Zitteliana

An International Journal
of Palaeontology and Geobiology

Series B/Reihe B
Abhandlungen der Bayerischen Staatssammlung
für Paläontologie und Geologie

26

4th International Symposium on Lithographic Limestone and Plattenkalk

Eichstätt/Solnhofen, Germany

September 12th-18th, 2005

- Abstracts and Field Trip Guides -

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Organised by

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Jura-Museum, Eichstätt

Martin Röper
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– Abstracts and Field Trip Guides –

Zitteliana	B 26	96 Seiten	München, 05.09.2005	ISSN 1612-4138

Editors-in-Chief/Herausgeber: Reinhold R. Leinfelder, Michael Krings
Volume Editor: Winfried Werner
Production and Layout/Bildbearbeitung und Layout:
Stefanie Klug

Bayerische Staatssammlung für Paläontologie und Geologie
Richard-Wagner-Str. 10, D-80333 München, Deutschland
http://www.palaeo.de/zitteliana
email: zitteliana@lrz.uni-muenchen.de

ISSN 1612-4138
Druck: Gebr. Geiselberger GmbH, Altötting

Published with the support of the
Deutsche Forschungsgemeinschaft (DFG)

Cover illustration: *Mesolimulus walchi* Desmarest; horse-shoe crab with its trail; Lower Tithonian, Solnhofen (BSPG AS I 944).

Umschlagbild: *Mesolimulus walchi* Desmarest; Pfeilschwanzkrebs mit Fährte; Lower Tithonian, Solnhofen (BSPG AS I 944).

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Zitteliana **B26**	71-85	4th Int. Symp. Lithogr. Limestone	München, 05.09.2005	ISSN 1612-4138

Field Trip C

Lithographic Limestones and Plattenkalk Deposits of the Solnhofen and Mörnsheim Formations near Eichstätt and Solnhofen

September 13th, 2005

By
Martin Röper
(English Translation: Martina Kölbl-Ebert)

Bürgermeister-Müller-Museum, Bahnhofstr. 8, D-91807 Solnhofen, Germany

The first stops will visit the Eichstätt-type Fossillagerstätte within the Solnhofen archipelago. The so-called lithographic Plattenkalk of Eichstätt forms an independent Plattenkalk basin and Fossillagerstätte. True lithographic stones, i.e. slaps that are suitable for lithography, are lacking. Within the Eichstätt basin, the workable platy limestone form a hose-like depositional area on the plateau between Wintershof in the east and Schernfeld and Schönau in the west. This includes several small Plattenkalk sub-basins, which are remnants of the palaeo-relief of the bedrock of the Eichstätt basin. On this field trip, we shall travel from east to west through these sub-basins. Due to an inversion of the relief the sub-basins show up as flat hills, which are separated by depressions. On the plateau, according to EDLINGER (1964) lie the sub-basins of Eichstätt, Weigertsdorf, Harthof-Obereichstätt and Schönau. Their exact lateral extension is mostly not known, and the sub-basins were mapped according to the area in which Plattenkalk fragments can be found in the soils. The Eichstätt and Weigertsdorf sub-basins represent the eastern part of the depositional area, the Harthof-Obereichstätt and Schönau sub-basins the western part. Near Wintershof-East the workable Plattenkalk has its greatest thickness with 18 metres. In the direction of the shallower facies towards the Solnhofen Basin the deposits become continuously thinner (towards Schernfeld and Schönau in the west).

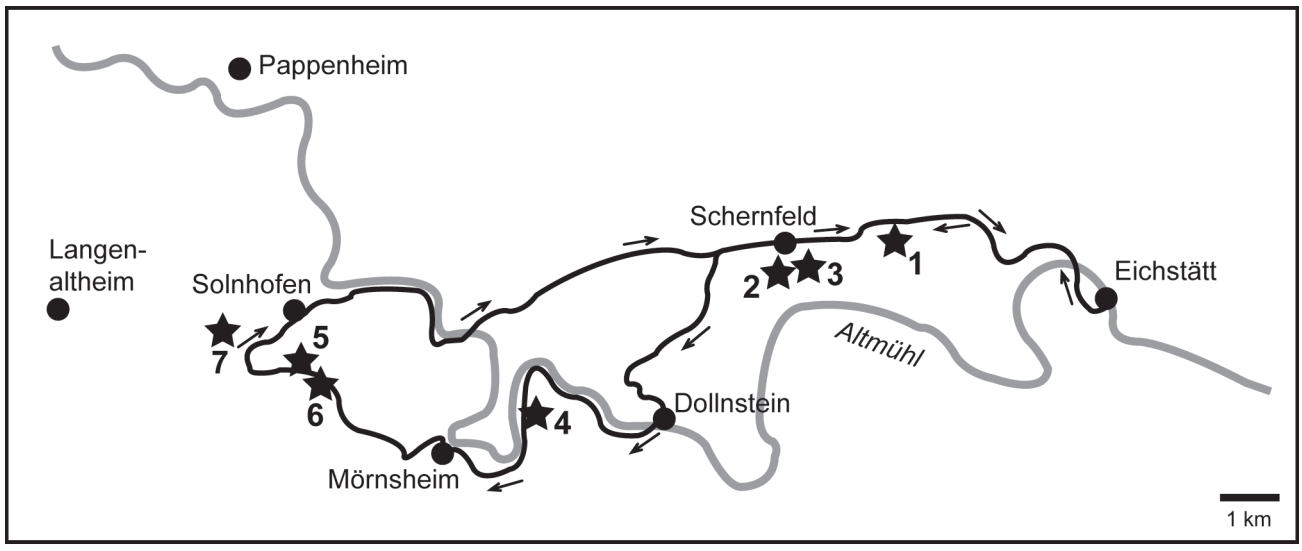


Figure 1: Location of the outcrops.

E-mail: m.roeper@solnhofen.de

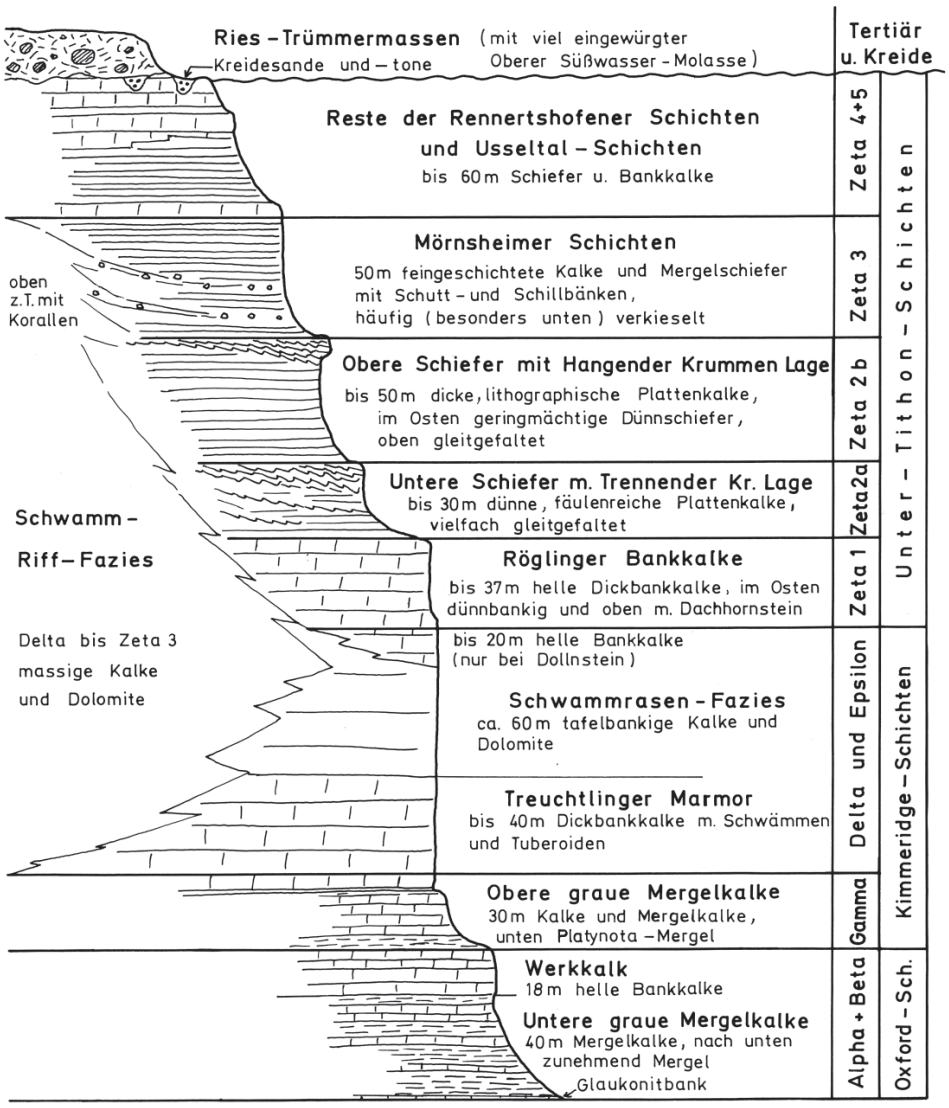


Figure 2: Lithostratigraphy and lateral facies variations of the Upper Jurassic of the Southern Franconian Alb (from Meyer & Schmidt-Kaler 1990).

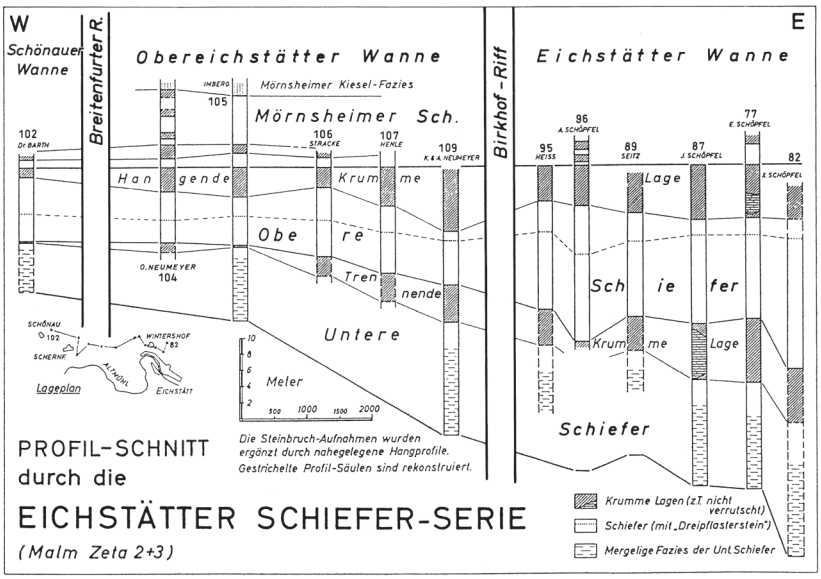


Figure 3: Sections of the plattenkalk sub-basins between Schönau and Eichstätt. Note that the Solnhofen Formation increases continously in thickness from west to east. Note also the reef barriers separating the sub-basins (e.g., Breitenfurt reef, Birkhof reef) (from Meyer & Schmidt-Kaler 1991)

Stop 1: Great quarry of Schernfeld-Birkhof, central area of the western part of the Eichstätt Basin, Harthof-Obereichstätt sub-basin. Lower Tithonian (Malm zeta 2b)

Geological map 1:25 000, sheet 7032 Bieswang;
quarry about 2 km east of Schernfeld
Ref.: Röper, Schweigert & Rothgänger (2001)
Fig. 4

The great quarry is worked by companies from Eichstätt as well as from Solnhofen to produce flagstones. It allows insight in a unique way into the central part of the Eichstätt Fossillagerstätte, more precisely into its western region, i.e. the centre of the Obereichstätt sub-basin. The quarry shows the upper part of the Solnhofen Formation, e.g., the parts above the "Trennende Krumme Lage" (TKL, slump horizons which separate the Lower and Upper Solnhofen Fm.). Workable are the some 10 m thick thin-platy Plattenkalk between the TKL and the "Hangende Krumme Lage" (HKL, upper slump horizon). Above the HKL, undisturbed Plattenkalk alternates with slumped horizons.

The Plattenkalk layers in the middle part of the section of Schernfeld-Birkhof is known for a relatively soft rock. Therefore, fossils from Wegscheid are much esteemed by collectors and preparators. The fossils are easy to prepare and of very good quality.

Fossils:

Some important ammonite taxa: *Hybonoticeras hybonotum* (Oppel), *Subplanites rueppellianus* Quenstedt, *Neochetoceras steraspis* Oppel, *Neochetoceras bous* (Oppel), *Lingulaticeras solenoides* (Quenstedt), *Taramelliceras franciscanum* Fontannes; *Streblites* sp., *Physodoceras* sp., *Pseudodiscospinctes ardescicus* (Fontannes) (*Perisphinctes ulmensis* Schneid), *Sutneria* sp.

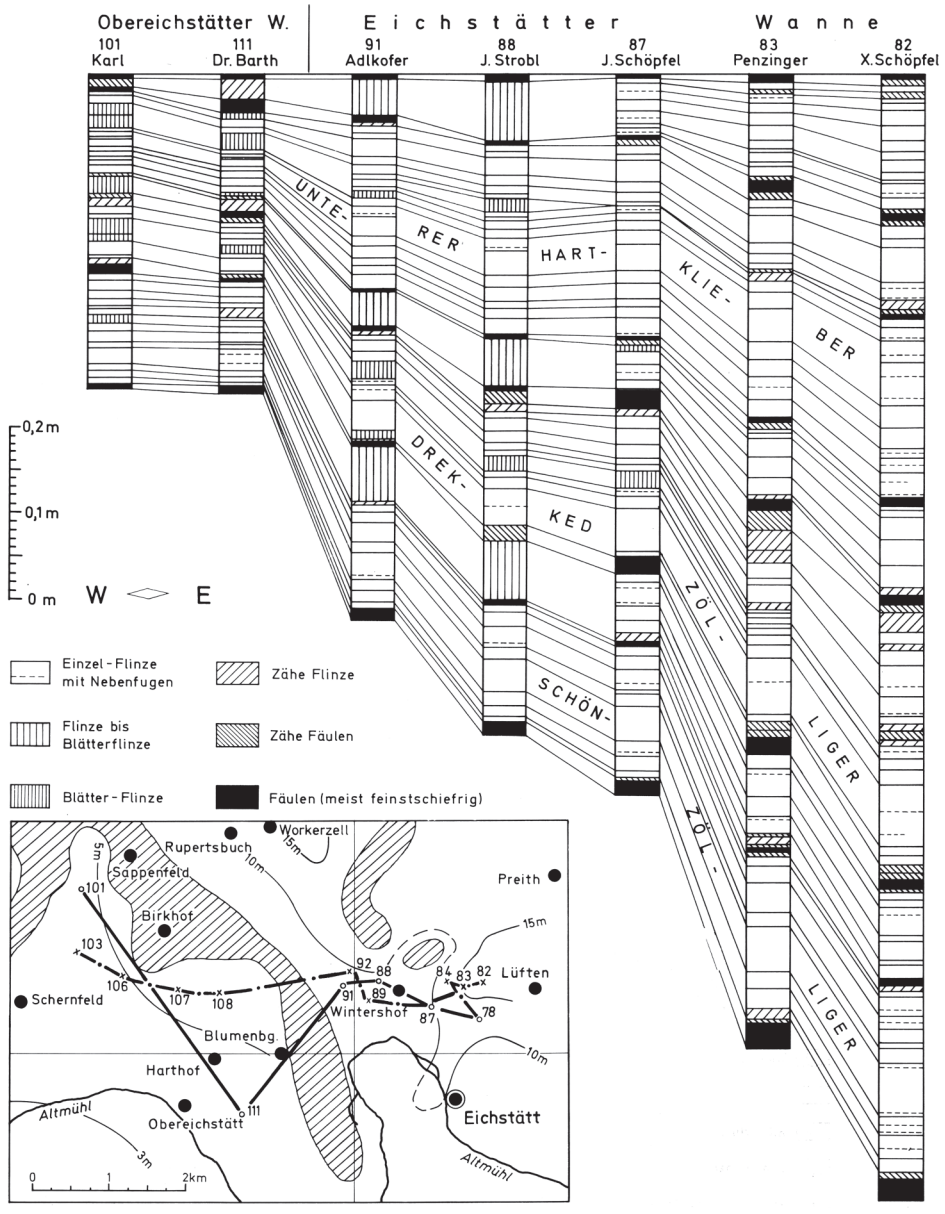


Figure 4: Detailed sections of the Upper Solnhofen Formation between Schernfeld and Eichstätt showing the general increase in thickness to the east (from Meyer & Schmidt-Kaler 1991).

Selection of some fossils very typical for the Harthof-Obereichstätt sub-basin:

Porifera: soft-bodied sponges with oysters growing on them
Gastropoda: *Rissoa* sp., *Spinigera* sp.)
Crustacea: *Anthonema problematicum* WALTHER, *Aeger elegans* MUENSTER, *Antrimpos speciosus* MUENSTER, *Drobna deformis* MUENSTER, *Palaeopentacheles redenbacheri* (MUENSTER), *Cancrinos latipes* MUENSTER
Insecta: giant cicadas *Protopsyche braucri* HANDLIRSCH, neurop-

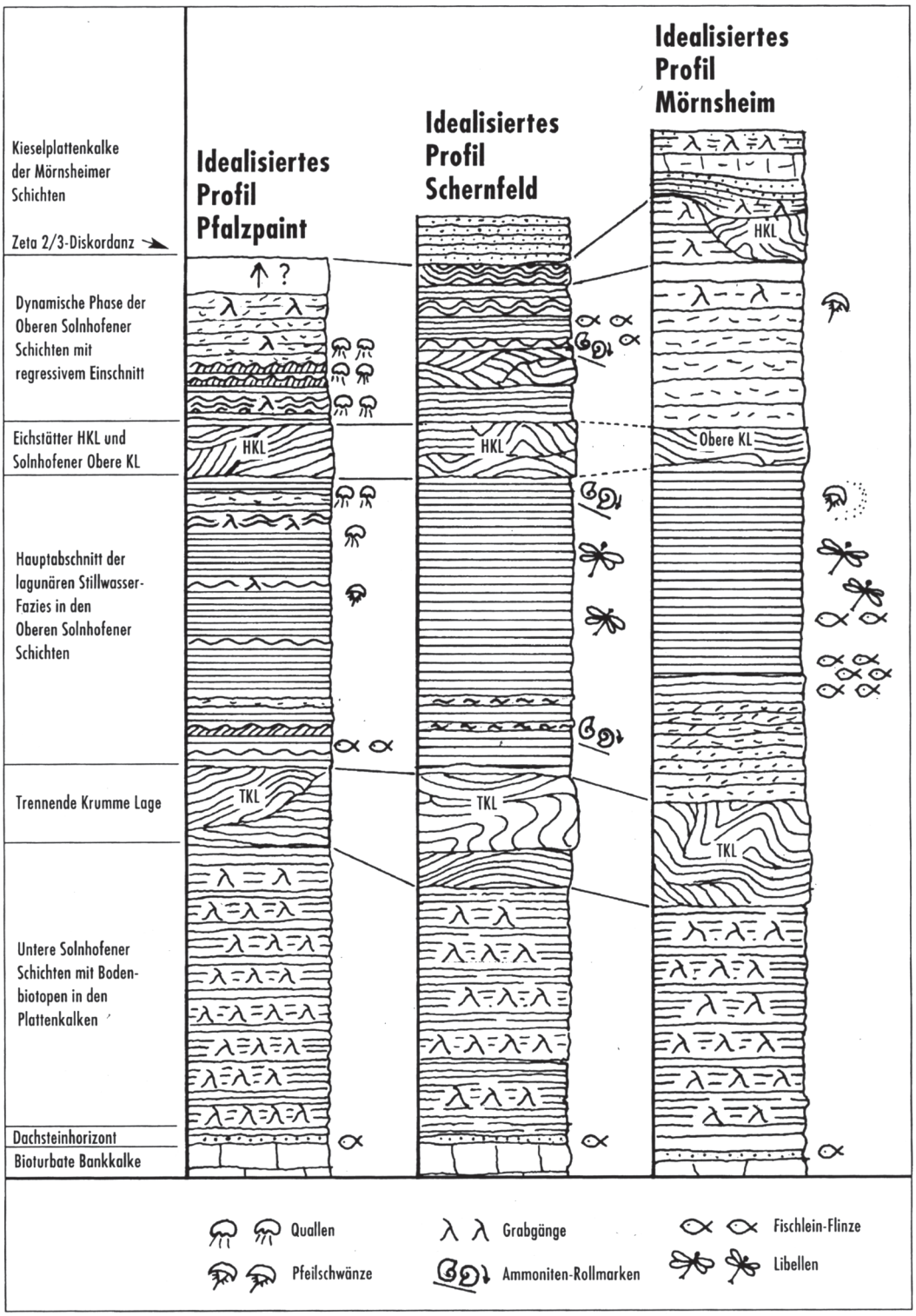


Figure 5: Comparison of generalised sections of the Upper Solnhofen Beds at the localities Pfalzpaint, Schernfeld and Mörnsheim. They show the general distribution of the „Krumme Lagen" (slump horizons) and the variability in thickness of the single plattenkalk units (from RÖPER at al. 2001).

teran *Mesochrysopa zitteli* (Meunier); the deposits in Schernfeld generally contain important locations for insect finds
Crinoids: *Saccocoma tenella* (Goldfuss)
Pisces: *Spathobatis bugesiacus* Thiollière, *Pseudorhina alifera* (Muenster), *Propterus microstomus* Agassiz, *Propterus elongatus* Wagner, *Arduafrons prominoris* Frickhinger, *Gyronchus macropterus* Agassiz, *Mesturus verrucosus* Wagner

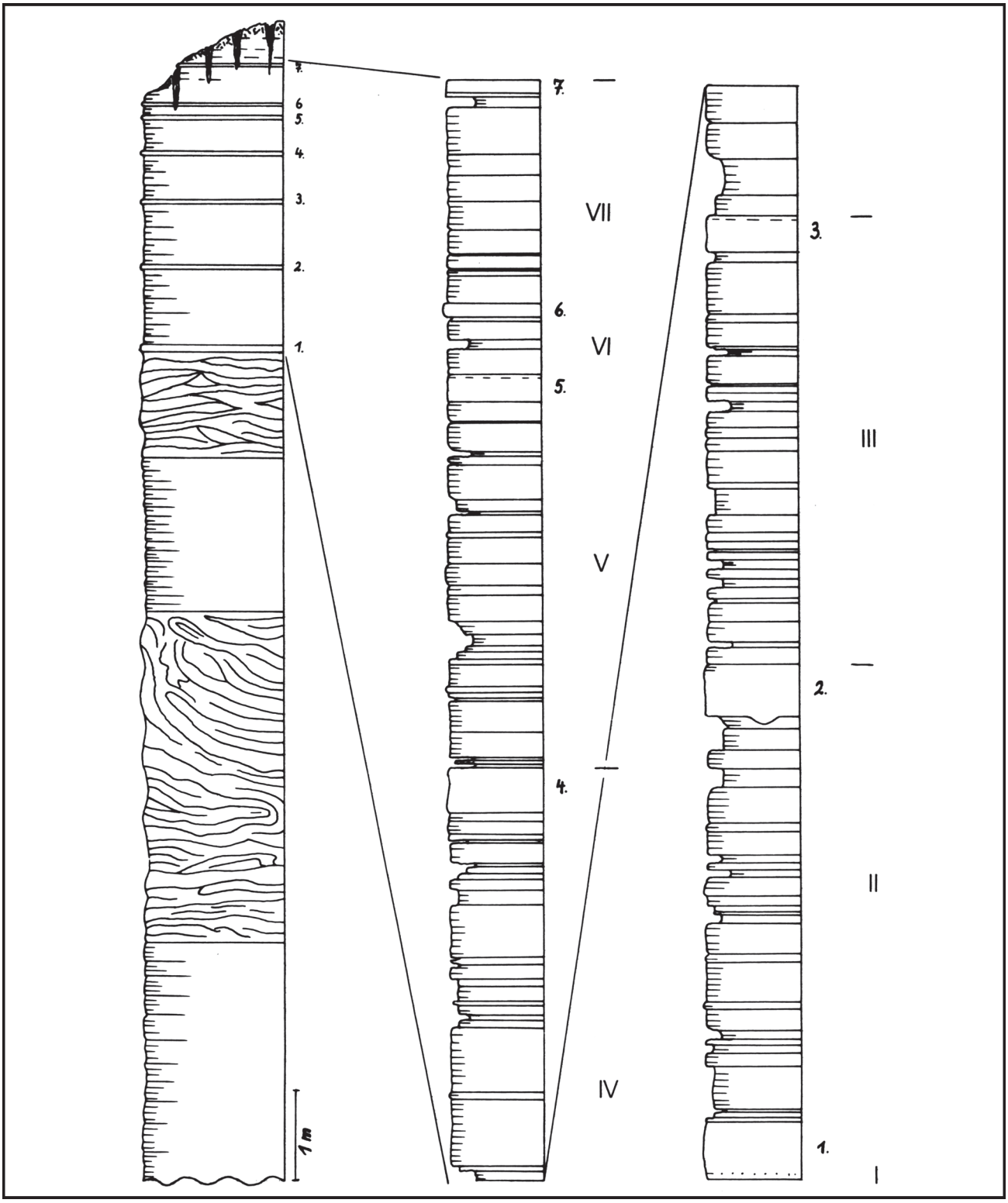


Figure 6: In the left: idealised section of the Imberg quarry of Schernfeld with the two „Krumme Lagen" (slump horizons) and, at the top, the seven „wilde Lagen 1-7" (wild layers, sligthly slumped horizons). Middle and right section: detailed sections from the top of the whole section above the upper „Krumme Lage" (from Gerhard & Mörs 1991).

Stop 2: Quarry "Am Sportplatz" of the company Niefnecker, S Schernfeld, Lithographic Plattenkalk in "Malm zeta 2b" and "Eichstätt Upper Krumme Lage"

Geological map 1:25 000, sheet 7032 Bieswang; R 4434800, H 5418300; quarry south of the Schernfeld near the "Sportplatz" (sports field)

Ref.: Meyer & Schmidt-Kaler (1983); Peitz (1992), Stolzenburg (1992)

Fig. 5

From east (Eichstätt sub-basin, Wintershof-East) to west (Schernfeld) the deposits of the "Upper Solnhofen Beds (Malm Zeta 2b)" get thinner and thinner bordering towards the Solnhofen Basin at the palaeo-relief (Edlinger 1964). Within the Obereichstätt sub-basin, this Niefnecker quarry is the western most. Farther west, there are only thin deposits in the area of the Schönau sub-basin (cf. Viohl 1983).

The quarry shows the classical stillwater-facies of the Upper Solnhofen Formation. Thin Flinz and Blätter-Flinz dominate widely, bordered by thin Fäule layers. The thin Flinz layers do not split as easily as in the area Birkhof and Blumenberg.

Peitz (1992) and Stolzenburg (1992) summarized the uppermost layers immediately below the "Eichstätt Upper Krumme Lage" in a lithological-macropalaeontological section. The enormous richness of some layers in *Saccocoma* is to be stressed. In facies, there is much correspondence with the parallel section in the Imberg quarry (stop 3, 200 m E of the section "Am Sportplatz"). Only in the taphonomy of the *Saccocoma* specimens there are significant differences. The latter outcrop contains considerably more disintegrated *Saccocoma* specimens than in the Imberg section.

The eastern as well as the western wall of the quarry show in ideal fashion sections of the some 3.5 m thick "Eichstätt Upper Krumme Lage". The near flat base of this inhomogeneous packet is clearly to be seen. Here ends abruptly the stillwater facies with its thin Blätter-Flinz. The following sediments within the "Krumme Lage" resemble more closely the "Solnhofen Plattenkalk Facies" than the "Eichstätt Shale Facies". According to Edlinger (1964), with the onset of the Krumme Lage, there is also a change in the sedimentation regime connected. The Krumme Lage consists of folded and slipped layers caused by slumping over, as it seems, very short distance. A general direction of movement is not apparent. The bedding is very different to Aldinger's "Krumme Lagen" in Nusplingen. Here they are widespread "carpets", which affect the complete area of the "Eichstätt Shale-Facies". Obviously they are parautochthonous deposits.

Above the 1.15 m thick "Wilde Lage" (i.e. "wild layer", a slump horizon) follow right up to the soil covering again thin layers of Blätter-Flinz with intercalated layers of Fäule. The same facies is resumed, as it dominated the conditions before the formation of the "Krumme Lage" (i.e. the wild layers). The upper layers, which have been already eroded at the quarry "Am Sportplatz", show up in the outcrop of the Imberg quarry 200 m further east (see stop 3).

Stop 3: Imberg quarry SE Schernfeld, Uppermost Lithographic Plattenkalk of the Eichstätt Basin, Lower Tithonian (Malm zeta 2b)

Geological map 1:25 000, sheet 7032 Bieswang; SE of Schernfeld, about 200 m E of Stop 2

Ref.: Gerhard (1990), Gerhard & Mörs (1991), Mörs (1990), Peitz (1992), Peitz & Peitz (1997)

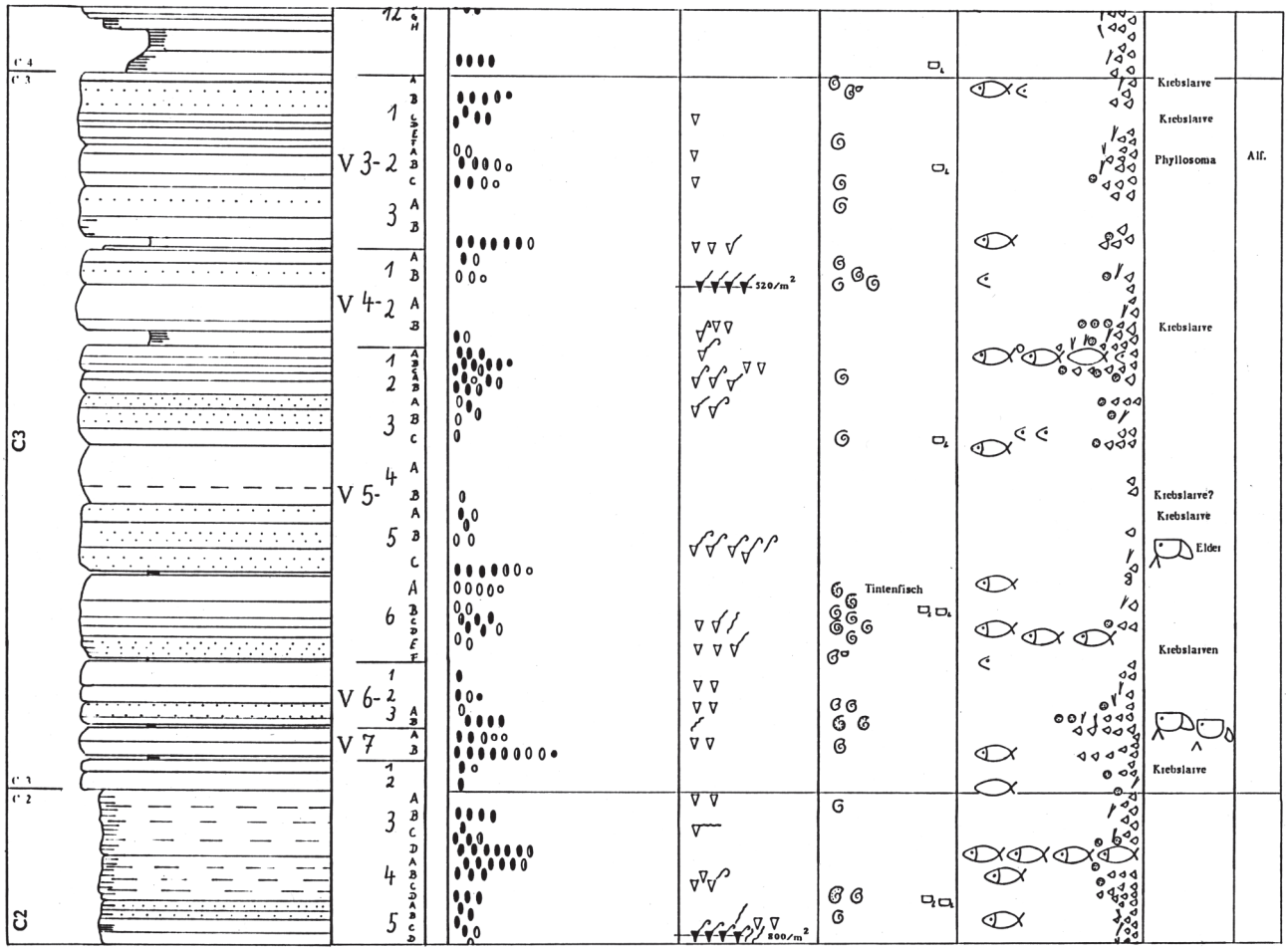
Figs 6-7

This outcrop is a protected quarry, declared a natural monument. Here, during the years 1987-1992, under the leadership of Prof. Dr. Horst Remy (Institute of Palaeontology, University of Bonn) and in cooperation with the Jura-Museum Eichstätt, the to this date most complete lithological-macropalaeontological combined section of the "Eichstätt Shale-Facies" was studied. The quarry shows in a near ideal fashion the Lithographic Plattenkalk above the "Eichstätt Upper Krumme Lage" and, additionally, another Krumme Lage. The combined section consists of three individual partial sections

- Imberg 1 a) younger beds up to the soils, with intermittent thick limestone banks, flute casts und imprints of rolling ammonite shells (Gerhard & Mörs 1991)
- Imberg 1 b) beds immediately above the "Upper Krumme Lage" with intermittent thick limestone banks up to the next "Krumme Lage" (Krüger 1992)
- Imberg 1 c) beds below the "Upper Krumme Lage", without thicker limestone banks (Peitz 1992, Stolzenburg 1992)

The section consists mainly of thin Blätter-Flinz and Fäule layers in between. The number of major breaks in sedimentation (bedding planes with microbial mats) is great. Below the "Eichstätt Upper Krumme Lage" (HKL) a stillwater-facies is dominant, as it is also typical for the central part of the Obereichstätt sub-basin. Above the some 3.6 m thick HKL follow again thin "paper-shale" and Fäule beds, however with occasional thick limestone banks, sediment-collapse, flute casts and, in the upper parts, also with imprints of rolling ammonite shells.

In the past, the layers within the Eichstätt HKL where considered to be very poor in fossils (Edlinger 1964) and the fossil spectrum of the beds was basically unknown. During the new investigation of the section, plant fossils proved to be rare in these beds (few conifers from the partial sections 1a and 1b). In the whole HKL a marine fauna dominates with ammonites, crustaceans and their larvae, *Saccocoma* and small teleosts. Especially Krüger (1992) points towards a high percentage of juvenile forms. The former investigators of the section considered the small *Anthonema* in accordance with the old interpretation as crustacean larvae. Polz & Tischlinger (2000) have described *Anthonema* now as a possible Mysidacean.



Legende

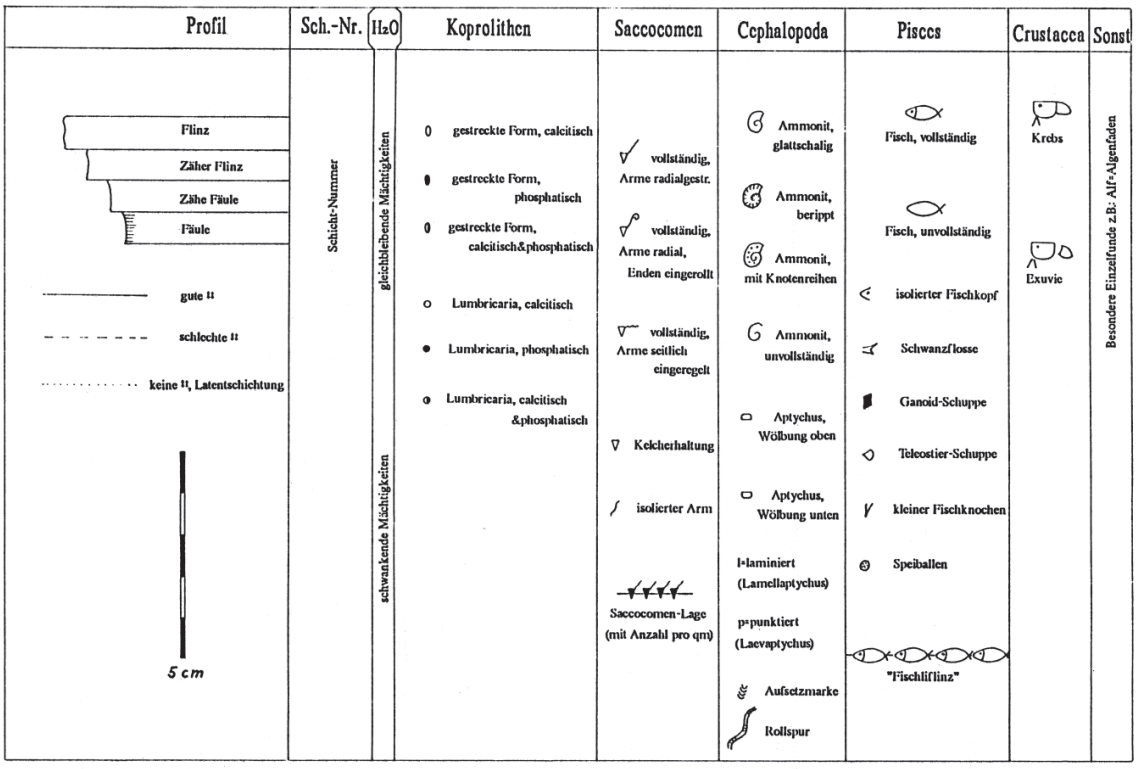


Figure 7: Detailed lithological-palaeoecological study of part III at the top of the section of the Imberg quarry near Schernfeld (cf. fig. 6, between wild layer no. 2 and 3) showing the distribution and abundance of the different fossils (from Gerhard & Mörs 1991).

Some more results of research into the sections are:

- Section 1A: of 257 registered ammonites 167 where smaller than 15 mm
- Section 1B: of 450 ammonites 427 where Oppeliids,
- The relation of swimming crustacean to benthic forms was in section 1c 3:1, in the sections 1a and 1b 2:1
- The sections noted 300 *Saccocoma* horizons with more than 50 specimens per square metre and up to 2600 specimens per square metre
- Mass deposits of *Anthonema* up to 2600 specimens per square metre (section 1b)

Krüger (1992), in speaking of her section coined the term "Schernfelder Kinderstubenfauna" i.e. Schernfeld nursery fauna. Also in other outcrops a high percentage of small fossils is known. The Schernfeld fossil site possible has a high percentage of such juvenile or small marine organisms in nearly all groups of its fauna.

The spectrum of ammonites is comparable with the Malm zeta 2b near Mörnsheim. Small, lamellaptychus-bearing taxa very much abound, especially *Lingulaticeras*, followed by *Neochetoceras* and small Perisphinctids. Of *Sutneria* and Aspidoceratids only few specimens are known, Hybonoticeratids have not been found.

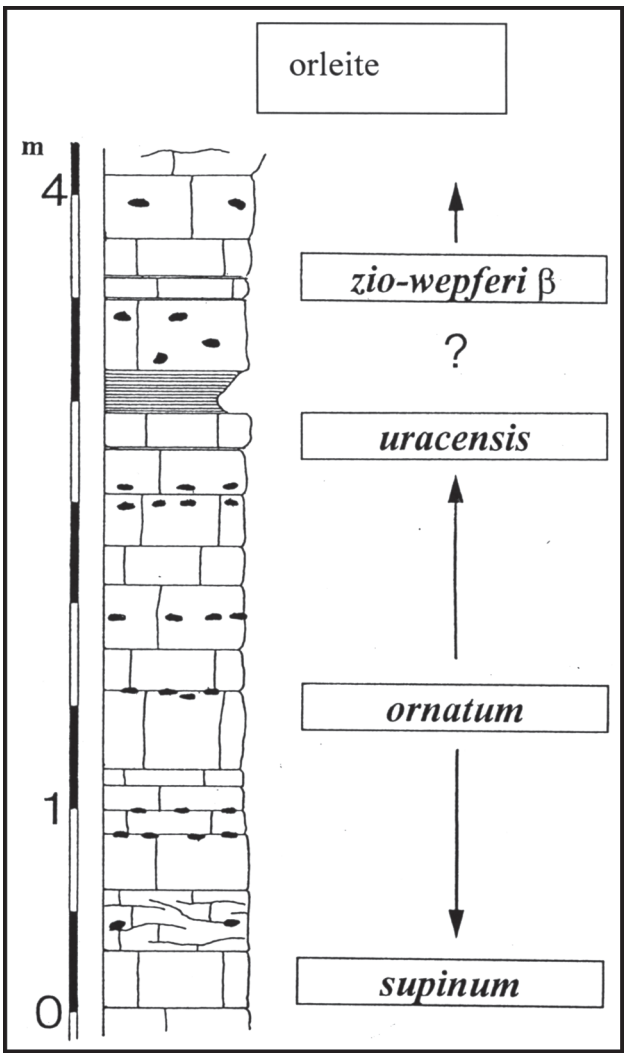


Figure 8: Lithology and stratigraphy of he upper part of the Torleite section, with the „Rote Lage" (red layer) of silicified plattenkalk facies (from Schweigert in Röper et al 2001).

Other fossil finds in the complete section (from Gerhard & Mörs 1991):

Plantae, Coniferopsida: *Brachyphyllum* sp. (section 1a)
Protozoa: Foraminifera (1a)
Gastropoda: *Rissoa* sp. (1a)
Bivalvia: *Liostrea* cf. *rugosa* Münster, (1a, 1b, 1c)
Vampyromorpha: *Plesioteuthis prisca* (Rueppel), (1a, 1b, 1c), *Acanthoteuthis* sp. (1a), *Muensterella conica* Wagner (1a), *Hibolithes* sp. (1a)
Ostracoda: undetermined taxa
Mysidacea: *Anthonema problematicum* Walther (1a, 1b 1c), *Elder ungulatus* Münster (1a, 1b, 1c), *Francocaris grimmi* Broili (1a, 1b, 1c)
Natantia (swimming crustaceans): *Antrimpos speciosus* Münster, *Antrimpos* sp. (1b), *Hefriga serrata* Münster (1a, 1b, 1c), *Hefriga* sp. (1b), *Aeger* sp.
Reptantia (lobsters): *Eryma modestiforme* (Schlotheim) (1a, 1b, 1c), *Mecochirus* cf. *brevimanus* Münster (1a), *Knebelia schuberti* (Meyer) (1b), *Mecochirus longimanatus* (Münster) (1b, 1c), *Palinurina longipes* Münster (1a, 1b, 1c), *Glyphea* sp. (1b), *Magila latimana* (Münster) (1c)
Crustacean larvae: *Phyllosoma* sp. (1a, 1b, 1c)
Insecta: one undetermined dragon-fly (1c)
Crinoidea: *Saccocoma tenella* (Goldfuss) (1a, 1b, 1c)
Pisces: *Caturus furcatus* Agassiz (1a), *Leptolepides sprattiformis* (Blainville) (1a, 1b, 1c), *Tharsis dubius* (Blainville) (1a, 1b, 1c), *Thrissops* sp. (1a, 1b, 1c), *Ascalabos voithi* Münster (1a)
Coprolites: *Lumbricaria*, elongated-phosphatic coprolites, tangled-phosphatic coprolites (*Medusites*, in the past interpreted as algae): (1a, 1b, 1c)

Stop 4: The Torleite Section SW Hagenacker

The Torleite Formation of the Upper Kimmeridgian (Malm epsilon)

Geological map 1:25 000, sheet 7132 Dollnstein, R 4429920, H 5415500; outcrop on the road from Hagenacker to Mörnsheim-Altendorf, ca. 1.5 km SW of the village of Hagenacker

Ref.: Meyer & Schmidt-Kaler (1983), Keupp (1987), Nybelin (1961), Röper et al. (2001); Zeiss (1964)

Fig. 8

This road section is the type-section of the so-called "Torleite Formation". The sequence consists of light-coloured,

flint-bearing limestone banks, which resemble strikingly to the Upper Felsenkalk-Formation of the Swabian Jurassic and show also a similar stratigraphical level. In some banks ammonites of the Setatum Subzone are present. In the higher part of the formation suddenly reddish, silicified Plattenkalk occur ("Rote Lage"; i.e. red layer). However, above it, flint bearing limestone banks continue. The exact age of the "Rote Lage" is not known. However, it still belongs probably to the Setatum Subzone. At least, the beds immediately below belong also to the Setatum Subzone, again higher there are already ammonites of the *zio-wepferi* Horizon beta. The *zio-wepferi* Horizon alpha, which, in the Swabian Jurassic, is rich in fossils and generally fairly thick, is missing here. The badly preserved ammonite fragments from the "Rote Lage" definitely do not belong to it. I.e., the "Rote Lage" is not, as it was presumed in the past, the base of the Tithonian.

The change in facies and the discontinuity on sedimentation is probably connected to tectonic movements at the boundary between Setatum/Ulmense Subzones, which show up in southern Germany more or less prominently (discontinuities, formation of breccias, onsets of marl sedimentation and coral facies). Within the "Rote Lage" some well-preserved teleosts have been found (Nybelin 1961). REM-studies by Keupp (1978) demonstrated the occurrence of Coccolithophorids like in other Plattenkalk.

Section and biostratigraphic data according to A. Scherzinger and G. Schweigert (pers. comm., cf. in Röper et al. 2001).

Stop 5: Quarry "Solnhofen Hummelberg", type-locality of the Plattenkalk Facies of the Lithographic Plattenkalk, Lower Tithonian (Malm zeta 2 b)

Geological map 1:25 000, sheet 7131 Monheim, R 4426250, H 5416800; quarry south (= above) the village of Solnhofen, situated NE of the Hummelberg.

Fig. 9

The type region of Solnhofen/Mörnsheim differs markedly in lithology and palaeontology from the thin slabs of the Eichstätt Plattenkalk. The true Lithographic Stone is only present in the region Solnhofen/Mörnsheim/Langenaltheim. Typical for the locality Solnhofen-Hummelberg is the co-occurrence of different types of Flinz:

- Flinz without notable lamination
- Flinz with prominent lamination
- Flinz with destroyed lamination

Major breaks in sedimentation with 1st order bedding-planes (coarse bedding-planes with microbial mats) in the "Plattenkalk-facies" are about seven times rarer than in the "Schiefer-facies". Most of the fossils are found on these bedding-planes, and therefore the "Plattenkalk-facies" of the type-locality appears to be equally seven times poorer in fossils than the "Schiefer-facies". 27 metres of Lithographic Plattenkalk at the Hummelberg show in the Flinz layers (i.e. without considering the Fäule layers) only 849 major breaks in sedimentation (the Imberg section of Schernfeld with 2.8 m Lithographic Plattenkalk alone has already 560 major breaks in sedimentation).

Important from a palaeontological perspective is the fact that in the Solnhofen area, we have much less of the soft-body preservation in fossils compared to Eichstätt and Schernfeld (fish with covering of scales at Eichstätt, skeleton-only fish fossils at Solnhofen, Keupp 1977). Even though this rule does have exceptions, the fossil preservation at Solnhofen and Mörnsheim is often much worse than at Eichstätt and Schernfeld. Additionally, between the two areas there are considerable differences in fauna (Röper et al. 2000). From a palaeogeographic point of view, the Solnhofen Basin is more open than the more restricted Eichstätt Basin.

In taking the idea of a typical conservation Fossillagerstätte with exceptionally well preserved fossils very literal, we should rather talk about the "Eichstätt/Schernfeld Fossillagerstätte" than the "Solnhofen Fossillagerstätte" and include Solnhofen only as a marginal area. However, since Solnhofen gave its name to the Fossillagerstätte being today internationally renown for it, we have the paradox of a type-locality, which does fit less the general definition of a conserving Fossillagerstätte than the Eichstätt Fossillagerstätte.

Differences between the Basins are:

- The Solnhofen Basin has by far the best quality of Plattenkalk (suitable for lithography, i.e. high density, hardness), but only few well-preserved fossils
- The Eichstätt Basin has only thin "shale"-flagstones (no lithographic stones; i.e. comparably softer surfaces), but the majority of well-preserved fossils
- The breaks in sedimentation are of shorter duration in the Plattenkalk-facies. Therefore we have thicker Flinz layers and fewer fossils than in the Eichstätt Schiefer facies

Solnhofen produces the best quality stone. Lithography and the *Archaeopteryx* are connected with the history of Solnhofen more than with any other locality in the Jurassic of the Frankonian Alb. Frickhinger (1994, 1999) has collected the fossil finds of "Solnhofen" (from museums, institutes and private collections) in two volumes under the title "Die Fossilien von Solnhofen" (i.e. the fossils of Solnhofen). However, considering the content, volume two should rather bear the title "the fossils of Eichstätt and Schernfeld", since 150 of the 250 figures specimens are from the "Eichstätt Schiefer facies", and only 14 specimens are from the type-locality Solnhofen. In contrast to Frickhinger (1999), Röper (2000) presented the Eichstätt and Schernfeld deposits as independent type of Fossillagerstätte, thus allowing a better comparison with the Solnhofen region.

From a geological point of view, the Solnhofen region has been presented very well, e.g. by Fesefeldt (1962) and Meyer & Schmidt-Kaler (1983, 1990, 1991, 1994). From a palaeontological

point of view, Solnhofen still seems to be rather unknown, the knowledge about some differences to Eichstätt notwithstanding (KEUPP 1977, VIOHL 1998). However, the more we learn about the locations of the fossil finds, the more we realise how much some fossils are typical for a very restricted area.

Example 1, taphonomy of dragon-flies: TISCHLINGER (1996) described several taphonomic features of Plattenkalk-dragon flies, however, he did not differentiate between occurrences of Eichstätt and Solnhofen. Later, detailed studies about the occurrence of the different types of preservation revealed the following results:

- In situ disintegrated dragonflies occur in the Solnhofen Basin
- Dragonflies with torsion (as a result of heating of the dead body) occur in the Eichstätt and Schernfeld Plattenkalk.

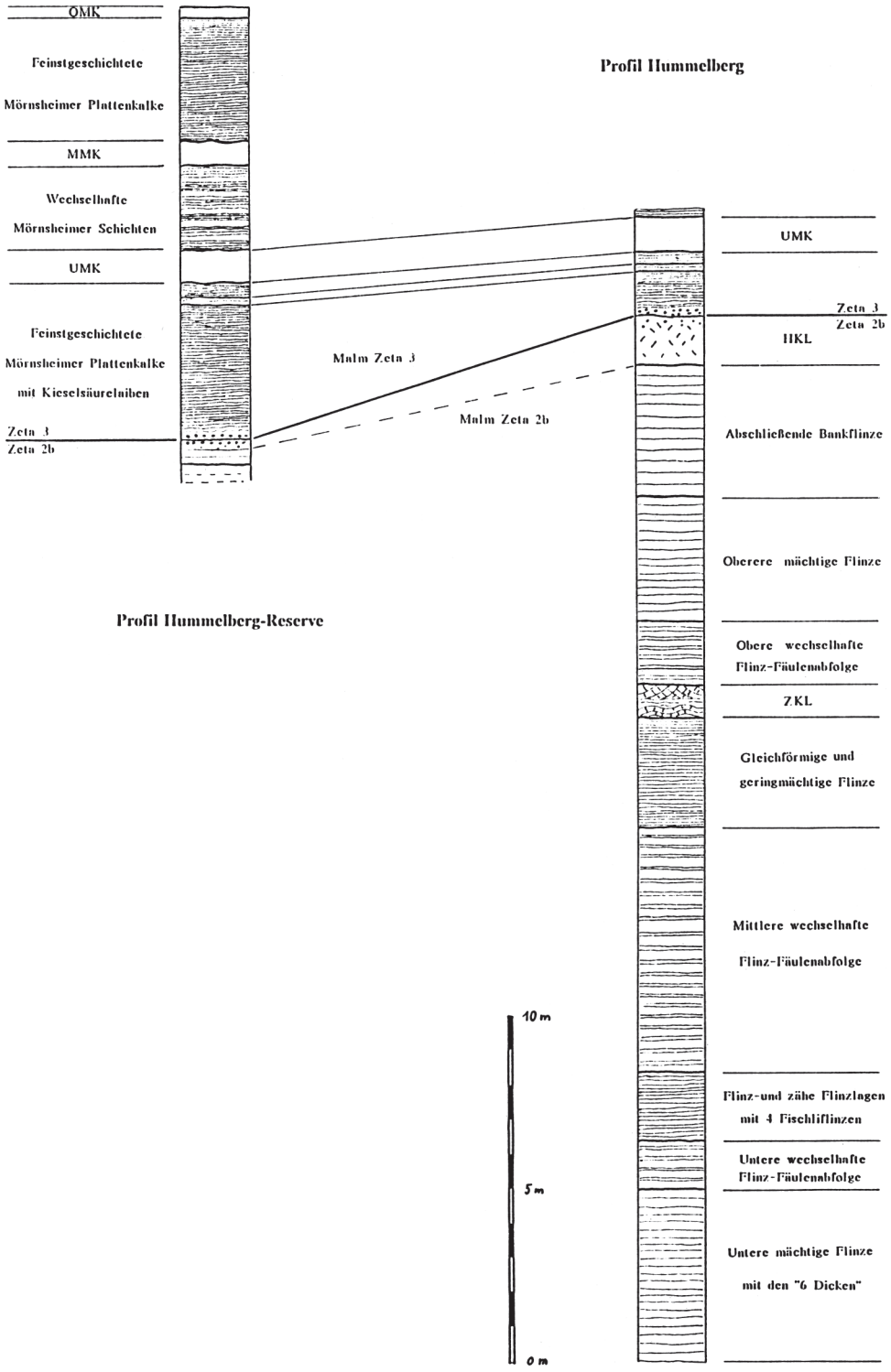


Figure 9: Generalized section of the Mörnsheim-Hummelberg quarry showing the plattenkalks of the upper Solnhofen Formation (Malm zeta 2b) and the oberlaying, partly silicified plattenkalks of the Mörnsheim Formation (from RÖPER 1991).

Example 2, echinoderms: The Solnhofen localities contain regularly allochthonous crinoids of the genus *Pterocoma* and ophiurids (rarely *Ophiurella*, sometimes *Sinosura*). None of these are known so far from the Eichstätt Basin.

Example 3, ammonites: *Neochetoceras bous* is typical for the Schernfeld region. *Paralingulaticeras lithographicum* and *Fontannesiella prolithographica* as well as *Hybonoticeras hybonotum* and *Hybonotella mundula* are typical for Solnhofen. Hybonoticeratids are generally more abundant near Solnhofen than near Eichstätt. Also, there are obvious differences in the fish and crustacean fauna between Solnhofen and Eichstätt.

Example 4, gorgonians: Sometimes, we find in the quarries imprints of fossils which probably belong to gorgonias. Such finds are typical for Langenaltheim; to a lesser extend also for Solnhofen and Mörnsheim. From the Eichstätt region no records of such organisms exist.

Typical fossils of the Solnhofen Basin (Malm zeta 2b)

Gorgonians: undetermined taxa
Crinoidea: *Pterocoma pennata* (Goldfuss)
Ophiuroidea: *Ophiurella speciosa* Muenster, *Sinosura* sp.
Vamphyromorpha: *Trachyteuthis hastiformis* (Rueppell)
Crustacea: *Eryon arctiformis* (Schlotheim), *Cycleryon propinquus* (Schlotheim), *Palaeastacus fuciformis* (Schlotheim), *Hefriga serrata* Muenster
Pisces: *Gyrodus hexagonus* Blainville, *Asthenocormus titanius* (Wagner), *Belonostomus muensteri* Agassiz, *Leptolepides sprattiformis* (Blainville)
Reptilia: *Scaphognathus crassirostris* (Goldfuss)

Stop 6: Plattenkalk Facies of the quarry "Mörnsheim Hummelberg"

Type-locality of the Mörnsheim Formation, Lower Tithonian, (Malm zeta 2b-3)

Geological map 1:25 000, sheet 7132 Monheim, R 4426300, H 5416600; quarry south (= above) the village of Solnhofen, situated NE of the Hummelberg, immediately south of the quarry of Stop 4

Ref.: Barfeld (1988), Brüll (1988), Fesefeldt (1962), Meyer & Schmidt-Kaler (1991, 1994), Pösges (1988), Röper (1990, 1991, 1992, 1997), Röper et al. (2001)

The Mörnsheim Hummelberg shows nearly the same sequence than the quarry "Solnhofen-Hummelberg" (Stop 4), with the difference that here, also Plattenkalk of the younger Mörnsheim Formation is exposed. For the first time, between 1985 and 1987, a lithological-macropalaeontological section was taken and documented in the "Plattenkalk facies" (Barfeld 1988, Brüll 1988, Pösges 1988, Röper 1990, 1991).

a) Lower part: Plattenkalk of the Solnhofen Formation

The some 37m thick section in the typical "Solnhofen Plattenkalk facies" is divided in three parts. The lower part consists of a "Dickflinz facies", which in parts shows very thick single Flinz beds with irregular thickness. Because of the low number of major sedimentation breaks this part appears to be very poor in fossils.

Typical fossil finds in the lower part: *Saccocoma tenella*, small Perisphinctids, small Oppeliids, *Hybonotella mundula*; *Mecochirus longimanatus* and *M. brevimanus*, small teleosts, fish scale-horizons; coprolites.

Fossil horizons (number): *Saccocoma* (7), Oppeliids (*Lingulaticeras*) and isolated Lamellaptychi (1), *Mecochirus* (1), scales and skeletal remains of small teleosts (9), coprolites.

The middle part starts with a stack of thick, high-quality Flinz in which the usually very prominent regular alternation of Flinz and Fäule is less obvious. Further above, the thickness of the individual Flinz beds gets thinner. Characteristic for this "Dünnflinz facies" is the very regular and constant layering of the Plattenkalk. Some horizons can be followed exactly through the whole quarry. With the change in lithology, the number of major sedimentation breaks increases, and thus, this part of the section is much richer in fossils.

Typical fossils of the middle part: juvenile *Liostrea* (oysters), *Saccocoma tenella*, small Perisphinctids, Oppeliids, Lamellaptychi, glass shrimps (*Elder ungulatus*), lobsters (*Mecochirus*, Eryonids, juvenile *Palinurina*); *Phyllosoma* larvae, horseshoe-crabs (*Mesolimulus*, partly with several metres long tracks), teleosts (several "Fischleinflinz" beds) and coprolites. This section also contains insects and rare ganoid fishes (*Belonostomus*, *Caturus*, *Gyrodus*).

Fossil horizons (number): *Saccocoma* (48), *Saccocoma*, fish bones and coprolites (1), *Saccocoma* and coprolites (2), "touch down marks" of Perisphinctids (1), Perisphinctids (2), Oppeliids (2), Glochicerates and Lamellaptychi (2), small teleosts *Leptolepides*, *Leptolepides* and *Tharsis* (5 "Fischleinflinz", i.e. small fish Flinz), coprolites (5). The number of *Saccocoma* specimens per square metre is smaller than in Schernfeld, the same is true for coprolites.

The upper part starts with the "Hangende Krumme Lage" (HKL; Upper slump horizon) (cf. Meyer & Schmidt-Kaler 1991). This guiding horizon leads through the whole of the Solnhofen region. With this horizon, the upper part of the Zeta 2b series begins and dates the formation of the "Hangende Krumme Lage" late into Zeta 2b (Röper 1991). Irregular stratification is reflected partly in considerable variability of thickness of the individual beds. Above the HKL follows a reversal of lithological facies, i.e. the "Dickflinz Facies" reappears. Disturbed fine-lamination of the Flinz layers is usual, individual Flinz beds reach up to 30cm thickness. In the SW part of the outcrop, the "Solnhofen HKL" sensu Fesefeldt (1962) forms the termination of the Lithographic Plattenkalk of the Upper Solnhofen Beds (Malm Zeta 2b). In the eastern part, this HKL is missing. Here the Mörnsheim Beds rest upon undisturbed Lithographic Plattenkalk. In the SE the uppermost

4.5 m thick sequence of the Lithographic Plattenkalk is eroded (cf. Röper 1991, 1997; Meyer & Schmidt-Kaler 1994). Because of the bad outcrop situation, the higher beds could only be studied in very small areas; the knowledge of their fossil content is fragmentary.

Typical fossils in the upper part: *Saccocoma tenella*, *Pterocoma pennata*, small Glochiceratids, Lamellaptychi, small Perisphinctids, "touch down marks" of Perisphinctids, *Mesolimulus*, occasionally bigger ganoid fish.

Fossil horizons (number): *Saccocoma* (2), Oppeliids (2), fish bones (2).

b) upper part: silicified plattenkalk of the Mörnsheim Formation

Above the Lithographic Plattenkalk of the Solnhofen Formation follow the fossil-rich Plattenkalk and limestone banks of the Mörnsheim Formation with *Subplanites moernsheimensis*. A summary of the zeta 3 section of the locality Hummelberg is given in Röper 1991, 1997. Further discussion of the "Mörnsheim Beds" follows in the description to the next outcrop in the Langenaltheim Haardt (Stop 7).

Stop 7: Quarry of Langenaltheim, Obere Haardt, Solnhofen Formation and Mörnsheim Formation, Lower Tithonian (Malm zeta 2b-3)

Geological map 1:25 000, sheet 7132 Monheim, R 4424000, H 54175000; big quarry on the road from Solnhofen to Langenaltheim

Ref.: Röper (1992, 1997), Wings (2000)

Figs 10-12

The Langenaltheim Haardt represents today the biggest quarry of the Solnhofen Plattenkalk companies. The quarry shows the some 30 m thick Plattenkalk series of the upper part of the Solnhofen Formation, the "Hangende Krumme Lage" (HKL) and, at the top, a some 6 m thick Plattenkalk series of the Mörnsheim Formation. The base of the quarry is the base of the Upper Solnhofen Plattenkalk above the "Trennende Krumme Lage" (TKL, "dividing Krumme Lage"). The excursion focuses on the upper parts of the upper Solnhofen Formation and the transition to the Mörnsheim Formation. The sequence is part

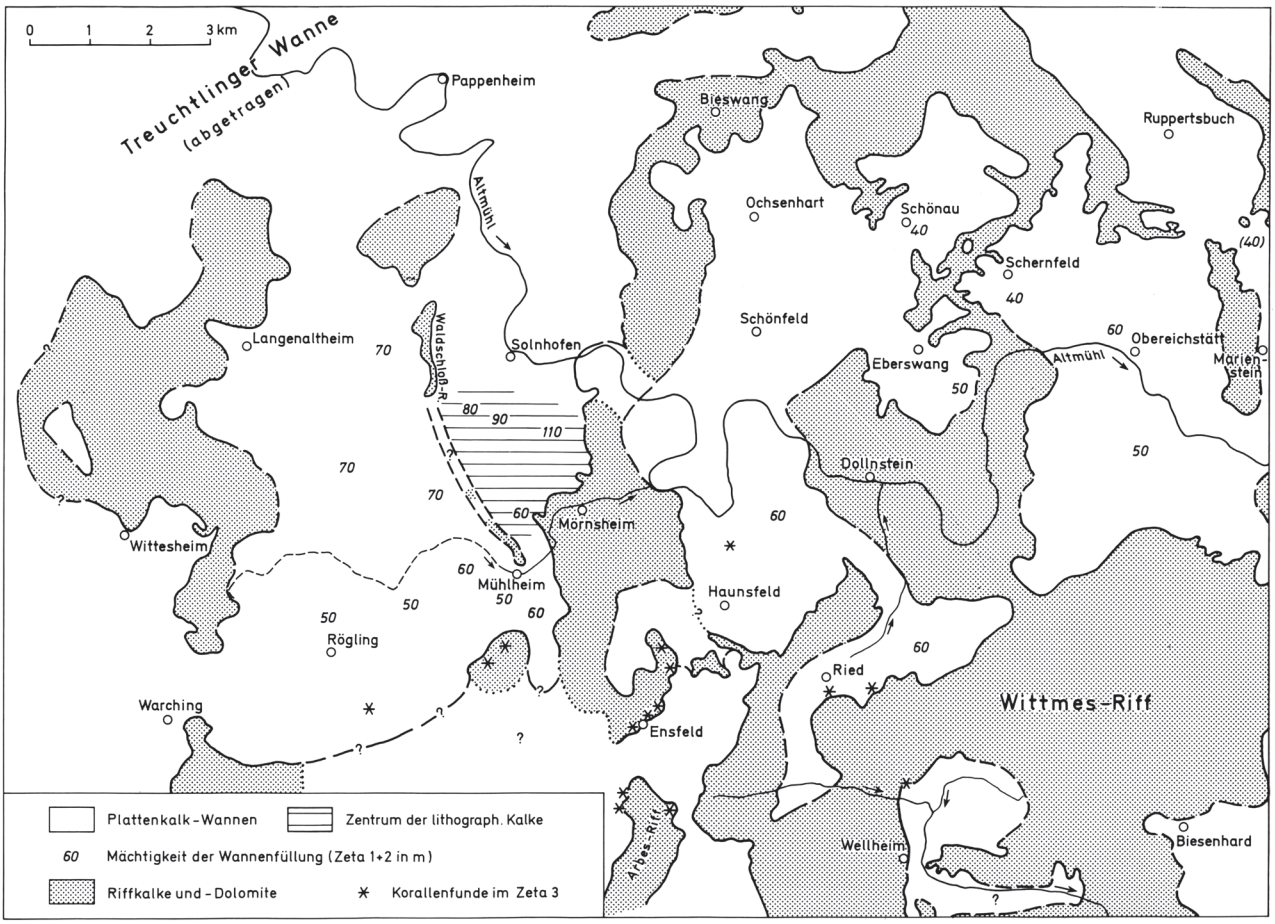


Figure 10: Distribution of reefs and plattenkalk basins / sub-basins in the Upper Kimmeridgian and Tithonian between Eichstätt and Solnhofen-Langenaltheim (from Meyer & Schmidt-Kaler 1991).

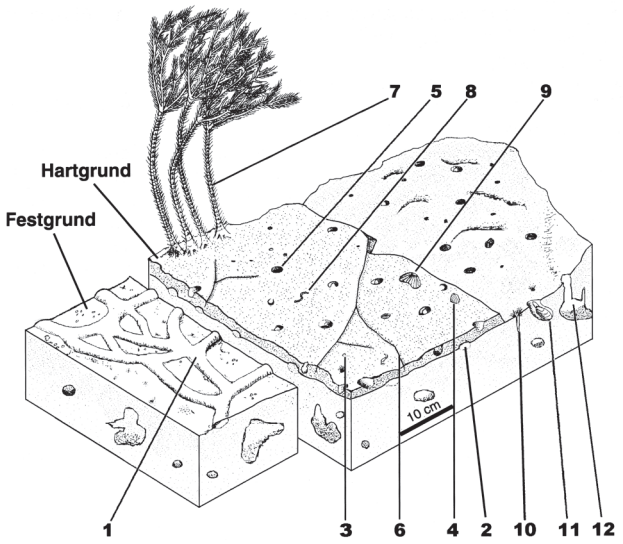


Figure 11: Reconstruction of the firm- and hardground ecosystems at the top of the upper Solnhofen Formation at Langenaltheim-Haardt (Lower Tithonian, Malm zeta 2b) (from WINGS 2000).

of the Langenaltheim sub-basin and is deposited in the west of the so-called Waldschloss-rise (cf. fig. 10, 12). The section of the Lithographic Plattenkalk consists mostly of thin Flinz and is rich in Fäule beds. According to MEYER & SCHMIDT-KALER (1994) the sediments of such sections have been less compacted than those of the sections with "Dickflinz-facies". Therefore, it was assumed that the "Solnhofen Hangende Krumme Lage" (HKL) slumped off the less compacted areas of the sub-basin. According to this idea, the formation of "Krumme Lagen" would be caused by a variable reaction of sediments during compaction.

Especially the middle part of the section seems to be characterised by a stillwater facies. In the upper part, there are often fossils with drag marks, and, in the uppermost layers, traces of benthic organisms occur. The quarry of the Obere Haardt is famous because of three *Archaeopteryx* specimens which were found here:

- *Archaeopteryx lithographica* VON MEYER, the "London specimen"
- *Archaeopteryx lithographica* VON MEYER, the lost "Maxberg specimen"
- *Archaeopteryx bavarica* WELLNHOFER, the "Munich specimen".

The Haardt is also known because of its "Fischleinflinze" (i.e. beds with numerous small teleosts) and also because of its many disintegrated fishes. Generally, the Haardt is poorer in fossils than the Eichstätt Plattenkalk. Typically, we have crustaceans with track-ways of several metres length; also we have a squid with a nine metres long drag-mark. To this date, there are no significant differences in the faunal spectrum compared to the neighbouring Solnhofen and Mörnsheim area. Both neighbouring areas are the major area of distribution for *Paralingulaticeras lithographicum* and *Fontannesiella prolithographica*. Differences in the ammonite fauna of Eichstätt/Schernfeld on one side and Solnhofen/Langenaltheim on the other have still to be discussed.

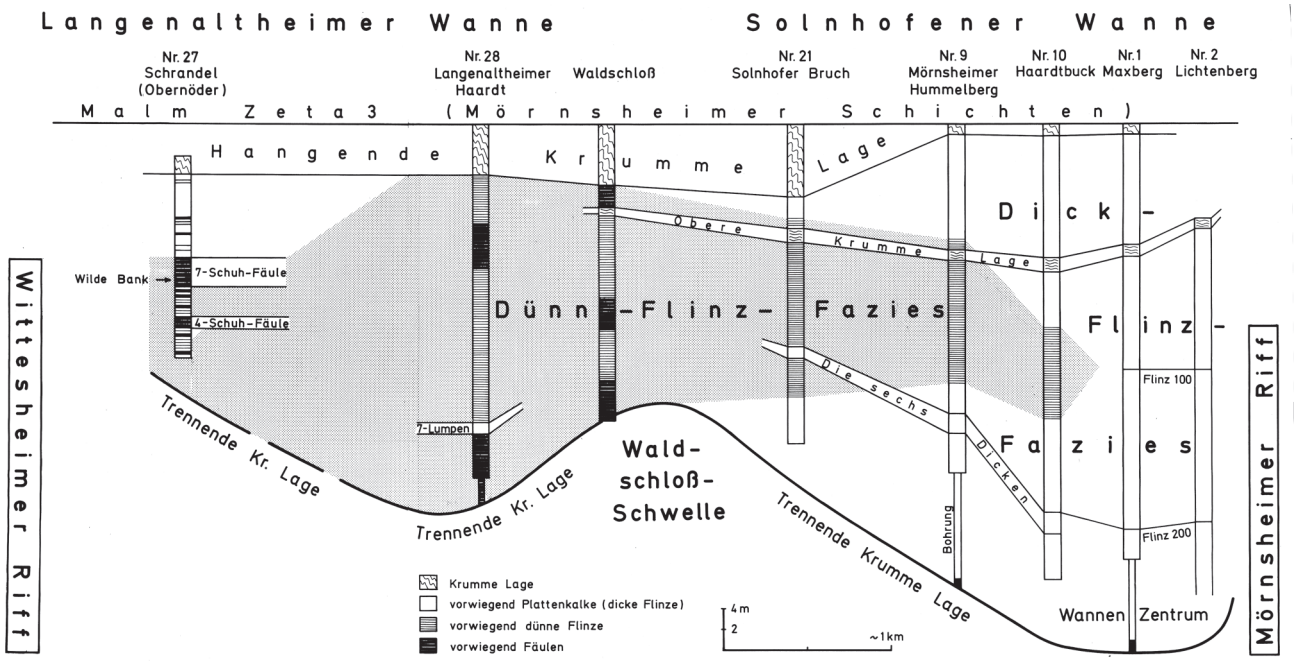


Figure 12: Distribution of the „Dick-Flinz-Fazies" (thick Flinz layers) and the „Dünn-Flinz-Fazies" (thin Flinz layers) in the sub-basins of Solnhofen in the east and Langenaltheim in the west. Note that the influence of the Waldschloß-Schwelle (Waldschloß swell) decreases during the Malm zeta 2 (from MEYER & SCHMIDT-KALER 1994).

First evidence of a hardground at the top of the Lithographic Plattenkalk

In 1991, a weathered rock-surface was discovered in Langenaltheim, after – as it seems – it had been exposed for about one or two years. Visible was a surface, resembling a hardground with burrows. To the surface, locally small bivalves were attached. There was also evidence of crinoid fragments of the sessile genus *Millericrinus*, also brachiopods and fragments of echinoids. Because of the surprisingly high number of crinoid fragments, Röper (1992) compared the situation with sub-tidal tidal-channels in the Dogger "Hauptrogenstein" of Switzerland. Following this discovery, the Jura-Museum Eichstätt in cooperation with the University of Erlangen investigated the matters. Meanwhile, this part of the section was described by Wings (2000). He showed the uppermost 5 m of the Lithographic Plattenkalk to contain benthic organisms, which is in accordance with other experience. The uppermost parts are characterized though the local appearance of the Solnhofen Upper Krumme Lage, which is missing completely in other areas. Also further west, the hardground was involved locally into later slumping. In 1991, it had not been possible to observe this fact, because only areas were accessible where silicified Plattenkalk of the Mörnsheim Formation followed immediately above the hardground. Wings (2000) discussed for the Langenaltheim hardground the possible influence of tidal or monsoonal currents, because the sessile bivalves showed regular orientation. Also he discussed a regressive phase, however opted afterwards for a local "benthic island", which was supposed to have been raised above a hostile deeper zone of the Langenaltheim Haardt. A connection between hardground and a possible regressive phase was denied, a water depth of 30-50 m was assumed.

Crucial for an understanding of the hardground ("Alternanzschicht") is its unusual stratigraphic position directly at the boundary of the Solnhofen/Mörnsheim-Formation, immediately at the facies-boundary between Lithographic Plattenkalk/Silicified Plattenkalk and also its position above beds, which already show a partial bioturbation. The Langenaltheim "Alternanzschicht" (i.e. the hardground, Wings 2000) lies exactly at the "Vorrennertshofen unconformity" sensu Roll. Similar to the higher beds of the Solnhofen Formation near Schernfeld and Pfalzpaint, the higher beds of the Solnhofen Formation at the Langenaltheim Haardt differ from the usual picture of the Solnhofen Fossillagerstätte.

Silicified Plattenkalk of the Mörnsheim-Formation

Above the "Alternanzschicht" follow the silicified Plattenkalk of the Mörnsheim Formation (marls, marly limestone, silicified Plattenkalk and interbedded limestone banks). The layers are partially finely laminated and in some parts very rich in fossils. Ammonites, squid, fishes and terrestrial plants are not rare. Similar to the locality Mörnsheim-Hummelberg, there is no interbedding of reef-debris. Only farther to the SW at the Mörnsheim-Horstberg such debris fans can be detected, in which also sponges occur. The Mörnsheim Horstberg, south of the Hummelberg is situated close to the Mörnsheim reef. The facies of the silicified Plattenkalk ("Mörnsheim Schuttfazies", i.e. Mörnsheim debris facies of Fesefeldt 1962) is generally very heterogeneous. In many horizons burrows of endobentic crustaceans cause a partial bioturbation.

In the silicified Plattenkalk of the Mörnsheim Formation *Paralingulaticeras lithographicum* and *Fontannesiella prolithographica* are even more abundant than in the Lithographic Plattenkalk.

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