 22.4m, 197: 23.4m, 198: 24.2m, 199: 25.3m, 200: 26.5m, 201: 27.5m, 202: 28.1m, 203: 29.8m); northeast of Limburg; Viséan; GK 5614 Limburg
204-212	3435209	5584175	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/13 (see appendix 13 for details; 204: 21.1 - 21.3m, 205: 21.25 - 21.4m, 206: 21.4 - 21.6m, 207: 21.55 - 21.75m, 208: 21.65 - 21.85m, 209: 24.05 - 24.2m, 210: 25.5 - 25.6m, 211: 25.7 - 25.85m, 212: 26.0 - 26.2m); northeast of Limburg; Viséan; GK 5614 Limburg
213-219	3435203	5584166	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/14 (see appendix 13 for details; 213: 9.5 - 9.6m, 214: 12.3m, 215: 21.8 - 22.0m, 216: 22.0 - 22.2m, 217: 25.4 - 25.5m, 218: 26.8 - 27.0m, 219: 28.2 - 28.6m); northeast of Limburg; Viséan; GK 5614 Limburg
220-222	3435241	5584128	Bruchberg sandstone formation (sandstone and dark slate); BK 3004/15 (see appendix 13 for details; 220: 13.3 - 13.4m, 221: 15.7 - 15.8m, 222: 16.9 - 17.2m); northeast of Limburg; Viséan; GK 5614 Limburg
223-225	3435281	5584069	Dark silty slate (basinal background sediment of the Bruchberg sandstone formation); BK 3004/17 (see appendix 13 for details; 223: 11.0 - 11.1m, 224: 16.15 - 16.25m, 225: 19.4 - 19.5m); northeast of Limburg; Viséan; GK 5614 Limburg
226-230	3435256	5584082	Dark silty slate (basinal background sediment of the Bruchberg sandstone formation ?); BK 3005/01 (see appendix 13 for details; 226: 4.9 - 5.0m, 227: 6.9 - 7.0m, 228: 8.8 - 8.9m, 229: 9.2 - 9.3m, 230: 10.1 - 10.2m); northeast of Limburg; Viséan; GK 5614 Limburg

231-233	3439866	5580424	Sandstone (finesand) with slate layers; BK 4036/15 (231: 14.5m, 232: 14.8 - 15.0m, 233: 16.0 - 16.1m); southwest of Niederbrechen; Lower Devonian; GK 5614 Limburg
234	3431490	5580240	Thin limestone layer in dark slate (?debris flow); outcrop opposite of Aardecker Mühle; ? Earliest Famennian; GK 5614 Limburg
235	3431490	5580240	Quartzitic pseudonodule in dark slate (?debris flow); outcrop opposite of Aardecker Mühle, ca. 1m north of AV 234; ? Earliest Famennian; GK 5614 Limburg
236	3431500	5580240	Dark slate with cherty nodules; outcrop opposite of Aardecker Mühle; Upper Emsian; GK 5614 Limburg
237	3431500	5580240	Dark slate with cherty nodules; outcrop opposite of Aardecker Mühle; Upper Emsian; GK 5614 Limburg
238	3431500	5580235	Dark slate with cherty nodules; outcrop opposite of Aardecker Mühle; Upper Emsian; GK 5614 Limburg
239	3431500	5580230	Dark slate with small cherty nodules; outcrop opposite of Aardecker Mühle; Upper Emsian; GK 5614 Limburg
240	3431500	5580230	Dark slate with small cherty nodules; outcrop opposite of Aardecker Mühle; Upper Emsian; GK 5614 Limburg
241	3431505	5580225	Dark slate, partly with small cherty nodules; outcrop opposite of Aardecker Mühle; Upper Emsian; GK 5614 Limburg
242	3431510	5580220	Dark slate; outcrop opposite of Aardecker Mühle; Upper Emsian; GK 5614 Limburg
243	3431510	5580215	Dark slate, partly with calcareous nodules; outcrop opposite of Aardecker Mühle; Earliest Eifelian; GK 5614 Limburg
244	3431510	5580215	Dark slate, partly with calcareous nodules; outcrop opposite of Aardecker Mühle; Earliest Eifelian; GK 5614 Limburg
245	3431510	5580215	Calcareous nodule in dark slate; outcrop opposite of Aardecker Mühle; Earliest Eifelian; GK 5614 Limburg
246	3431510	5580210	Calcareous nodule in dark slate; outcrop opposite of Aardecker Mühle; Earliest Eifelian; GK 5614 Limburg
247	3431510	5580210	Clayey-calcareous nodule in dark slate; outcrop opposite of Aardecker Mühle; Earliest Eifelian; GK 5614 Limburg
248	3431510	5580210	Calcareous nodule in dark slate; outcrop opposite of Aardecker Mühle; Earliest Eifelian; GK 5614 Limburg
249	3431030	5593220	Culm-greywacke; west of Niederzeuzheim; Lower Carboniferous; GK 5514 Hadamar
250	3431100	5593250	Culm-greywacke ("quartzite"); west of Niederzeuzheim; Lower Carboniferous; GK 5514 Hadamar
251	3444660	5593260	*Posidonia* - slate: dark, blackblue, bluegrey to grey slate, partly flaser bedding; Kahlhau, ca. 5m south of AV 10; Lower Carboniferous; GK 5515 Weilburg
252	3442540	5590690	Dark slate; outcrop (quarry) at street to Christianshütte, 1m away from AV 15; Lower Devonian; GK 5515 Weilburg
253	3442400	5590840	Black to darkbluegrey slate, partly with minor intercalations of quartzose (silt) layers; south of former railway station Schupbach, 5m north of AV 18; Emsian; GK 5515 Weilburg
254	3440560	5587710	Clayey-calcareous nodule in dark slate; southwest of Oberhofer Mühle; Devonian; GK 5515 Weilburg

255	3440560	5587710	Calcareous nodule in dark slate; southwest of Oberhofer Mühle; Devonian; GK 5515 Weilburg
256	3440980	5589460	Finegrained greywacke -pseudonodule in dark slate (? debris flow); west of Eschenau; ? Earliest Famennian; GK 5515 Weilburg
257	3440980	5589460	Large (>1m) greywacke -pseudonodule in dark slate (? debris flow); west of Eschenau; ? Earliest Famennian; GK 5515 Weilburg
258	3440980	5589460	Dark slate with greywacke -pseudonodules (? debris flow); west of Eschenau; ? Earliest Famennian; GK 5515 Weilburg
259	3431500	5580250	Finegrained debris flow; outcrop opposite of Aardecker Mühle; Early Famennian; GK 5614 Limburg
260	3431680	5580160	Laminated calcareous silt-bed (reworked pyroclastic deposits?) in dark, partly flinty, slate; small outcrop at street (3m south of a traffic-signpost, ca. 30m north of a abandoned slate quarry) opposite of ruin Aardeck; ?Middle Devonian (Givetian); GK 5614 Limburg
261	3431830	5580240	Reworked pyroclastic deposit (silt-finesand), laminated to thin bedded, greygreen-grey; outcrop below the ruin Aardeck; Early Frasnian (similar to Dillenburg layers); GK 5614 Limburg
262	3431830	5580245	Limestone beds (grey, beds up to 0.35m) with grey-blackgrey slaty intercalations; outcrop below the ruin Aardeck; due to findings of KEGLER (K 21, app. 2) middle to upper Givetian; GK 5614 Limburg
263	3431820	5580235	Calcareous nodule in reworked pyroclastic deposit (silt-finesand), laminated, greygreen-grey; outcrop below the ruin Aardeck; Early Frasnian (similar to Dillenburg layers); GK 5614 Limburg
264	3434550	5583900	Dark, partly flinty, slate with sandstone intercalations (up to 8cm); northern slope of the Greifenberg near Limburg; Lower Carboniferous; GK 5614 Limburg
265	3441020	5589450	Dark slate with pillow-diabas; west of Eschenau; Middle - Upper Devonian; GK 5515 Weilburg
266	3440580	5587650	Sandstone-pseudonodule (finesand, 1.0 x 0.6m) in dark slate; southwest of Oberhofer Mühle; Devonian (sandstone of Lower Devonian age due to petrographic analysis); GK 5515 Weilburg
267	3440600	5587610	Diabas-pseudonodule in dark slate; southwest of Oberhofer Mühle; Lower Devonian; GK 5515 Weilburg
268	3442380	5590880	Black flinty slate (pseudonodules to layers) with intercalations of dark slate; south of former railway station Schupbach; Upper Emsian; GK 5515 Weilburg
269	3442380	5590880	Dark slate, partly intruded by diabas; south of former railway station Schupbach; Emsian; GK 5515 Weilburg
270	3442395	5590920	Calcareous nodule (brownish to darkgrey) in dark slate with finesand intercalations and -partly- horizons of cherty nodules; south of former railway station Schupbach; Early Eifelian; GK 5515 Weilburg
271	3442395	5590910	Calcareous nodule (brownish to darkgrey) in dark slate with finesand intercalations and -partly- horizons of cherty nodules; south of former railway station Schupbach; Early Eifelian; GK 5515 Weilburg
272	3442385	5590880	Diabas, intruded in dark slate; south of former railway station Schupbach; Emsian; GK 5515 Weilburg
273	3442395	5590920	Quartz in dark slate with calcareous nodules and finesand intercalations and -partly- horizons of cherty nodules; south of former railway station Schupbach; Early Eifelian; GK 5515 Weilburg

274	3442270	5590260	Light-yellowbrown, sandy to quartzose, partly laminated slate with intercalations of lightgrey quartzose layers; ca. 1.5m uphill from the street to Christianshütte; Upper Devonian; GK 5515 Weilburg
275	3444660	5593260	*Posidonia* - slate: dark, blackblue, bluegrey to grey slate, partly flaser bedding (= "untere Faunenbank" of DILLMANN, compare app. 2: D9); Kahlhau; Lower Carboniferous; GK 5515 Weilburg
276	3442160	5589650	Diabas-block ('bomb sag') in dark slate with thin, laterally inconsistent sandstone- and limestone-layers; south of Christianshütte; Upper Devonian (Famennian); GK 5515 Weilburg
277	3442160	5589650	Schalstein (reworked pyroclastics) showing cross-bedding; south of Christianshütte; Upper Devonian (Famennian); GK 5515 Weilburg
278	3442170	5589670	Dark to grey slate with calcareous nodules /layers above Schalstein (reworked pyroclastics); south of Christianshütte (compare B4, app. 2); Upper Devonian (Famennian); GK 5515 Weilburg
279	3442200	5589840	Dark slate with thin, laterally inconsistent finesand-layers; south of Christianshütte; Upper Devonian (Famennian); GK 5515 Weilburg
280	3442220	5589870	Dark to grey slate with calcareous nodules; south of Christianshütte; Upper Devonian (Dasbergian); GK 5515 Weilburg
281	3442240	5589840	Dark slate with pillow-diabas ca. 30m uphill from AV 280; south of Christianshütte; Upper Devonian (Famennian); GK 5515 Weilburg
282	3442320	5589900	Dark slate with finesand-intercalations and indet. brachiopod- and ?coral- remnants; southeast of Christianshütte; Upper Devonian; GK 5515 Weilburg
283	3442340	5589940	Dark slate with greywacke-intercalations and indet. brachiopod- and ?coral- remnants; southeast of Christianshütte; Upper Devonian; GK 5515 Weilburg
284	3442410	5590100	Laminated sandstone (fine- to medium sand, greenish-grey, bedded); east of Christianshütte; Devonian; GK 5515 Weilburg
285	3431390	5580470	Submarine pyroclastic flow deposit (greenish-grey) intercalated by calcareous nodules and dark slate; north of Aardecker Mühle; Middle to Upper Devonian; GK 5614 Limburg
286	3431390	5580470	Submarine pyroclastic flow deposit (greenish-grey) intercalated by dark slate; north of Aardecker Mühle; Middle to Upper Devonian; GK 5614 Limburg
287	3431370	5580420	Pyroclastic deposit (medium-coarse sand); north of Aardecker Mühle; Middle to Upper Devonian; GK 5614 Limburg
288	3431320	5580590	Calcareous dark slate; north of Aardecker Mühle; Upper Devonian; GK 5614 Limburg
289	3431320	5580590	Calcareous dark slate; north of Aardecker Mühle; Upper Devonian; GK 5614 Limburg
290	3440890	5588770	Flinty slate, bedded, reddish and grey to black, sample taken from lightgrey bed; south of Eschenau; Lower Carboniferous; GK 5515 Weilburg
291	3440890	5588770	Flinty slate, bedded, reddish and grey, 10cm below AV 290; south of Eschenau; Lower Carboniferous; GK 5515 Weilburg
292	3440680	5587985	Thin layer of dark slate in bedded black flinty slates; north of Oberhofer Mühle near Hofen; Lower Carboniferous; GK 5515 Weilburg

293	3440675	5587990	Greengrey slate, laminated, with silt- finesand intercalations and conodonts on bedding planes; north of Oberhofer Mühle near Hofen; Upper Devonian (Nehdenian); GK 5515 Weilburg
294	3440965	5588135	Dark (green-grey) laminated slate with silt- to finesand-intercalations; north of Oberhofer Mühle near Hofen; Lower Carboniferous (?); GK 5515 Weilburg
295	3440560	5587710	Calcareous layer (0.6 x 4.0m) in dark slate; southwest of Oberhofer Mühle; Middle-Upper Devonian; GK 5515 Weilburg
296	3434250	5583880	Pyroclastic deposit (green-grey), 10m below CAHENSLY hut; Greifenberg near Limburg; Middle - Upper Devonian; GK 5614 Limburg
297	3434150	5583580	Dark slate, platy, directly behind the Kreuzweg- (pilgrims path-) signpost XIV near the Kreuz-Chapel, Greifenberg near Limburg; Upper Devonian (Frasnian); GK 5614 Limburg
298	3434850	5584000	Dark slate with flaser-bedding and finesand intercalations (up to ca. 1.5 x 0.1m); northern slope of the Greifenberg near Limburg; Lower Carboniferous; GK 5614 Limburg
299	3441150	5588550	Red limestone (type "Cephalopodenkalk"); north of Oberhofer Mühle (near P 5, see app. 2); Upper Devonian; GK 5515 Weilburg
300	3442390	5589640	Dark (weathered: yellowish) slates with finesand-intercalations and partly up to 10 cm thick beds of grey to black flinty slates (compare B1, see app. 2); forest path above eastern bank of Kerkerbach between Eschenau and Christianshütte; Lower Carboniferous; GK 5515 Weilburg
301	3431470	5580230	Greywacke-pseudonodule (green-grey, calcareous along joints) in dark slate (?debris flow); outcrop opposite of Aardecker Mühle, behind a hut; ? Earliest Famennian; GK 5614 Limburg
302	3440675	5587990	Greengrey silty slate, with silt- finesand intercalations (ca. 2m away from AV 293); north of Oberhofer Mühle near Hofen; Upper Devonian (Nehdenian); GK 5515 Weilburg
303a	3435580	5579550	Sandstone (finesand, greengrey - reddish, weathered: yellowish-brown); Mensfelder Kopf west of Mensfelden; Lower Devonian; GK 5614 Limburg
303b	3435650	5579560	Sandstone (medium-coarse sand, greengrey - reddish, weathered: yellowish-brown); Mensfelder Kopf west of Mensfelden; Lower Devonian; GK 5614 Limburg

F 7 Listings of figures and tables

F 7.1 Listing of figures

F 7.2 Listing of tables

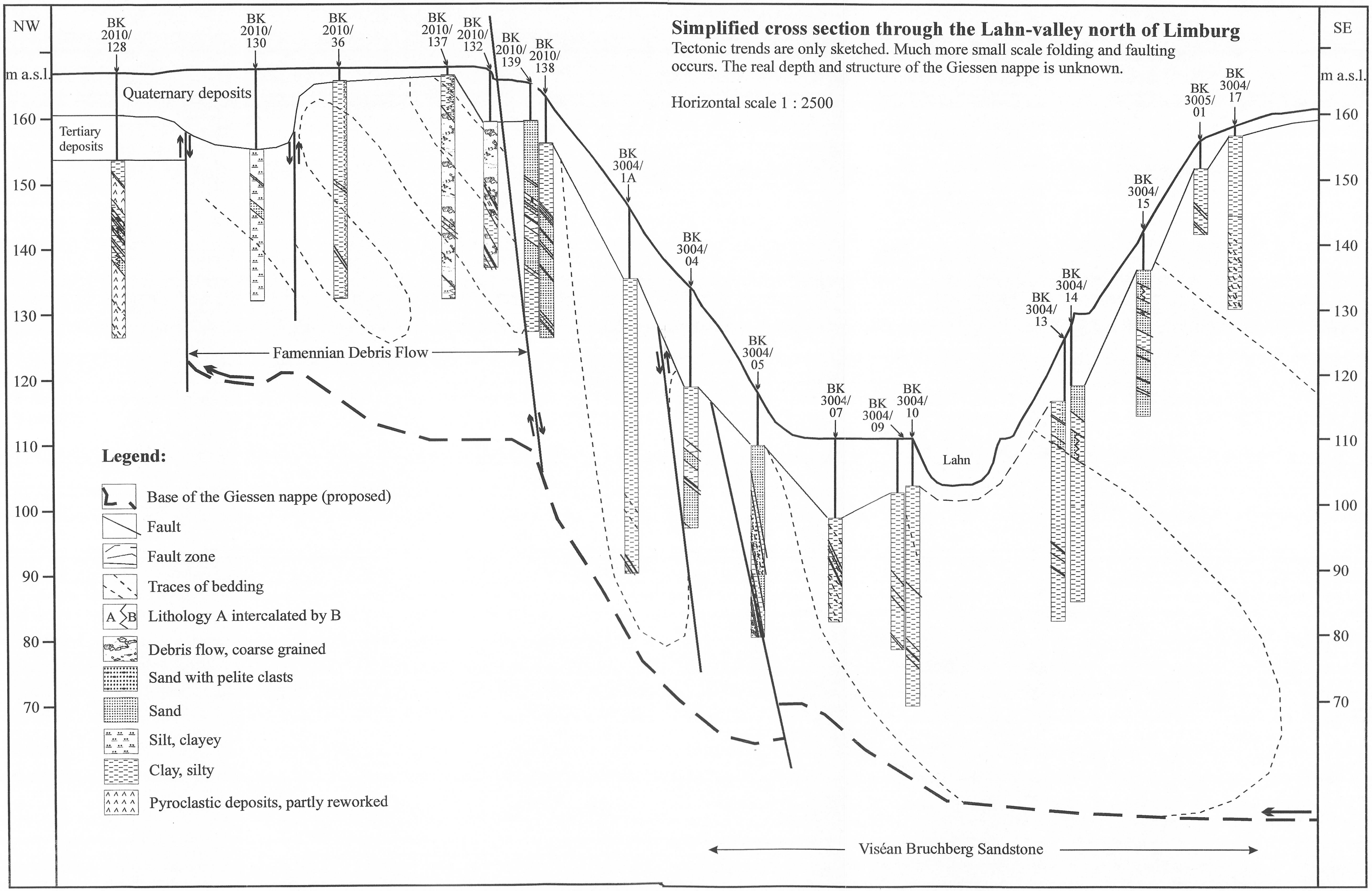
Enclosures

Discontinuity network of the outcrop opposite of the Aardecker Mühle

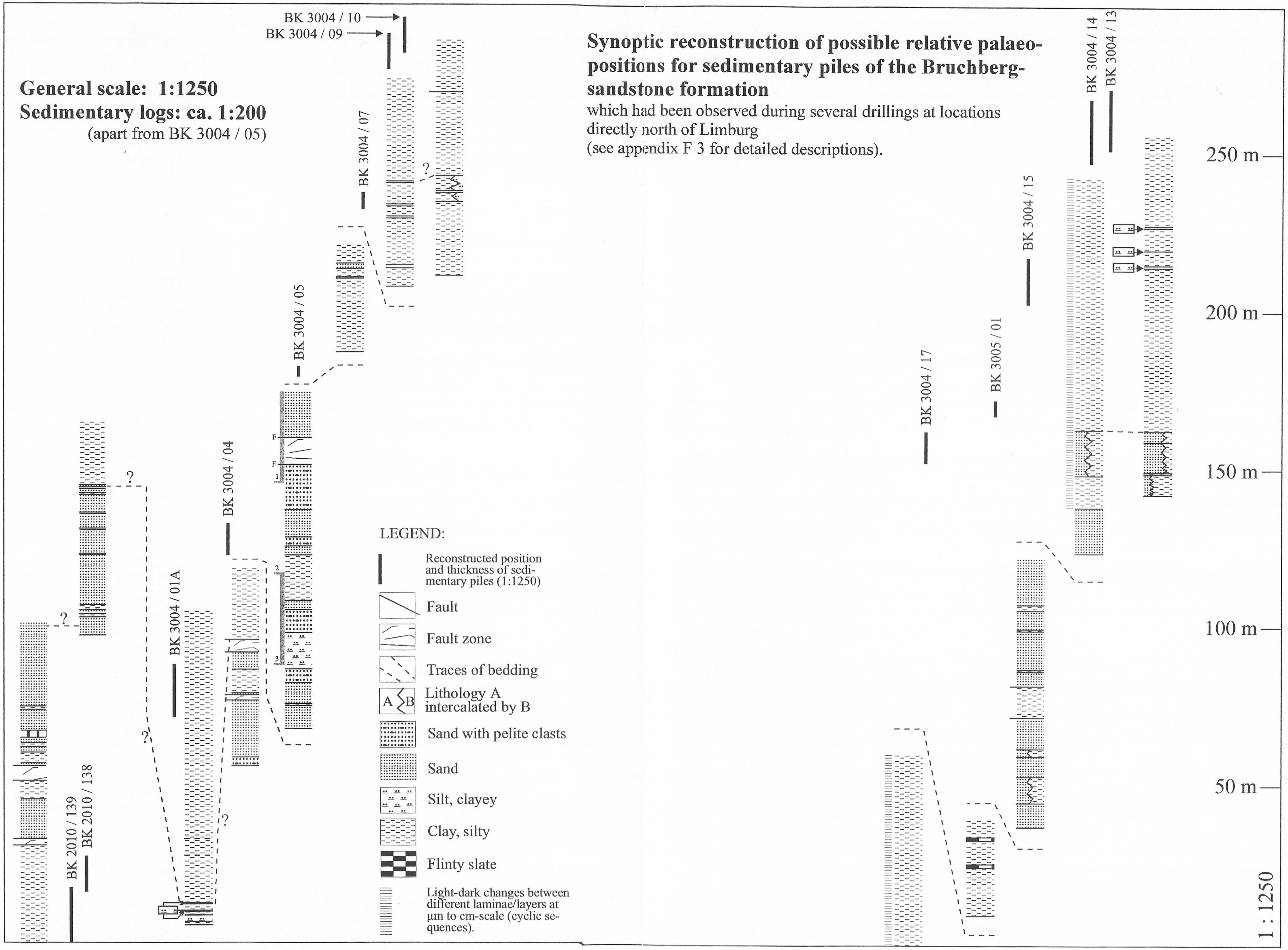
(E [34]31510 - N [55]80250, geological map 5614 Limburg)

Illustrated features:
a) observed discontinuity network
b) sample locations (AV 9, 236-248)
c) enlarged details used for fractal analysis (Aardeck A - D)
d) data derived from the fractal analysis (fractal dimensions)

	FRACTAL DIMENSION of the		
	discontinuity network (D_{dn})	fracture density (D_{fd})	block density (D_{bd})
Aardeck A	1.97	2.70	2.73
Aardeck B	1.95	2.72	2.72
Aardeck C	1.98	2.73	2.77
Aardeck D	1.95	2.62	2.70



Simplified cross section through the Lahn-valley north of Limburg
Tectonic trends are only sketched. Much more small scale folding and faulting occurs. The real depth and structure of the Giessen nappe is unknown.
Horizontal scale 1 : 2500
NW
SE
m a.s.l.
160
150
140
130
120
110
100
90
80
70
BK 2010/ 128
BK 2010/ 130
BK 2010/ 36
BK 2010/ 137
BK 2010/ 132
BK 2010/ 139
BK 2010/ 138
BK 3004/ 1A
BK 3004/ 04
BK 3004/ 05
BK 3004/ 07
BK 3004/ 09
BK 3004/ 10
BK 3004/ 13
BK 3004/ 14
BK 3004/ 15
BK 3005/ 01
BK 3004/ 17
Quaternary deposits
Tertiary deposits
Famennian Debris Flow
Lahn
Viséan Bruchberg Sandstone
Legend:
Base of the Giessen nappe (proposed)
Fault
Fault zone
Traces of bedding
A B
Lithology A intercalated by B
Debris flow, coarse grained
Sand with pelite clasts
Sand
Silt, clayey
Clay, silty
Pyroclastic deposits, partly reworked



General scale: 1:1250
Sedimentary logs: ca. 1:200
(apart from BK 3004 / 05)
Synoptic reconstruction of possible relative palaeo-positions for sedimentary piles of the Bruchberg-sandstone formation
which had been observed during several drillings at locations directly north of Limburg
(see appendix F 3 for detailed descriptions).
BK 3004 / 10
BK 3004 / 09
BK 3004 / 07
BK 3004 / 05
BK 3004 / 04
BK 3004 / 01A
BK 2010 / 139
BK 2010 / 138
BK 3004 / 17
BK 3005 / 01
BK 3004 / 15
BK 3004 / 14
BK 3004 / 13
250 m
200 m
150 m
100 m
50 m
1 : 1250
LEGEND:
Reconstructed position and thickness of sedimentary piles (1:1250)
Fault
Fault zone
Traces of bedding
Lithology A intercalated by B
Sand with pelite clasts
Sand
Silt, clayey
Clay, silty
Flinty slate
Light-dark changes between different laminae/layers at µm to cm-scale (cyclic sequences).


Geological Sketch Map 1:25000
Area between Weilburg and Holzheim
Lahn-syncline, Rheinisches Schiefergebirge. Only Palaeozoic strata are presented.
Compiled and in parts newly mapped by André W. VOGT (1994-98);
with the usage of maps from KAYSER & KOCH (1886), AHLBURG (1918), DILLMANN (1952), KEGLER (1967), HENTSCHEL & THEWS (1979), MUNK (1981), KAPP (1987), PETER (1994).
GIESSEN NAPPE
Lower Carboniferous
Darkgrey, clayey to silty, partly sandy slates, flinty slates (Kieselschiefer), crinoid limestone, intrusive & pillow-basalt (Deckdiabas), tuff layers and sandstone (Bruchberg-Sandstein)
Upper Devonian (early Famennian):
Darkgrey (-greenish) finegrained greywacke & debris flow deposits (dark slates, siltstones, greywacke, sandstones)
Upper Devonian
Grey to darkgrey, also reddish to greenish clayey to silty slates with intercalations of pyroclastic deposits, reworked pyroclastics (Schalstein) and calcareous layers and lenses
Middle Devonian (Givetian) and Upper Devonian
Basic (diabas) and rhyolitic (keratophyr) volcanics, pyroclastic deposits and reworked pyroclastics (Schalstein)
Middle Devonian (Givetian) and early Frasnian
Reef- and reef-derived limestones (Massenkalk, Plattenkalk, etc.)
Middle Devonian (Eifelian, partly Givetian)
Darkgrey to black slates, partly with silty-sandy or calcareous intercalations (small layers or lenses)
Lower Devonian (Emsian)
Darkgrey to black slates, partly with intercalations of: flinty slates, siltstones, sandstones or calcareous layers and lenses; minor occurrences of keratophyr (rhyolitic magma)
Outline of a mappable area.
Outline of proposed nappe structure with dip-directions.
Major thrusts.
Major antiforms / synforms.
Geological maps 1:25,000:
LIM = Limburg, sheet 5614
HAD = Hadamar, sheet 5514
WEI = Weilburg, sheet 5515
Birlenbach
Freiendiez
Limburg
Dehrn
Niedertiefenbach
Allendorf
Sonner-Bach
Dietkirchen
Schupbach
Hasselbach
Ruin Aardeck
Holzheim
Flacht
Mühlen
Esch-hofen
Steeden
Kerkerbach
Emsbach
Gaudern-bach
Hofen
Eschenau
Christians-hütte
Linter
Ennerich
Runkel
Niederneisen
Lindenholzhausen
Kirsch-hofen
Odersbach
Weilburg
Wirbelau
Lahn
Aar
A
A'
B
B'
C
C'