Zitteliana

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26

4th International Symposium on Lithographic Limestone and Plattenkalk

Eichstätt/Solnhofen, Germany

September 12th-18th, 2005

- Abstracts and Field Trip Guides -

München 2005

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Organised by

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Jura-Museum, Eichstätt

Martin Röper
Bürgermeister-Müller-Museum, Solnhofen

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and GeoBio-CenterLMU

– Abstracts and Field Trip Guides –

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

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Field Trip D

The Nusplingen Plattenkalk and Other Fossil Sites in the Western Swabian Alb (SW Germany)

September 17th/18th, 2005

By
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First day (Saturday 17th, 2005)

The field trip starts in Eichstätt and goes to the western part of the Swabian Alb, to the area of the Upper Danube valley. From the town of Sigmaringen westwards the Danube valley is developed as a canyon in which the Upper Jurassic rocks are well exposed. First we give an overview on the geological setting, common lithologies, and the palaeoenvironment of the Upper Jurassic. Few kilometres north of the Upper Danube valley, two important sites of "Plattenkalk" exist: the Kolbingen Plattenkalk and the more famous Nusplingen Plattenkalk. The first locality is visited on Saturday, the latter on Sunday. The accommodation from Saturday to Sunday will be a guest house in the small village of Beuron, aside a large monastery.

Stop 1: Schaufels and other rocks of the Upper Danube Valley between Sigmaringen and Beuron

Geological Map 1:25 000 sheet 7920 Leibertingen,
R 3505400, H 5328100

The Schaufels rock is one of the most famous rocks for climbing activities in the Upper Danube Valley area. In a facies mapping study the previously undifferentiated Upper Jurassic massive limestone facies (Massenkalke Formation) of an area of ca. 8 km^2 W of the Schaufels (including the Schaufels itself) ranging from the time equivalents of the "Untere Felsenkalke" (ki2) to the "Liegende Bankkalke" (ki4) formations has been differentiated into 11 facies types (Volk et al. 2001) (Fig. 2).

The investigated massive limestones can be subdivided into **five facies groups (FG I-V)** and by a more detailed classification into **eleven facies types** (FT-1-11).

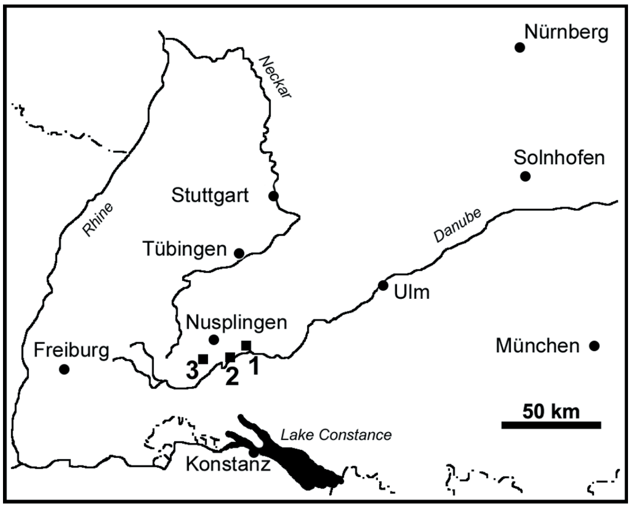

Figure 1: Map showing the location of stop 1-3 (first day) and the fossil site Nusplingen, 12 km N of the River Danube, SW Germany. Modified from Dietl & Schweigert (2004)

Flaser-bedded limestones and sponge-marl facies (FG-I) can be differentiated into mud- to packstones containing sponges and tuberoids (FT-1), sponge-rich wacke- to floatstones (FT-2), and sponge-marls (FT-3).

Thick-bedded facies types of the Kimmeridgian (FG-II) are built up by wackestones with silicification and sponges (FT-4), and wacke- to packstones with sponges (FT-5).

The peloid-lithoclast-ooid sand facies (FG-3) consists of peloid-lithoclast-wackestones with sponges and occasional silicification (FT-6), peloid-lithoclast-wacke- to packstones with sparse sponges (FT-7), ooid-lithoclast pack- to grainstones (FT-8) and stromatolitic boundstones in peloid-lithoclast-ooid sands (FT-9).

Micritic breccias and tuberolites of the higher Kimmeridgian (FG-4) are built up of FT-10.

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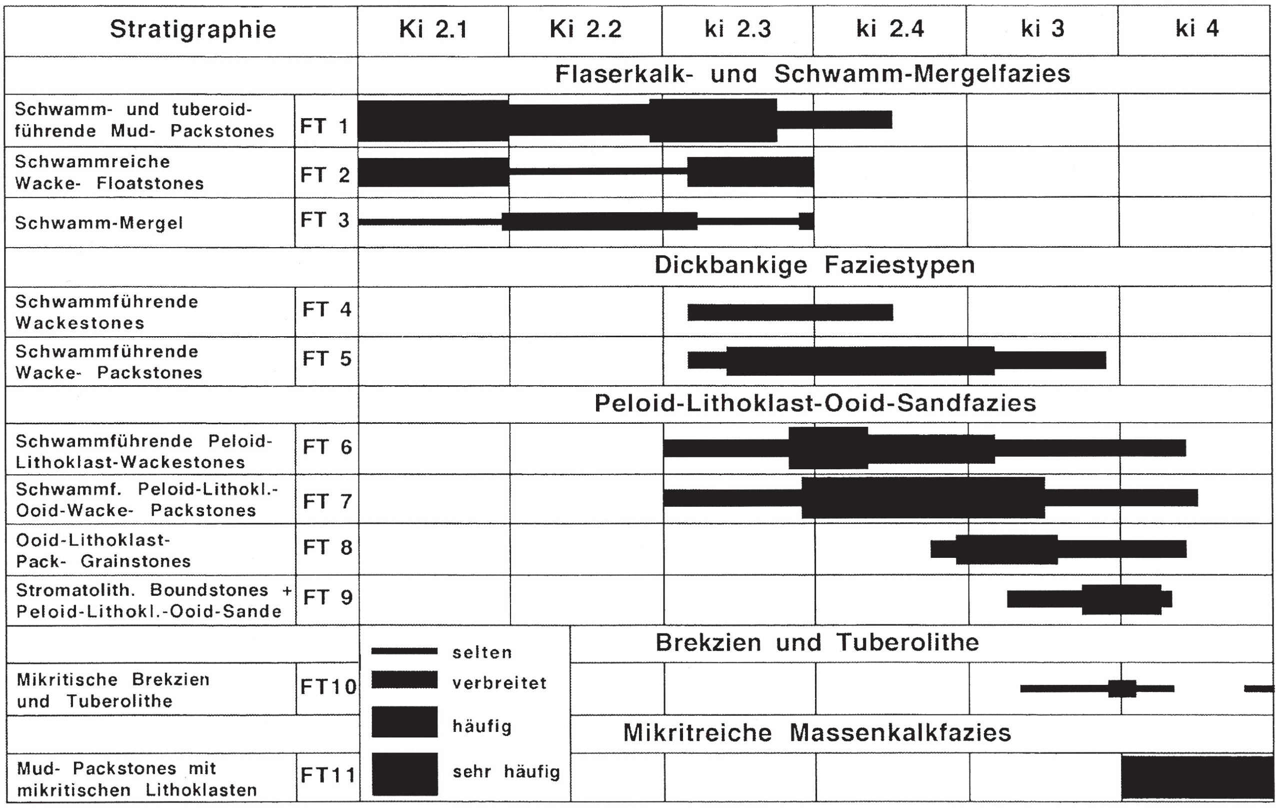

Figure 2: Distribution of facies groups (FG-I-V) and the subdivision in facies types FT-1 to FT-11 in the Kimmeridgian. Their relative abundance is indicated as rare, common, abundant, and very abundant (Volk et al. 2001).

The **massive limestone facies of the Ki4** consists of mudstones to packstones with micritic lithoclasts (FT-11).

Diagenetically strongly altered sediments (FG-5) are represented by saccharoidal, vuggy dolomite (so-called Lochfels), and recrystallized, orange-brown sediments of FT-7.

The distribution of facies types is controlled by the evolution of relative sea level changes. In the stratigraphic succession there is a trend towards a shallower depositional environment from the ki2 to the ki3, reaching a maximum at the transition ki3/4. Whereas the beginning of ki2 micritic sediments of the flaser-bedded limestones and sponge-marl facies prevail, towards the ki2.4 there is a progressive shift towards more carbonate-rich sediments of the peloid-lithoclast-ooid sand facies. The depositional environment of the sand facies is interpreted as a carbonate platform with minor morphological features where carbonate sand shoals have been deposited in a water depth of less than 10 m (Volk et al. 2001). From the ki2.4 lenses of ooid-lithoclast-packstones to grainstones (FT-8) and stromatolitic boundstones (FT-9) can be found within the wide-spread areas of peloid-lithoclast-ooid wackestones to packstones (FT-7). The shallow marine environment of moderate to episodic higher water energy is indicated by the presence of primary open interparticle porosity in which marine isopacheous cements occur locally followed by granular cements occluding the relic pore space.

A cyclic development in the deposition of these facies types was revealed in the latest study on these sediments from the same area by Pawelleck & Aigner (2003). First analyses of these type of carbonate sands in the area of the Schaufels were carried out by Schaller & Koch (1996) (Fig. 3) who already gave hints to the cyclic development of these shallow water sediments in a profile of 84 m thickness of the Kimmeridgian 2.4 to the Kimmeridgian 3 which gives a detailed analyses of the sediments of this interval as indicated by Volk et al. (2001). The section can be subdivided from base to top in three units as follows: (A) sponge bearing peloid wackestones to packstones (21 m), (B) ooid-peloid packstomnes to grainstones (30 m), and (C) carbonate sand facies with abundant microbial crusts and stromatolitic boundstones rich in sponges.

All these interpretations are completely contrasting the former interpretation as massive sponge-algal reefs or sponge-magnafacies to be deposits in a water depth of some tens to even 150 m as reported by many authors. Basic ideas on the sedimentation of carbonate sand facies and the distribution of real spongiolites were published by Koch et al. (1994) (Fig. 4) from the Swabian Alb opening the window for a new insight in the formation of so-called sponge build-ups (sponge-reefs, sponge-biostroms etc.) in the Upper Jurassic of Southern Germany. This facies development is assumed for most outcrops in the direction to Beuron as indicated by moderate horizontal thick-bedded limestones which are typical of carbonate sand deposits and proven by local samples indicating the same facies. This carbonate sand facies occurs in direction to Sigmaringen up to the quarry of Thiergarten, where dolomitic sponge-buildups are developed (Heiss 1990). This facies marks the slope facies of carbonate sands settled by

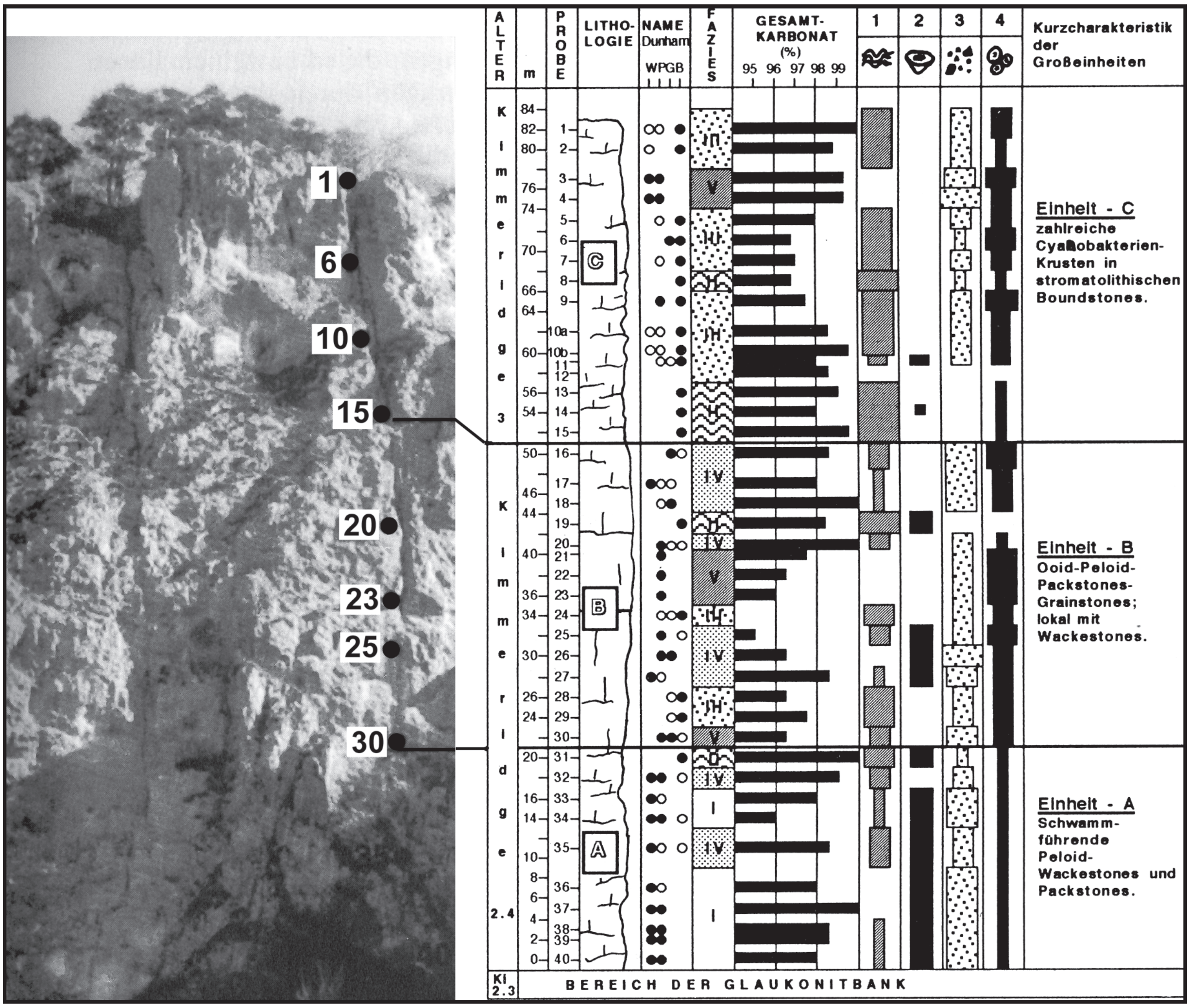

Figure 3: The Schaufels section. Besides geological age, thickness and position of samples the following parameter are indicated: the classification according to DUNHAM (1962), the five different facies types according to SCHALLER & KOCH (1996), the carbonate content, and the semiquantitative estimated amount of components (1 = microbial crusts, 2 = sponges, 3 = peloids, 4 = ooids). Furthermore the three large units A, B, and C are indicated (from SCHALLER & KOCH 1996).

sponges and interfingering with a deeper basin facies according to the model of KOCH et al. (1994).

The deposition of sponge-marls is restricted to depositional environments with a lower water energy level. The deposition of more micritic limestones in the ki4 is interpreted as relative sea level rise.

Stop 2: Viewpoint "Knopfmacherfelsen" W of Beuron

Geological Map 1:25 000 sheet 7919 Mühlheim a. d. Donau, R 3496500, H 5321250

During the Pleistocene the River Danube eroded a canyon into the Upper Jurassic rocks of the southern border of the Swabian Alb. At a tourist viewpoint called "Knopfmacherfelsen" the enormous palaeorelief formed by late Kimmeridgian sponge-microbial mounds and corresponding lithologies is excellently visible. Although the rock is rather massive in appearance ('Massenkalk Formation') and very poor in age-diagnostic guide fossils, some major marker surfaces allow a good resolution even in the logs of drill holes. In the east, at the monastery of Beuron, the Massenkalk rocks have thin marly intercalations pointing to the 'Glaukonitbank' marker bed of the Untere Felsenkalke Formation in bedded facies.

South of "Knopfmacherfelsen" the massive rocks are forming an atoll-like structure, which is, however, open to the direction of the Danube valley. In his overview on the development of the Upper Jurassic in Swabia GWINNER (1976) presented a nice sketch of this area (Fig. 5). We are looking at the northern border of this structure; with the castle of Bronnen on top of the rock. The incorporated basin in the South is filled by the bedded facies of the upper Kimmeridgian, the Liegende Bankkalk and Zementmergel formations of late Kimmeridgian age (Beckeri Zone, Ulmense Subzone). These strongly bioturbated basinal deposits are coeval with the laminated Nusplingen Plattenkalk which is located about 10 km to the north. In a Pliocene karstic fill located between

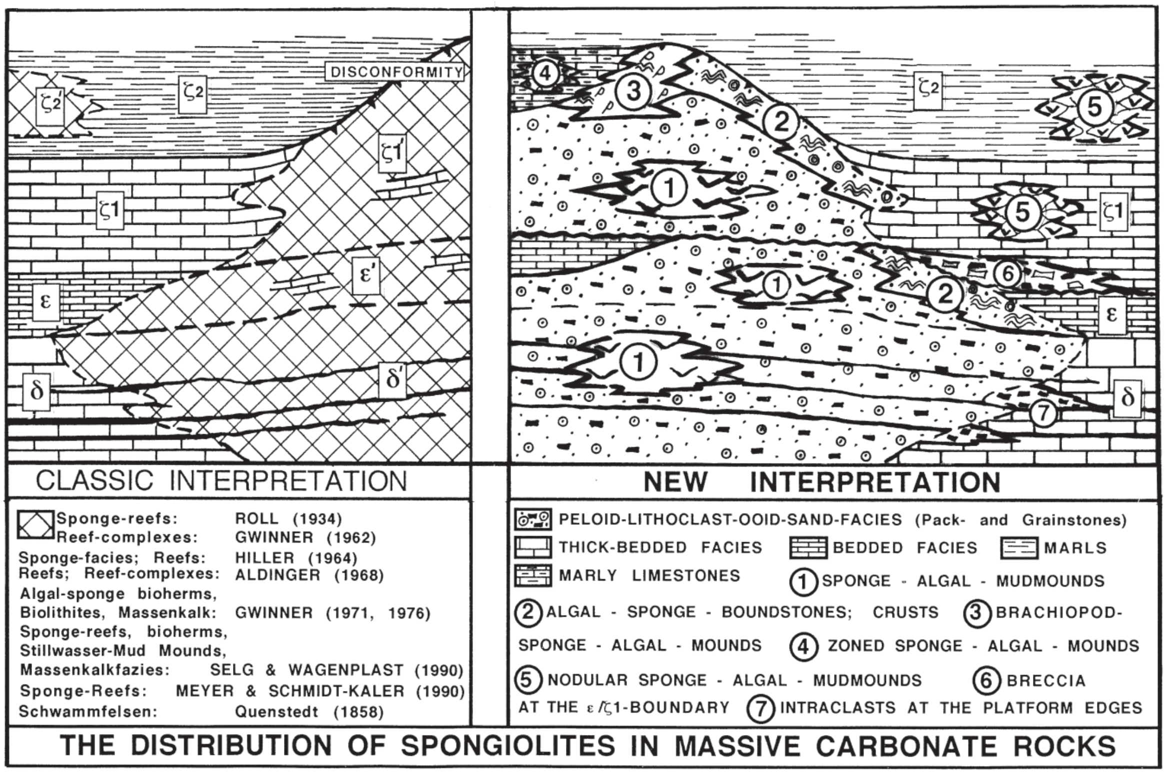

Figure 4: The distribution of spongiolites in massive carbonate rocks (reef-complexes, Massenkalk, etc.). Comparison of the classical interpretation with the new interpretation by Koch et al. (1994). Note that the peloid-litholasts-sand facies makes up the largest amount of the "Massenkalke". The spatial distribution of real algal-sponge build-ups in and around the sand facies is interpreted to be caused by varying hydrodynamic conditions triggered by the palaeogeographic distribution of the sand facies.

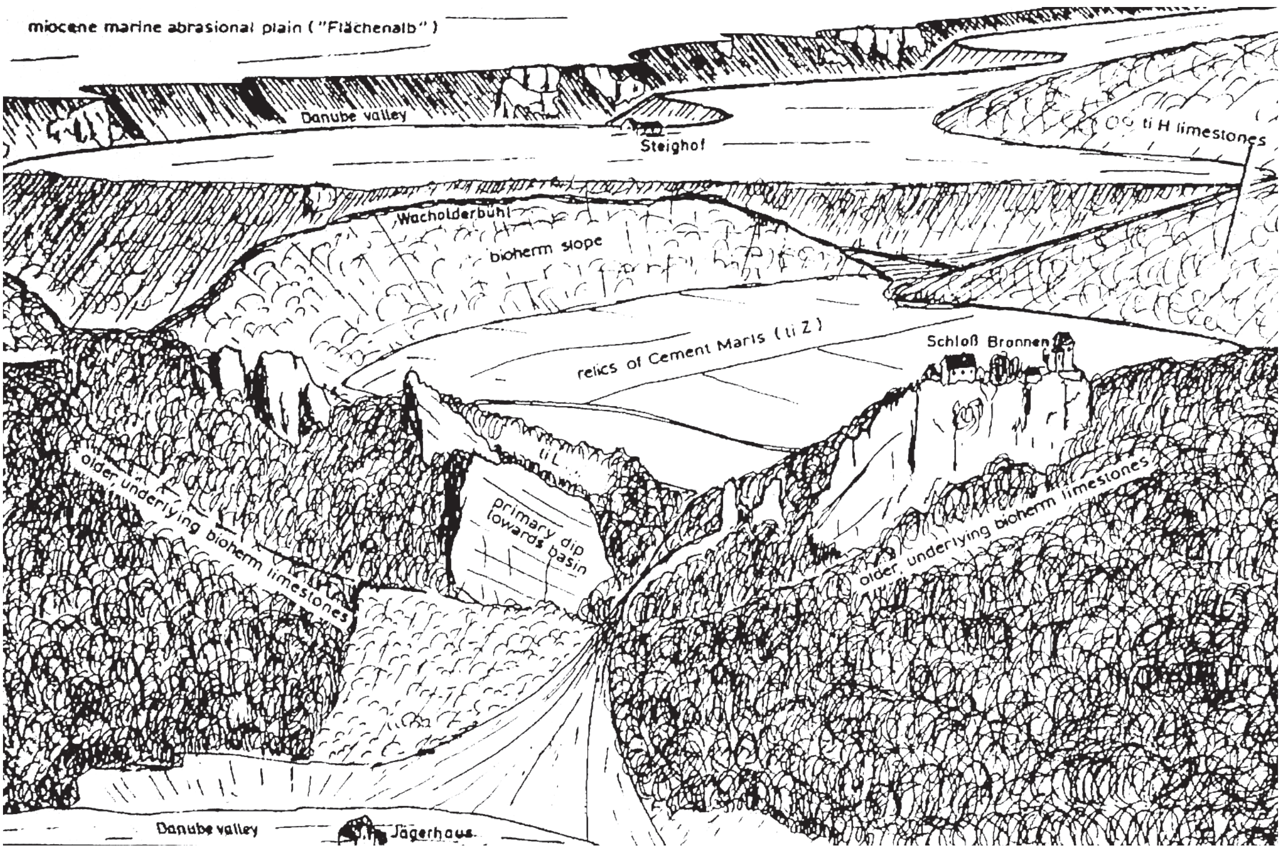

Figure 5: Sketch of the area in the vicinity of viewpoint "Knopfmacherfelsen" showing the former palaeorelief of the Upper Jurassic prepared by erosion (from Gwinner 1976).

Beuron and "Knopfmacherfelsen" several reworked Jurassic hermatypic corals like *Isastrea* were found (Franz et al. 1997). They indicate the local occurrence of coral reefs and shallow conditions in the Upper Jurassic of this area.

Stop 3: The Kolbingen Plattenkalk

Geological Map 1:25 000 sheet 7919 Mühlheim a. d. Donau, R 3490450, H 5326500

About 5 kilometres N of the village of Kolbingen there is an area where a platy limestone was quarried over centuries, even since the times of the Romans. Today the last quarry is almost abundant, and only temporarily this "Kolbingen Plattenkalk" is still exploited. The world-famous naturalist Alexander von Humboldt (1823) was the first to mention this locality, and he compared it with the Solnhofen Lithographic Limestone of Franconia. More than one decade later, about 6 kilometres to the north, the Nusplingen Plattenkalk was discovered by F. A. Quenstedt, and both occurrences were often correlated. However, from this Kolbingen Plattenkalk macrofossils have never been recorded, and also its exact stratigraphical position remained unknown. New investigations have been carried out but the results are still unpublished; a preliminary version is presented here.

Within the quarry area, the Kolbingen Plattenkalk overlies a massive, reddish- to violet-coloured dedolomite (Massenkalk Formation). The total thickness of this member is about 5 metres. It consists of 2 different lithologies, of which today only the lower one is still visible in the field. It is made up of a 2.5 metres thick, finely laminated yellowish to brownish limestone (Fig. 6). Macrofossils have not been found yet, only some round, irregularly scattered structures on bedding planes may be interpreted as ichnofossils. At some places the laminates were overlain by a grey micritic limestone, which weathers into thin plates. This pseudo-lithographic fabric results from shear planes crossing at very low angles. The cleavage surfaces of the plates are covered with typical plumose structures. Both Gwinner (1976) and Temmler (1966) erroneously interpreted these plumose structures (Fig. 7) as a complex system of sloping scratches. It cannot be excluded that the cleavage follows a hidden cross bedding which is not discernible because of the fine micritic material.

350 metres SW of the quarry area, towards the Lippach valley, there is a well-exposed outcrop of the Upper Jurassic. The section starts with the Obere Felsenkalk Formation, bedded micritic limestones with horizontal layers of siliceous concretions. Within this formation several ammonite faunal horizons of Setatum Subzone of the late Kimmeridgian have been recognized. The Liegende Bankkalk Formation overlies the Obere Felsenkalk Formation with a sharp disconformity. The Liegende Bankkalk Formation consists of thinner-bedded greyish micritic limestones interfingering with sponge-microbial rock-forming mounds. Near the top of the section there is a thicker marl bed which can be classified as belonging to the Zementmergel Formation. At the top there is a brownish dolomitic bed which grades into a finely laminated, not recrystallized Kolbingen Plattenkalk. Several trace fossils, small-scale cross bedding and so-called '*Kinneya* ripples' on bedding planes indicate a very shallow environment. Interestingly the bedding planes are strongly dipping to the west, whereas the Kolbingen Plattenkalk in the quarry area lies almost horizontal. This shows that the Kolbingen Plattenkalk was not deposited in a basin as the nearby Nusplingen Plattenkalk, but on a high structure. Looking again at the lamination of the Kolbingen Plattenkalk in the quarry area its cyclicity strongly resembles that of tidal laminates (cf. Archer & Feldman 1994, Tessier et al. 1995, Buatois et al. 1997). Within the section about 100 cyclothems can be counted. This very rapid sedimentation rate and an environment unfavourable for nektonic animals like ammonites or belemnites are probable reasons for the lack of macrofossils.

Biostratigraphically the uppermost fossiliferous bed little below the laminates belong to the Ulmense Subzone of the late Kimmeridgian (*zio-wepferi* Horizon beta, see Schweigert 1998). This means that the formation of laminates started little earlier in the nearby Nusplingen Plattenkalk than here at the Kolbingen site. But unless the Kolbingen Plattenkalk is an approximate time equivalent to the Nusplingen Plattenkalk, it differs strongly both in lithology and genesis.

The outcrops of the Kolbingen Plattenkalk and the Nusplingen Plattenkalk are separated from each other by a zone

Figure 6: Rock sample from the laminated lower part of the Kolbingen Plattenkalk.

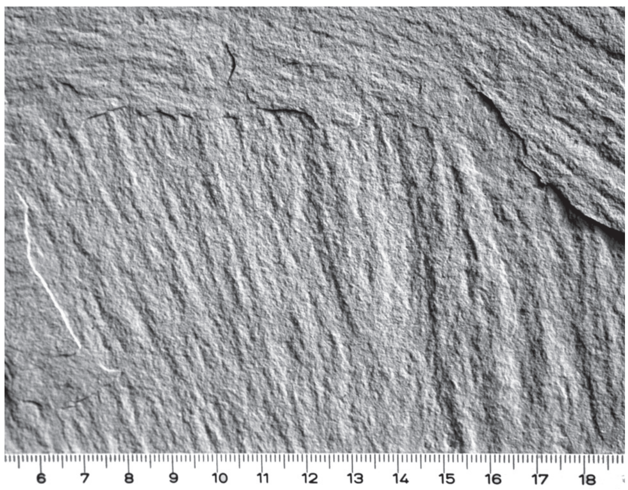

Figure 7: Plumose structures occurring in the micritic upper part of the Kolbingen Plattenkalk.

of intensive diagenetic recrystallization ("Zuckerkörniger Lochfels"). Possibly this recrystallization results from an intra-Jurassic freshwater diagenesis occurring in the subcrop of small islands. Additional hints for this assumption are dedolomite clasts in turbidites of the Nusplingen Plattenkalk (BANTEL et al. 1999), some insects, many land plants and plant debris, several pterosaurs, and the recent discovery of a piece of fossil charcoal.

Second day (Sunday 18th, 2005)

The field trip starts in Beuron and follows the Bärental valley northwards to the village of Nusplingen. The outcrops are located W of the village on the "Westerberg" hill. Along the road from Nusplingen to the "Westerberg" an Upper Jurassic is exposed mainly consisting of spongiolithic limestones of Oxfordian to Kimmeridgian age. In an abandoned quarry the strong palaeorelief developed in this area is well visible.

Geological setting of the Nusplingen Plattenkalk

The Nusplingen Plattenkalk, also known in literature as "Nusplingen Lithographic Limestone", represents a 'Fossil Lagerstätte' similar to the famous lower Tithonian Solnhofen Lithographic Limestone in Bavaria. It is located in the western part of the Swabian Alb, about 12 kilometres N of the Upper Danube Valley (Fig. 1). It is the only occurrence of fossiliferous laminated limestones in Swabia. These laminated limestones were deposited in a more or less anoxic environment of a lagoon surrounded by sponge/microbial mounds. Some of them were partly tectonically uplifted over the sea level as small islands. The palaeoenvironment of the Nusplingen lagoon is reconstructed in Fig. 8.

Spectacular fossils from the "Nusplinger Plattenkalk" were reported since the middle of the 19th century. Several excavation campaigns took place, at first with more commercial aspects

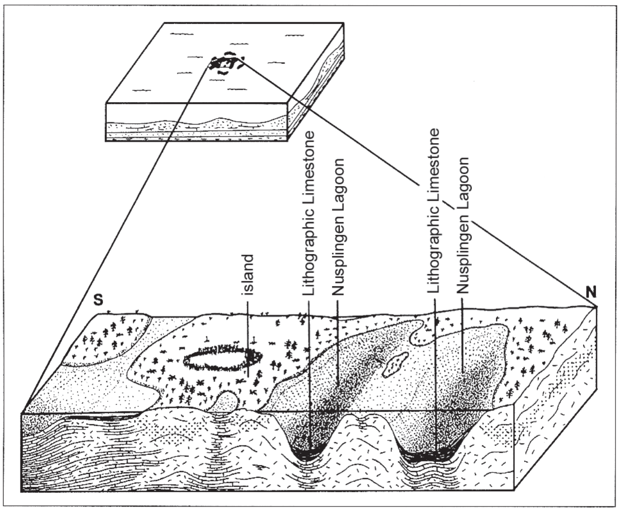

Figure 8: Reconstruction and palaeogeographic setting of the Nusplingen lagoon – without scale. From DIETL & SCHWEIGERT (2004).

as prospecting for limestones to be used for lithography or for roof tiles, later restricted to scientific interests. The Nusplingen Plattenkalk Limestone is of late Kimmeridgian age (Fig. 9) and thus approximately 0.5 my older than the lithographic limestones of Solnhofen and Eichstätt. Since 1983 the whole area of the Nusplingen Plattenkalk is a Protected Excavations Area because of its extraordinary fossils. The Nusplingen Lithographic Limestone is actually well exposed and excavated in two small quarries (Nusplingen and Egesheim quarries). The total thickness of the Nusplingen Plattenkalk is between 10.5 and 17 metres (Fig. 10). Detailed sections are described in DIETL et al. (1998) and in BANTEL et al. (1999). General overviews on this fossil site are given in DIETL & SCHWEIGERT (1999, 2001, 2004), for a bibliography of older publications see SCHWEIGERT (1997).

New excavations by the Natural History Museum of Stuttgart in the above mentioned two quarries have proliferated new data on sedimentology, palaeoecology, taphonomy, biostratinomy, and especially on the fossil content of the Nusplingen Lithographic Limestone. Since 1993 more than 8.000 fossils were recovered. They belong to 320 taxa, many of them are new. They tell us interesting stories about sea life in or around the Nusplingen lagoon and from the surrounding shallow sea of the Upper Jurassic in SW Germany. In contrast to Solnhofen Nusplingen had a pelagic situation far away from larger continental islands like the Rhenish and Bohemian Massifs in the N and in the NE. Another interesting aspect is the preservation of the fossils within the Nusplingen Plattenkalk. Some of the fossils which are embedded in bituminous layers occurring in the upper part of the succession exhibit an extraordinary preservation of organic matter.

Fossil content

The Nusplingen Plattenkalk yields a significant amount of debris from the nearby reefs and from the water column. Among the microfossils the coccolithophorids are of great importance, because they characterize the laminates as marine alginites. Some bedding planes exhibit structures pointing to a temporary development of microbial mats. More than 60 species of radiolarians were identified by dissolving the limestone with acid.

In the higher part of the succession, especially in the bituminous layers, many land plants occur. They are derived from nearby uplifted islands and still preserved with their organic tissue showing finest anatomical details like cell-structures and stomata. Some years ago we were even able to identify amber. This amber occurs in situ within the resin vessels of araucariacean cone scales.

The most frequent invertebrate fossils of the Nusplingen Plattenkalk Limestone are ammonites and their aptychi. Some ammonites are very spectacular because they are preserved with their complete jaw apparatuses and stomach contents. The lower jaw is the well-known calcitic aptychus, whereas the upper jaw which was originally chitineous is preserved in carbon. Also nautilids have been found with both jaws still in the body chamber, sometimes even together with stomach-content. The belemnites occur frequently with a single species. Their guards are very often bitten by predators. Teuthoids are often preserved with their ink sacs. Some years ago we discovered the first teuthoids with their beaks still in original position.

Among the arthropods, marine polychaetes sometimes exhibit soft tissue preservation. The horseshoe crab *Mesolimulus* is quite rare. One of the specimens, however, shows its compound eyes and even the muscles preserved, together with microbial layers covering the phosphatic muscle tissue (Briggs et al., in press). The newly excavated fossils include the first record of a Jurassic centipede. Other remarkable fossils are several insects like beetles and dragonflies. Most of these specimens are preserved in organic matter. Decapod crustaceans, especially natants, are typical of the Nusplingen Plattenkalk, and many of them are well-preserved. About 20 different taxa have been recorded. One of them still shows its compound eyes. At the end of the annual campaign of 2004 a marine isopod has been found, also with its preserved compound eyes. Other benthic organism such as echinoids, brittle stars and crinoids occur only sporadically. Especially the echinoids are usually bitten resulting from the activity of predators. The most frequent echinoderm, however, is the small planktonic crinoid *Saccocoma*. The isolated ossicles of this crinoid also occur within the widespread coprolites known as *Lumbricaria*, which were produced by ammonites – as it is demonstrated from crop contents.

Among the vertebrate fauna the fishes predominate. They are represented by Selachians, holocephalans and numerous actinopterygians. Most typical of the Nusplingen Plattenkalk is the endemic angel shark *Squatina acanthoderma* which is preserved with its complete skeleton and the outline of the skin.

Reptiles rarely occur. They are represented by three genera of pterosaurs and at least two genera of marine crocodiles. In summer 2004 the excavation team of the Stuttgart Museum recovered an almost complete skeleton of a *Geosaurus* with remains of the skin and its stomach content.

In contrast to the typical Lithographic Limestone of Solnhofen, the ichnofauna of the Nusplingen Plattenkalk is much more diverse, but mostly restricted to special layers. Coprolites are generally frequent indicating marine life in the water column above the anoxic sea floor.

Stop 1: Type locality of the "Nusplingen Plattenkalk"

Geological Map 1:25 000 sheet 7819 Meßstetten,
R 3491520, H 5331810

The type locality of the Nusplingen Plattenkalk is a small outcrop from the first half of the 19th century. For the first time the famous Jurassic geologist F. A. Quenstedt from the University of Tübingen visited this locality in 1839 and described the "Nusplingen Plattenkalk" in 1843 from here. Although

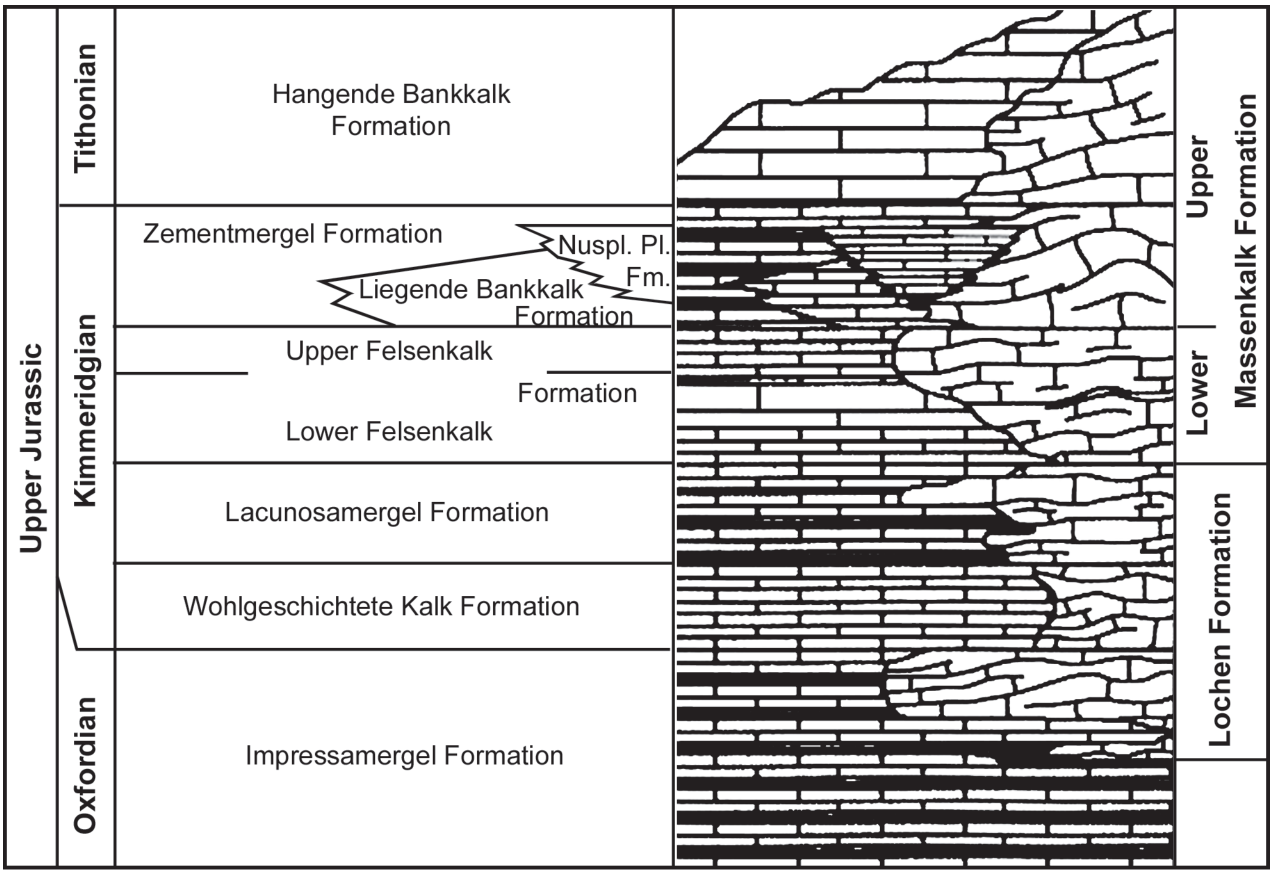

Figure 9: General stratigraphical position of the Nusplingen Plattenkalk Limestone (Nuspl. Pl. Fm.) within the Upper Jurassic of Swabia (S Germany). From Dietl & Schweigert (2004).

QUENSTEDT was not able to find many fossils at that time, he concluded that the Nusplingen Plattenkalk is much richer in fossils that than the Lithographic Limestones of Solnhofen. The small quarry goes back to the activity of a local farmer which was characterized by QUENSTEDT as an "industrial farmer".

Stop 2: Nusplingen Plattenkalk in the Egesheim quarry

Geological Map 1:25 000 sheet 7819 Meßstetten,
R 3490540, H 5331580

The Egesheim quarry was exposed for extraction of road material in 1979/80. Because of intervention of the State Museum of Natural History Stuttgart the quarrying stopped at the end of 1980 because of the danger to destroy important fossils. Here are the lowermost 5 metres of the Nusplingen Plattenkalk Formation exposed. In this outcrop the excavations reached the bottom of the plattenkalk lagoon formed by the so called Liegende Bankkalk Formation, a highly bioturbated micritic limestone thus contrasting the nearly non-bioturbated lithographic facies. The bottom of the lagoon is dipping with about 15 degrees. In other outcrops the submarine relief can reach until 45 degrees. The western border of the lagoon consists of sponge/microbial mounds. They are exposed directly behind the blockhouse. Some years ago there was isolated slumping fold exposed within the laminated facies of this quarry.

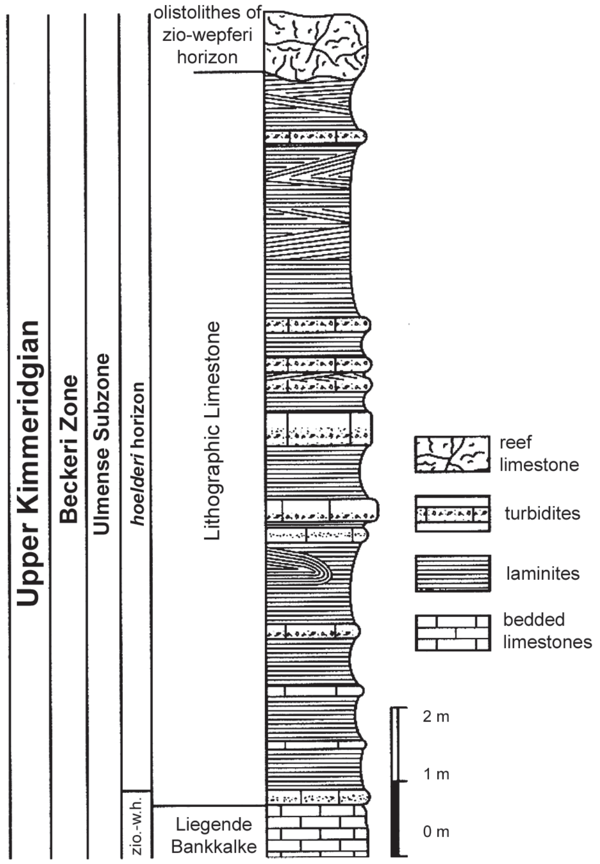

Figure 10: Detailed section of the Nusplingen Plattenkalk and its stratigraphical position within the upper Kimmeridgian. The thickness of the Nusplingen Plattenkalk in the figured section is of about 10.5 m. From DIETL & SCHWEIGERT (2004).

Stop 3: Nusplingen Plattenkalk in the Nusplingen quarry

Geological Map 1:25 000 sheet 7819 Meßstetten,
R 3490630, H 5331690

The exploitation of the limestones in the Nusplingen quarry goes back until the middle of the 19th century. Since that time the Nusplingen Plattenkalk has been excavated sporadically for commercial purposes. At the same time the first important fossils were recovered, but lacking any detailed data. The first scientific excavation started in 1929 under the supervision of the University of Tübingen. But it took not much longer than one summer. Two other scientific excavations (1935, 1962) carried out again by the Geological Institute of the University of Tübingen were also restricted to a single summer campaign. The State Museum of Natural History in Stuttgart started new excavations in 1994. Since that time the excavations are going on with great success.

During the new excavations only the uppermost five metres of the Nusplingen Plattenkalk were exposed. The total thickness of this formation within this quarry area is about 10.5 metres. Especially in the upper part of the section some bituminous layers are remarkable in respect of their extraordinary preservation of fossils. They are easy to identify due to their blue-grey colour. Within the succession of the laminated limestones, several turbidites with graded bedding (so-called "allodapic limestones") and several thicker bioturbated beds indicating a better oxygenation are intercalated. The turbidites yield angular lithoclasts and other components like calcareous ooids, sponge spicules, and even some fragments of hermatypic corals from shallow areas surrounding the lagoon. With the help of these maker beds it is possible to correlate the outcrops in the two quarries. Also some silica layers occur throughout the basin. In the Nusplingen quarry it is visible that the deposition of laminated limestones stopped abruptly. From the nearby sponge/micobial reefs, a lot of boulders had been broken off, gliding into the central parts of the lagoon as olistholiths, where they were deposited directly above the laminated limestone. This olistholith cover reaches a thickness of several meters. The allochthonous nature of these boulders is indicated by geopetal fillings in hollow fossils (e. g. brachiopods) and several ammonites significantly older than those from the underlying laminates. Below the boulder beds, the original stratification of the laminates is strongly disturbed by folding, boudinage, lateral compression, and repetition by stapling. We presume a strong seaquake being the reason for this dramatic event. Because of Cainozoic erosion no data about the younger Upper Jurassic of this area are available.

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