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Excursion A 5

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Platform-basin transition of Bajocian-Bathonian oolitic carbonates in the southern Rhine Graben and Basle area

Field Leaders

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Introduction

The excursion leads from the Basel area into the Southern Rhine Graben around Kandern and Freiburg (Fig. 1). The development of the eastern part of the Hauptrogenstein carbonate platform and the transition into adjacent marly basin will be discussed especially with respect to the reservoir characteristics of the oilfield in the Offenburg-Bühl area (Fig. 2). Outcrops which document characteristic development of different parts of the complete Hauptrogenstein sequence and tectonic features will be visited in the Basel area and around Kandern in the Vorbergzone (Fig. 1).

Geological setting

During the Middle Jurassic a shallow-marine carbonate platform, the Burgundy Platform or 'Plate-Forme Septentrionale' developed in central Europe, at that time covered by an epicontinental sea (Fig. 4). During the middle Bajocian to middle Bathonian the western segments of this carbonate platform were dominated by bioclastic calcarenites, whereas in the eastern and central areas a broad oolitic belt developed, extending southward to the marginal basins of the opening Tethys (e.g., Ziegler, 1990). The oolitic series is named Hauptrogenstein Formation in northern Switzerland and southwestern Germany. Further to the east the platform facies is replaced by a marl-dominated facies (Klingnau Formation, previously called "Parkinsonien Beds", Fig. 3) which probably formed in a somewhat deeper part of the epicontinental sea.

For the Hauptrogenstein Formation in Switzerland a biostratigraphic frame was established (Gonzalez, 1993, 1996; Gonzalez and Wetzel, 1996) which allows to describe the oolitic series in relation to sea-level changes (Fig. 5). The Hauptrogenstein Formation is composed of three shallowing-upward successions, each capped by a hardground. These successions are called in accordance to Gonzalez and Wetzel (1996) Lower Oolitic Series, Upper Oolitic Series, and Coarse Oncolite/Spatkalk. Within these series a number of lithostratigraphic units has been established (Fig. 3 and 6).

The first shallowing-upward succession (Lower Oolitic Series) started to form during the Blagdeni Subzone with marly beds and intercalated tempestites which increase in frequency upsection. Oolitic sedimentation started in the central Jura in the Niortense/Subfurcatum Subzone. The 0.2-2 m thick, cross-bedded oolites are attributed to a tidal, shallow-marine high-energy setting. At the same time, the oolitic beds in the eastern Jura contain up to 35% mud, and a low energy setting is inferred (Lower Acuminata Beds). During the Garantiana Zone oolite belts prograded eastwards reaching the Aare River. An up to 70 m thick oolitic succession was deposited during a period of moderate sea-level rise and a steady subsidence.

The second shallowing-upward succession started in the early Parkinsoni Zone. The production of ooids ceased during a sea-level highstand and marls and bioclastic limestone accumulated in northern Switzerland; the Homomya Marls in the western and the Upper Acuminata Beds in the central and eastern Jura. Later, a drop in relative sea-level during the late Parkinsoni Zone re-established ooid production (Upper Oolitic Series).

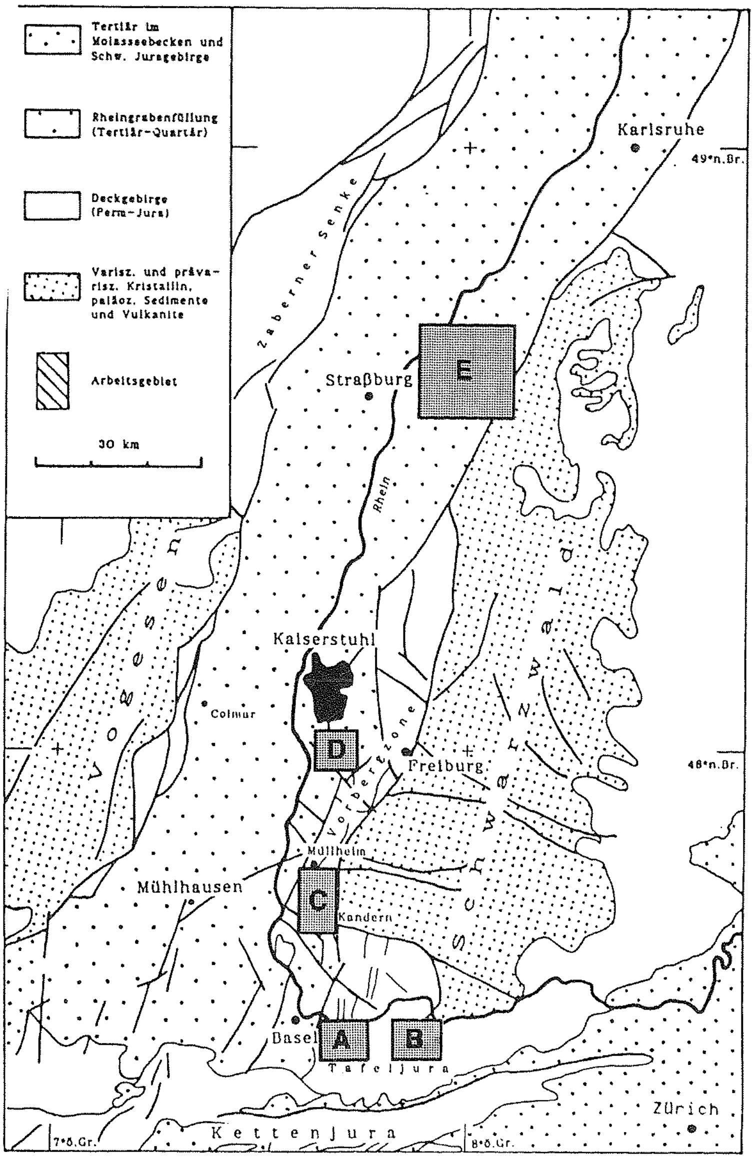

Fig. 1: Geologic tectonic map of the southern Rhinegraben with the location of the Kandern area in the Vorbergzone (from ERNST 1991). Overview of the field-trip-route in the Southern Rhine Graben and in the Basel area. A = Gisliflue area (Fig. 13), B = Liestal (Fig. 14), C = Liel and Kandern-Vorbergzone (Fig. 15 -18), D = Tuniberg (Fig. 19-22), E = Offenburg oilfield (Fig. 23-25).

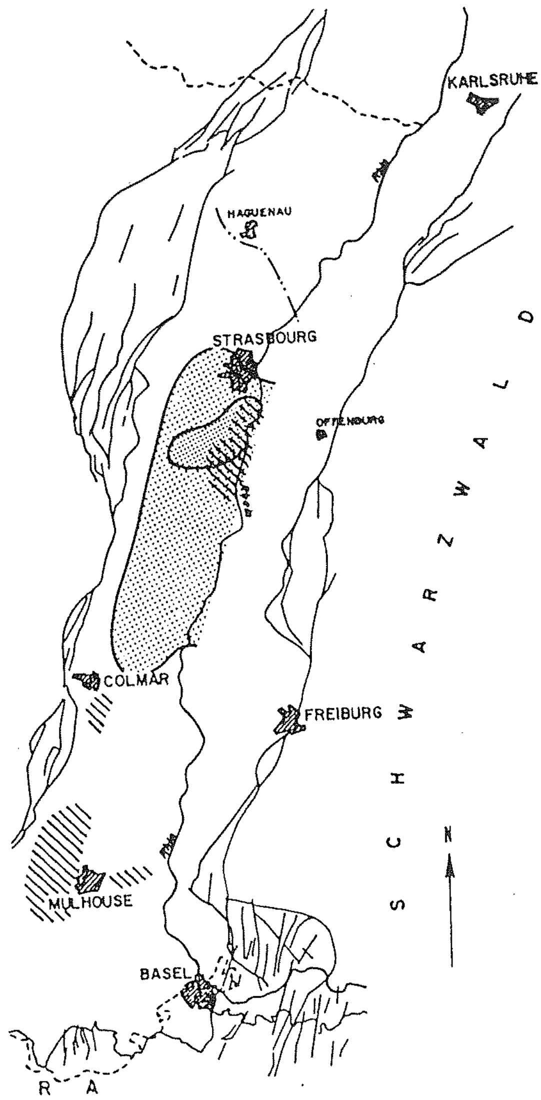

Fig. 2: Porosity and fracturing of reservoir rocks in the Hauptrogenstein of the southern Rhinegraben oilfields.

-·-·-·- Northern boundary of the Hauptrogenstein-Facies. /// - Zone of fracturing in the reservoir. Porosity measured from plugs.

10 15 %

The third shallowing-upward succession started during the latest Bajocian and earliest Bathonian (Zigzag Zone). Marly sediments rich in coarse bioclasts (Movelier Beds) are again interpreted as formed during a relative sea-level highstand. They are overlain by micritic oncolites in the western Jura; to the east, sparry bioclastic, locally cross-bedded limestones occur ("Spatkalk"), probably deposited by storms and tides. The deposition of the "Spatkalk" lasted until the early Middle Bathonian, prograding eastward and covering the top of the basinal Klingnau Formation.

The facies belts within the Hauptrogenstein and Klingnau Formations suggest the evolution of middle Jurassic, north-south trending oolitic barriers dominated by tides. Back-barrier facies belts formed to the west including micrites, pelmicrites, patch reefs, and oncolites. Off-barrier assamblages formed to the east of the barrier. A decrease in production of sediments, as evidenced by platformwide facies changes and in the thickness of shallowing-upward successions, was probably caused by changes in water circulation and/or climate. On the other hand, more or less abrupt changes in thickness and facies within the successions suggest differential subsidence.

The area visited during the first part of the field trip lies within the oolitic belt at the southeastern margin of the Burgundy Platform. However, the eastward and northeastward boundary of the oolitic

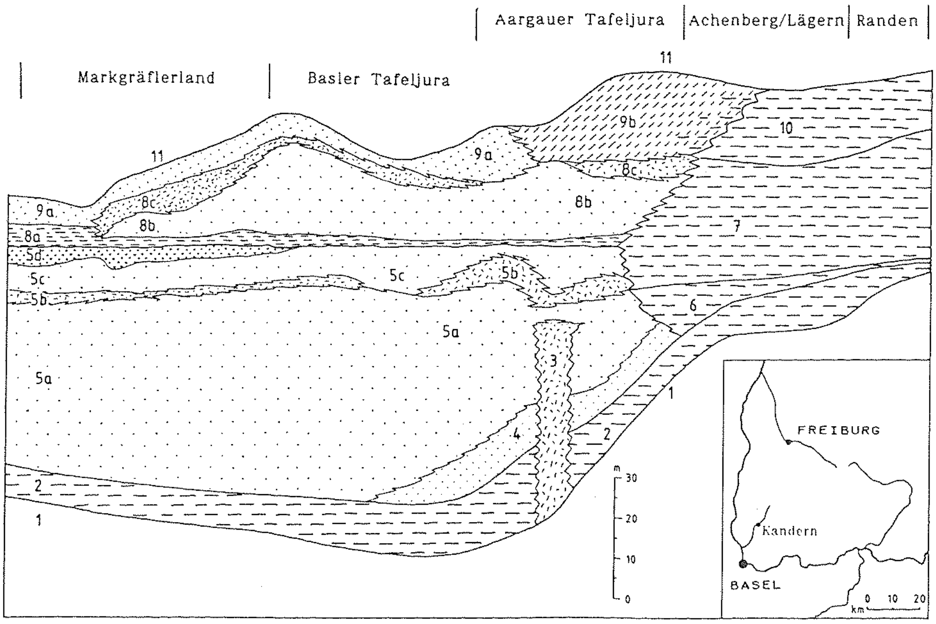

Fig. 3: Schematic cross section of facies interfingering at the SE border of the Hauptrogenstein carbonate platform (from ERNST 1991). **1:** *humphriesianum* Oolite, **2:** blagdeni Beds, **3:** coral-limestone of Gislifluh, **4:** Lower Acuminata Beds, **5a:** Lower Hauptrogensteine s.l.: "Lower Pentacrinus Beds" up to cross-bedded oolites with schill beds, **5b:** meandrina Beds, **5c:** coral bearing Hauptrogenstein (according to SCHMASSMANN), **5d:** Mumienbank, **6:** Subfurcaten Beds, **7:** Parkinsonia Beds, **8a:** Homomyen Marls, **8b:** Upper Hauptrogenstein s.str., **8c:** *movelierensis* Beds, **9a:** *ferrugenia* Beds,**9b:**"Spatkalke",**10:***wuerttembergis* Beds,**11:***varians* Beds (ERNST 1991).

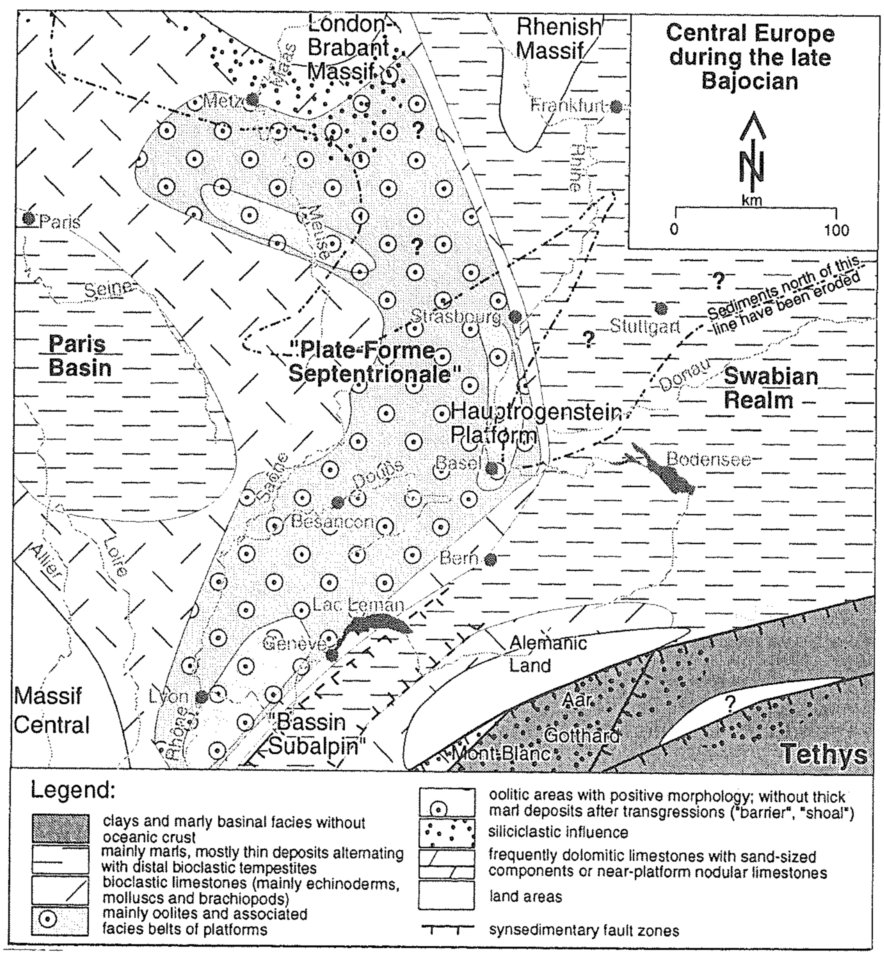

Fig. 4 Paleogeographic, palinspastic reconstruction of Central Europe during the late Bajocian after Gonzalez and Wetzel (1996).

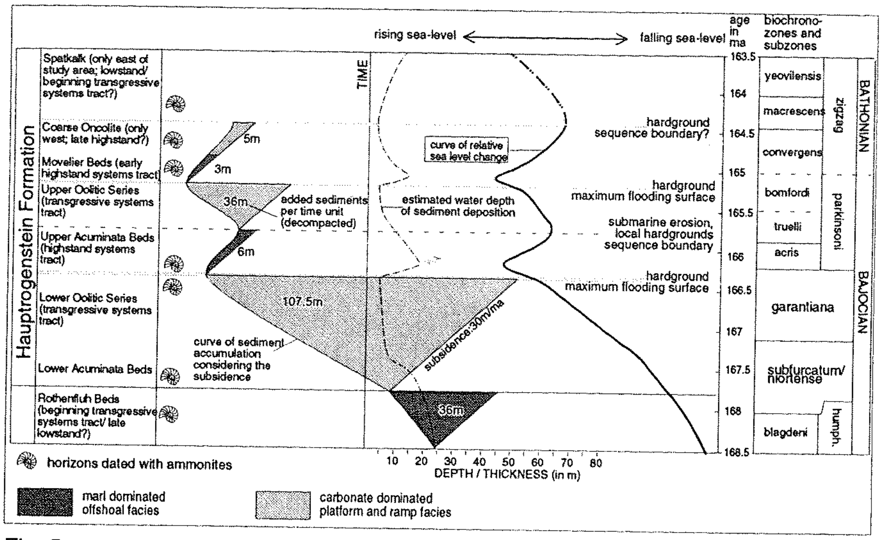

Fig. 5

Fig. 5 Tentative qualitative evaluation of relative third-order sea-level changes in northern Switzerland during the late Bajocian to early Bathonian. Thickness of decompacted sedimentary units and estimation of depositional depth refer to a section close to Lausen [Stop 4]. Figure from Gonzalez and Wetzel (1996).

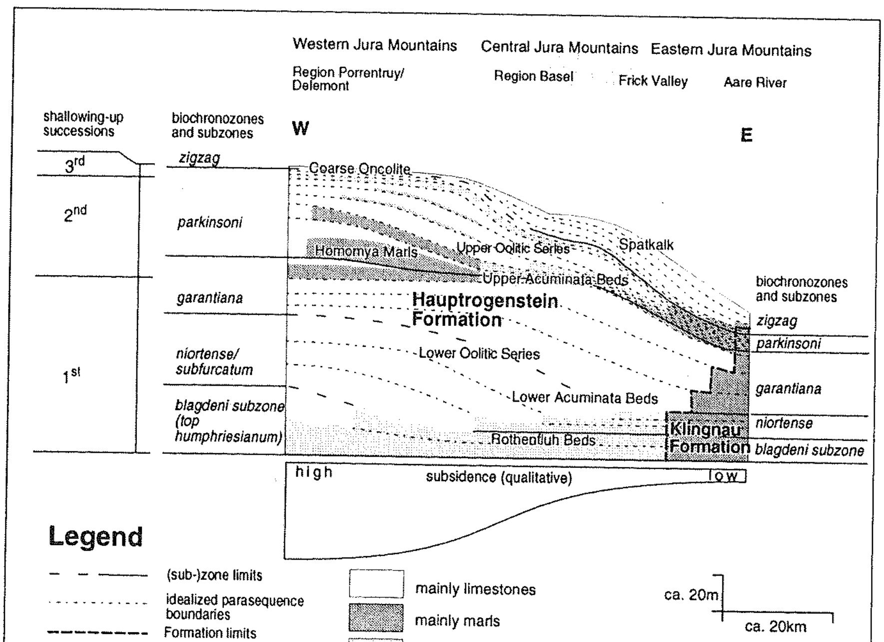

Fig. 6

Fig. 6 Correlation of lithostratigraphic units of the Hauptrogenstein and Klingnau Formations. Simplified, schematic west-east cross-section showing the arrangement of some lithostratigraphic units. Time-lines cut oblique sigmoidally through the platform, reflecting the progradation of the oolitic units towards the east during the development of the platform and ramp system. Figure from Gonzalez and Wetzel (1996).

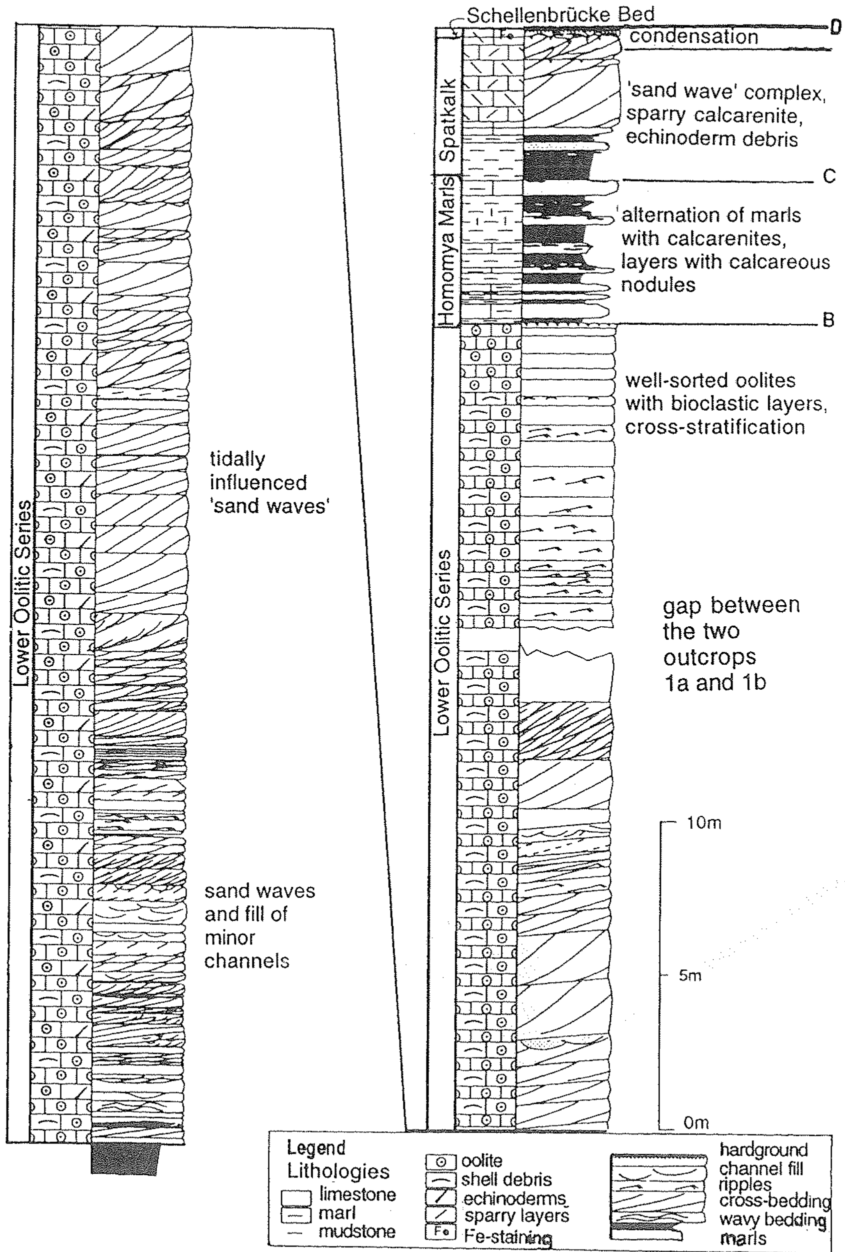

Fig. 7 Composed section of Stops 1a and 1b

facies is somewhat tentative due to later erosion (see Fig. 4). A well documented platform-basin transition is exposed in the subsurface of the oilfield in the Offenburg-Bühl area and will be discussed on the base of log correlations, cross-sections, and core samples demonstrated.

Excursion route

Road log [Stop]:

Bad Säckingen - Brugg - Auenstein[1] - Holderbank (AG)[2] - Veltheim - Thalheim[3] - Aarau - Sissach - Lausen[4] - Basel - Kandern - Liel[5] - overnight - (6) Riedlingen - (7) Kandern - (8) Merdingen - (9) Merdingen - Offenburg

Description of stops

Stop 1: Margin of the oolitic platform; quarries of the Jura Cementfabrik Aarau-Wildegg

Two outcrops in this large quarry area will be visited.

a "Oberegg", Swiss Coordinates 653.900/252.700 (see Fig. 13, No. 1a)

b "Unteregg", Swiss Coordinates 653.950/252.800 (see Fig. 13, No. 1b)

In the two quarries the basal and the topmost part of the Hauptrogenstein Formation is very well exposed.

a) In this quarry the Lower Oolitic Series is exposed. Bioclastic, bioturbated marl-limestone alternations are overlain by oolitic tempestites becoming increasingly thick upsection (Fig. 7). The oolitic facies *sensu stricto* consists of complex tidal sand waves which show a paleo-flow to the south and hence, point to ebb-tide dominance. The tidal sand waves are arranged in complexes which are bound by erosive reactivation surfaces. Their

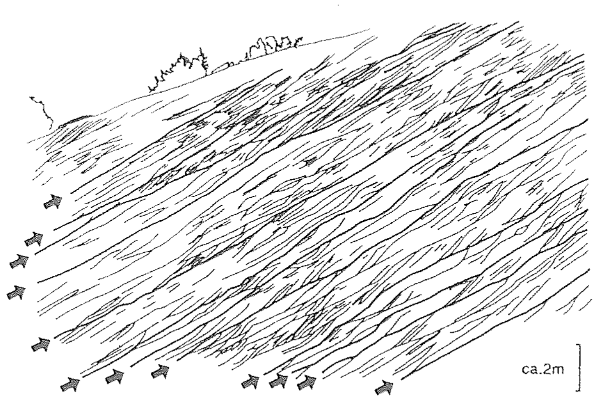

Fig. 8 Cross-bedded oolites of the Lower Oolitic Series (Stop 1a) corrected for regional dip. A dominant south-going ebb tidal current is documented by large foresets. The most foresets show an asymptotic geometry pointing to high current velocities. The upper parts of the forests have been eroded supposedly by flood tidal currents and/or storms.The 'sand waves' are arranged in horizontally more or less continuous packages; the boundaries between these packages (arrows) are marked by marls and/or fill of minor channels. Convex reactivation surfaces, small ripples on the foresets, and calcarenite lenses might have been produced by flood tidal currents.

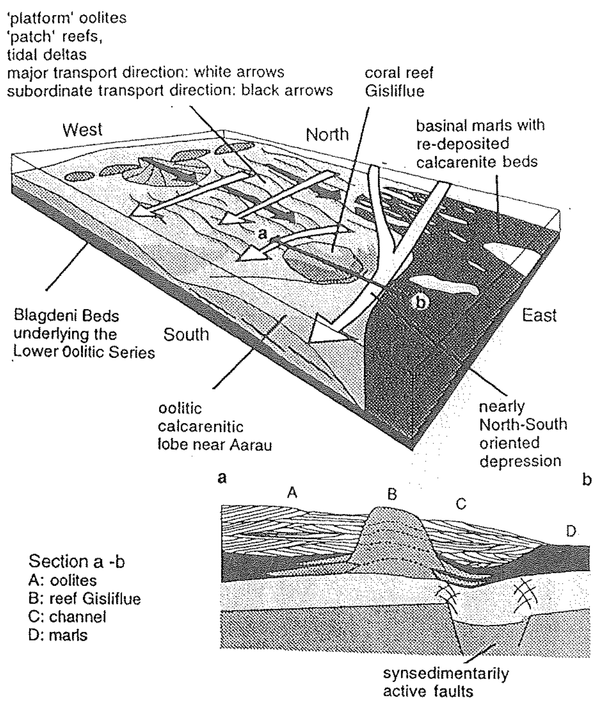

Fig. 9 Paleogeographic reconstruction for the outcrops at the southeastern side of the 'Hauptrogenstein' platform (upper part). A strong ebb-tide current probably was probably channelized in a depression and transported oolitic and bioclastic material to the south. The reef of the Gisliflue is located at the western margin of this depression. The section a-b (lower part) schematically shows how this situation might have been developed.

formation is ascribed to the reverse current (Fig. 8). The sediment consists of radial concentric ooids and ruditic bioclasts. A considerable proportion of the ooids has some dark laminae which might have been formed under reducing conditions in the back-barrier setting (Fig. 9).

b) In a road cut, the upper part of the Hauptrogenstein Formation and the transition to the basinal equivalents of the Hauptrogenstein can be seen. The top of the Lower Oolitic Series (Bajocian) is covered by a hardground which in turn is overlain by the basinal equivalents of the Upper Oolitic Series (Bathonian). Bioturbated marls alternate with bioturbated bioclastic layers, supposedly deposited by storms. Above the marls the large-scale cross-beds of a tidal sand-wave belonging to the "Spatkalk" is exposed. The top of the "Spatkalk" is formed by a 40 cm thick condensed layer, the so-called "Schellenbrücke Schicht" which was studied in detail by Gygi et al. (1973) and which is useful as reference horizon.

Stop 2: Basinal marls exposed in the inactive quarry Holderbank, Holderbank Cementfabrik AG

Swiss Coordinates 655.500/252.800 (see Fig. 13, No. 2)

The visited part of the section (Fig. 10) is made up of Bathonian (and upper Bajocian?) marls with intercalated bioclastic layers. The "Schellenbrücke Schicht" which is also found in this outcrop is underlaing the "Spatkalk", but further downsection no ooids are present although this outcrop is only about 3 km away from the oolite barrier system [Stop 1]. Therefore the platform margin must have been stable for a considerable time span which has been longer than the time during which the platform prograded from Burgundy to the Aare River. A paleo-valley focusing currents is invoked to explain this phenomenon (Fig. 9).

Stop 3: Reef exposed at the Gislifluh

Swiss Coordinates 650.525/252.950 (see Fig. 13, No. 3)

The only major reef of the Hauptrogenstein Formation is exposed.The reef nucleation and growth started in the Bajocian and the corals seem to have grown on top of a bioclastic sand-wave made-up by a high proportion of echinoderm debris. This structure is located in the southeastern part of the platform and might have been developed due to differential subsidence and/or currents, both preventing the reef of being buried by oolites (Figs. 3 and 10).

Stop 4: Basal crinoid beds of the Lower Oolitic Series exposed in the quarry Stockholden, Brodtbeck AG, Lausen

Swiss Coordinates 624.775/257.625 (see Fig. 14, No. 4)

The basal parts of the Hauptrogenstein are exposed in this quarry, in particular the crinoid beds of the Lower Oolitic Series can be seen (Fig. 11). Meyer (1988) carefully investigated these beds. In several layers nearly complete specimen of *Chariocrinus andreae* (Desor) can be found, a small-size species which commonly occurs in NW Switzerland, especially in the basal parts of the Hauptrogenstein Formation (cf. Hess 1975). These layers can be used as marker horizons for the corrleation of the Lower Oolitic series to the Kandern area in the Southern Rhine Graben (Ernst 1991). The find of Strenoceras give an age of the Niortense Zone.

Litho- and biostratigraphic analyses suggest that during that time a morphologically slightly differentiated carbonate ramp prograded from NW to SE. The western part of the ramp was dominated by oolite bars whereas marly carbonate sands accumulated to the SE. The crinoids lived in a subtidal environment, probably in channels between oolitic bars. Orientation of the crinoid stems and dune foresets point to a paleo-current direction from NNW to SSW (Meyer, 1988).

The crinoids preferably lived on a coarse-grained sandy substrate in high densities, up to 400 individuals per m^2. They were adapted to high current velocities. The crinoid colonies were buried by moving ooid dunes and/or died owing to the stagnation following plankton blooms which might have been similar to red tides (Meyer, 1988). Increased concentration of C_{org} in marls covering the crinoid beds may support this hypothesis. The fill of the channels due to the overall progradation of the platform changed the paleoenvironment so severely that the substrate was not recolonized.

Crinoids are often found along the margin of the oolitic platform. Since these organisms are known to prefer food-rich environments, they might have used platform waters which became enriched in plankton on the platform. Alternatively, the common occurrence of crinoids along the eastern and southeastern margin of the platform may point to food carried by an amphidromal current system from the Bohemian land mass in the northeast to the platform margins; the latter idea is supported by the occurrence of palynomorphs belonging to the North-European province (Smelror, 1993).

Stop 5: Back-barrier oncolites exposed near Liel

German Coordinates 33.96.150/52.90.140 (see Fig. 15, No. 5)

The back-barrier lagoonal facies of the Lower Oolitic Series (Bajocian in age) is exposed in this outcrop, the so-called "Mumienbank" which was studied in detail by Ernst (1989, 1990, 1991). The "Mumienbank" (Figs. 12 and 17) consists of cm-sized oncolites which commonly have a gastropod as nucleus. The oncolites rest on oolites which show minor channeling. The boundary between both lithologies is erosive. Within the oncolites, two beds can be distinguished, each about 1 m thick; the lower consisting of up to 1 cm-diameter oncolites, whereas the upper beds contains even larger ocncolites. The bedding is indistinct, but at some places a sorting of the oncolites can be observed. Episodic currents probably of storm origin reworked the lagoonal material and led to a oncoid-supported fabric.

Stop 6 : "Mumienbank"-facies variations and coral-sponge bioherms in the *movelierensis* Beds Riedlingen

German Coordinates 33.96.150/52.90.140

In comparison to the Liel outcrop the "Mumienbank" (60 cm and 350 cm thickness) is more massive and composed of varying facies types overlying each other. Within the 350 cm thick unit an alternation of oncoid layers and oolitic layers can be observed indicative of an interfingering of the oncoid and ooid facies. Some oncoids (10 - 50 mm diameter) reveal deformation features which are interpreted to have occurred during early compaction of moderately lithified oncoids (Ernst 1989). The "Mumienbank" is overlain by the Homomya Marls (200 cm thick) documenting a stepwise development of ooid beds into the overlaying Upper Hauptrogenstein (Upper Oolitic Series). The top of the unit is interpreted as an omission surface. The disconformity is overlain by the *movelierensis* Beds (600 cm) which are characterized by marly intercalations of reef debris and by bioherms of up to 100 cm in size.

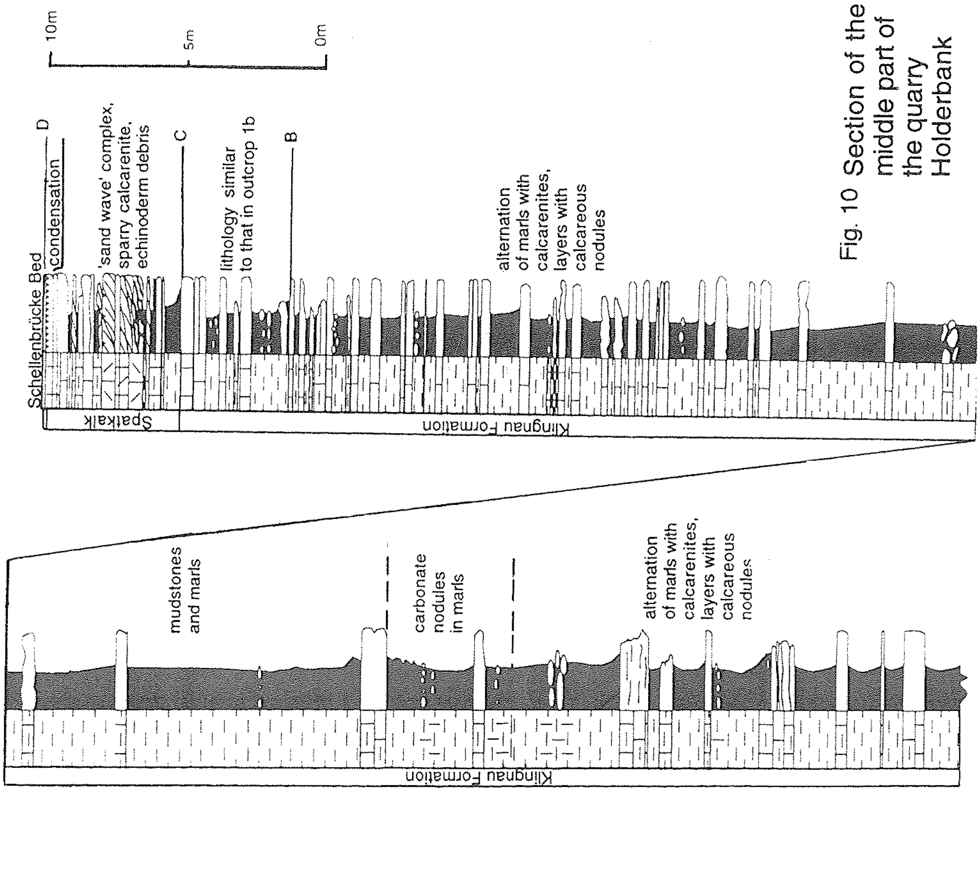

Fig. 10 Section of the middle part of the quarry Holderbank

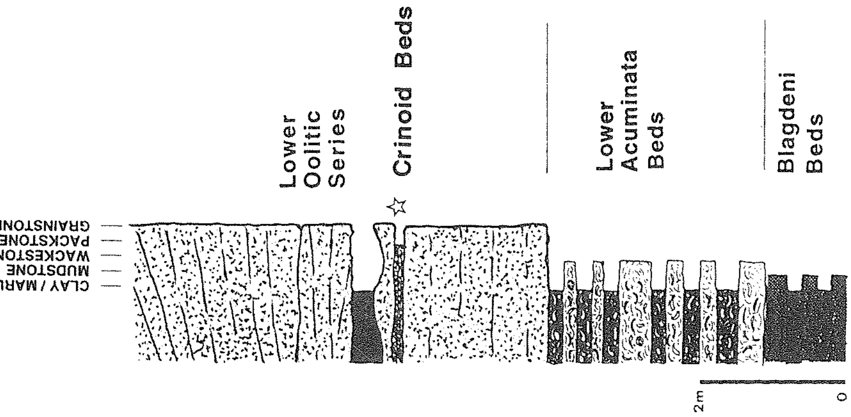

Fig. 11 Section of the quarry in Lausen (from Meyer, 1988)

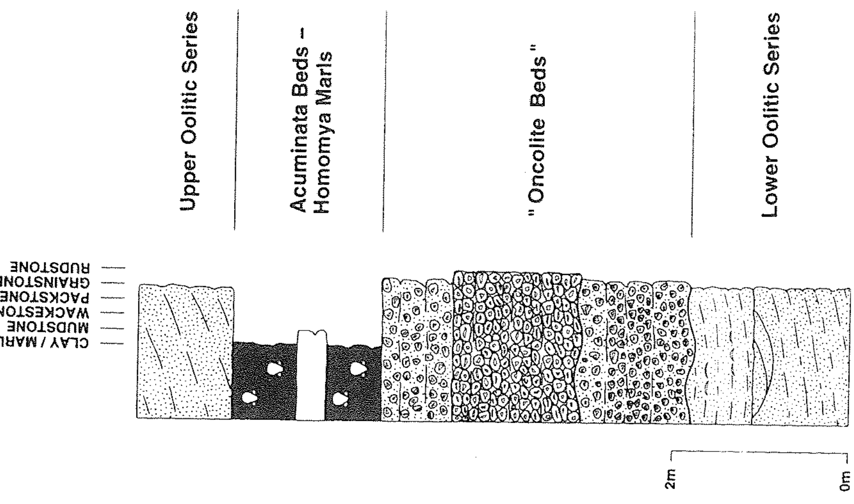

Fig. 12 Section of the outcrop near Liel

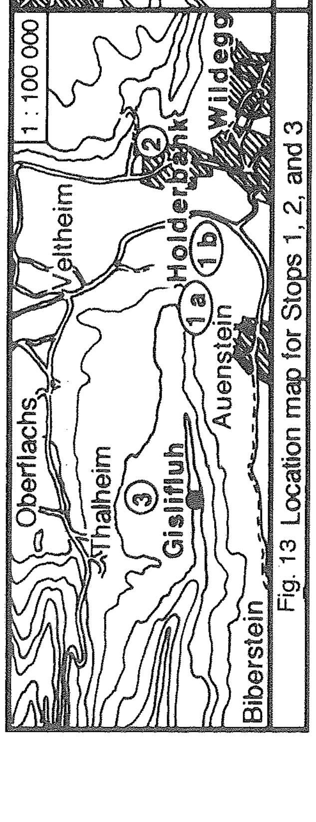

Fig. 13 Location map for Stops 1, 2, and 3

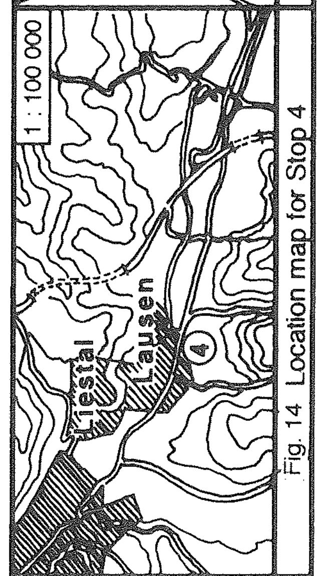

Fig. 14 Location map for Stop 4

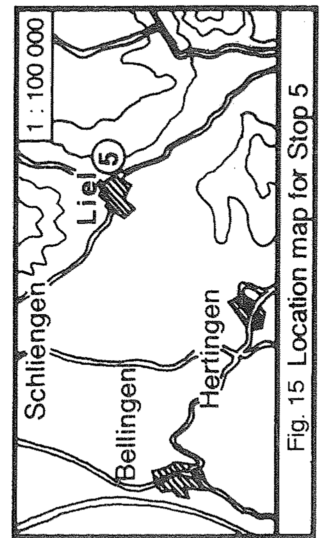

Fig. 15 Location map for Stop 5

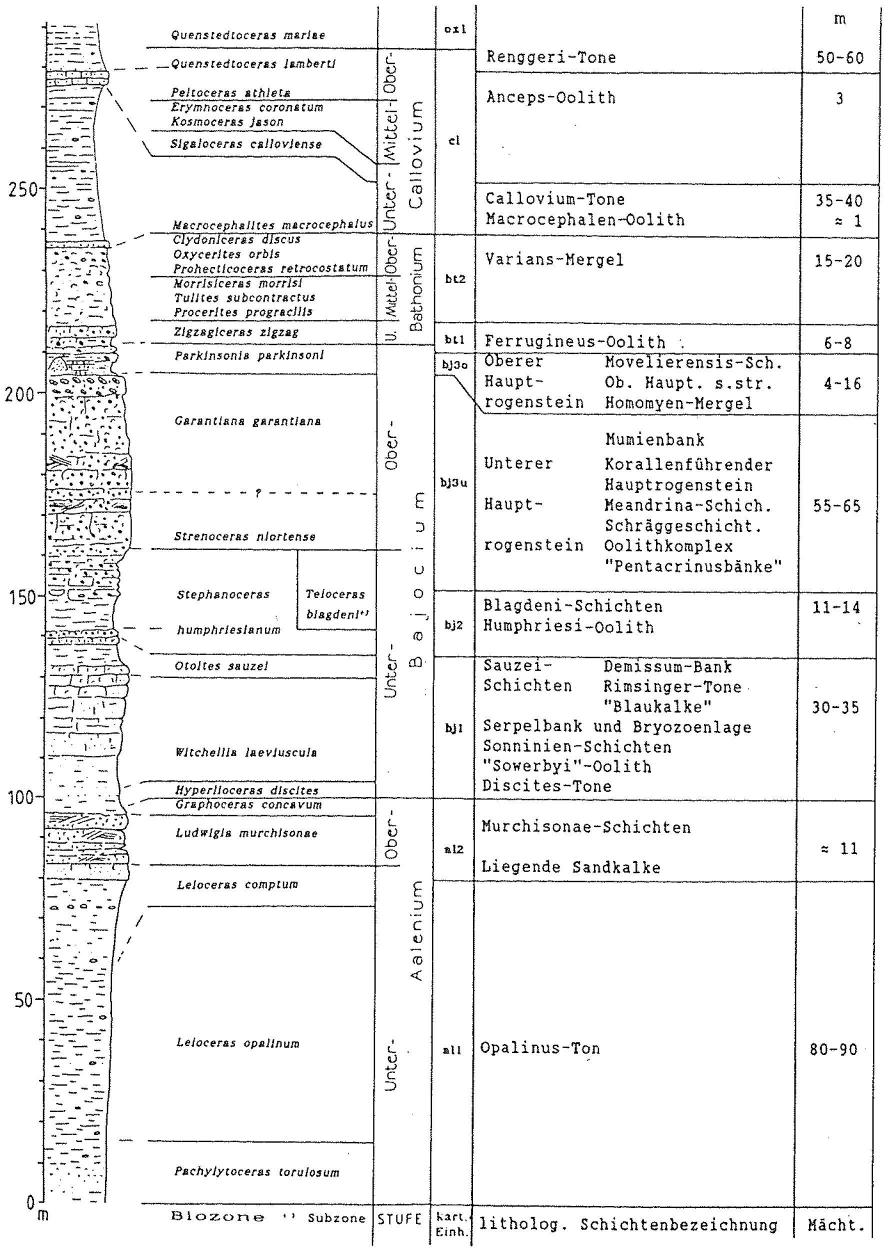

Fig. 16: Lithologic and biostratigraphic subdivision of the Middle Jurassic (Dogger) in the area of Kandern (from Ernst 1991).

Stop 7: Reworking horizon, "Mumienbank", bored small bioherms, N- and S- Bohlhölzle
German Coordinates 33.98.350/52.87.330 and 33.98.260/52.87.030

The outcrops at the Bohlhölzle at the road Riedlingen - Kandern expose a complete section reaching from the *garantiana* - zone to the *ferrugineous* Beds (about 26 m thick). The oolites of the *garantiana* - zone (about 6 m thick) are interrupted by a nodular horizon which is interpreted as reworking horizon within a 3.5 m thick oolitic series. The "Mumienbank" is composed of different beds of varying thickness mainly characterized by well-sorted oncoids of 30 mm diameter, embedded in a micritic matrix revealing synsedimentary deformation.

Thereon two beds, 120 cm and 180 cm thick which include the Homomya Marls, document the transition to the Upper Hauptrogenstein (Upper Oolitic Series) which consists of cross-bedded ooid layers. The ooids reveal dissolution and compaction features.

The oolite is overlain by the *movelierensis* Beds containing small cm to dm-sized bioherms composed of sponges and hydrozoans (Chaetetidae) that grew on a Fe-encrusted hardground. Borings in the bioherms are filled by greenish sediment.

The uppermost part of the section consists of a reef debris facies rich in bryozoans, porifera, echinoids and molluscs.

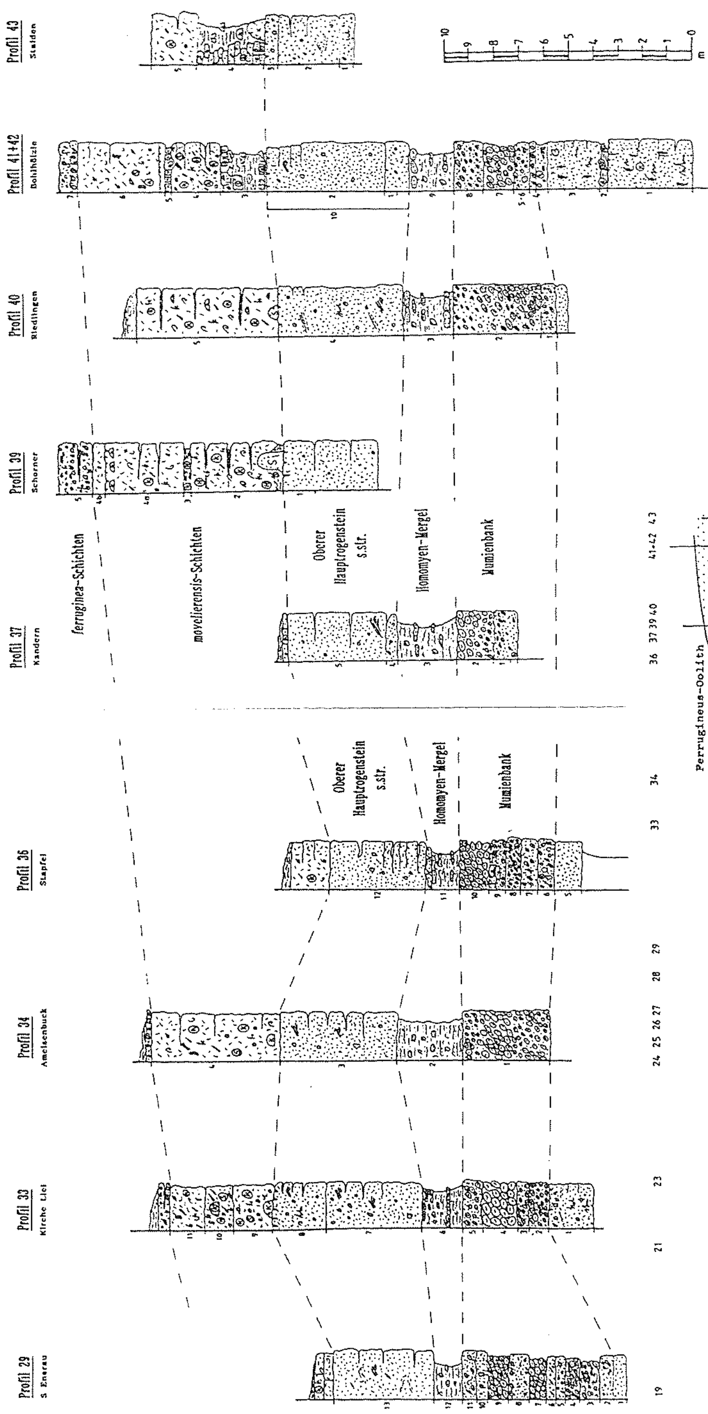

Fig. 17: Stratigraphic sections of the Hauptrogenstein in the Kandern area as analyzed by ERNST (1991). Position of the sections are given in Fig. 18.

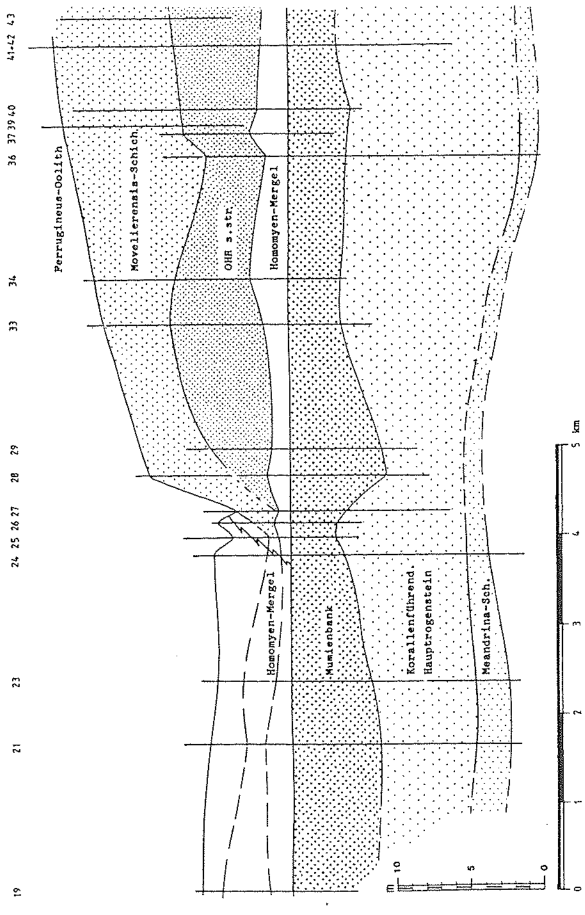

Fig. 18: Lithofacies development and interfingering of beds (*meandrina* Beds - *feruginea* Beds) in the Kandern area (from ERNST 1991).

Stop 8: Tuniberg-N, Merdingen, limestone quarry of the Mathis Company

Main features to be observed are bedding and composition of the Lower Oolitic Series. The Tuniberg (Figs. 19-21) is subdivided into a northern block (Tertiary) and a southern block (Jurassic) by a fault of 150 m vertical displacement. The beds of the southern block slightly dip to the East and some small blocks slipped in western direction. Minor faults striking NE-SW parallel to the Rhinegraben can be identified in the Merdingen quarry revealing vertical displacement of 1-2 m. Larger faults in the area show 180 m (near Menzingen) and the so-called Tuniberg-fault in the West vertical displacement of more than 1000 m (Groschopf et al. 1977).

The quarry is located at the northern part of the Tuniberg (Fig. 19) and exposes the uppermost part of the Lower Hauptrogenstein (Lower Oolitic Series) composed of oolitic limestones nearly throughout (Fig. 22). Only locally beds of the Upper Hauptrogenstein occur (Fig. 20). In the uppermost part of the section analyzed (Fig. 22) the "Mumienbank" is reduced in thickness compared to the Kandern area. This interval is composed of about 1 m thick beds: Ooid- and oncoid-rich beds and abundant biogenic allochems as bryozoans, corals and hydrozoans alternate. The bimodal grain size of ooids and oncoids in a generally such poorly sorted sediment is typical for reworking and multicycle sedimentation.

The top of some beds reveal borings and intensive cementation by coarse granular calcite which was formed by meteoric diagenesis. Generally an early marine cementation by isopachous rims prevails which is now diagenetically overprinted by later meteoric influx.

More clayey layers (below 4 % non-carbonates) are indicated by somewhat higher amounts of potassium (Fig. 22) reflecting an slightly increased illite-content due to a greater terrestrial detrital input (suspension load).

Stop 9: The Offenburg oilfield

The recovery and production data and the historical development of the Offenburg oilfield are discussed in comparison to the outcrops visited before showing different facies developments and diagentic features of the Hauptrogenstein. Additionally samples from drilling wells of the oilfield will be presented. A general outline on reservoir rocks and oilfields in the southern Rhine Graben is given.

9.1 The reservoir rock (general outline)

The main reservoir of the Offenburg oilfield is positioned in the oolitic Hauptrogenstein facies. The marl content increases and alters the reservoir characteristics rapidly from bottom to top and in northern and eastern directions from the Offenburg oilfield as well. North of a line Hagenau - Appenweier the Hauptrogenstein facies is replaced by the marly basinal facies.

The Hauptrogenstein is generally characterized by a cyclic sedimentation of marls, oolites and "Spatkalke". Interparticle pores are nearly completely closed by sparry calcite cement. Larger amounts of dolomite can occur in the Upper and Middle Hauptrogenstein (= Lower and upper part of the Upper Oolitic Series). In the Freiberg Süd well-I, drilled for hydrothermal energy, the Hauptrogenstein consists of 70-90% dolomite.

The overlying calcareous Ferrugineus Oolite and the Hauptrogenstein generally form important aquifers. The Hauptrogenstein commonly is strongly fractured often causing a sudden, tremendous loss of drilling-mud.

The Hauptrogenstein forms a marked seismic reflector which can be well used for correlation and the calculation of the top of the unit. A maximumn depth of the Hauptrogenstein-top is found NW of Strassburg at 2500 m.

9.2 Porosity and Permeability of the reservoir rock (general outline)

The uppermost part of the Hauptrogenstein consists of a compact limestone with fractures filled by granular calcite. Bed thickness changes abruptly

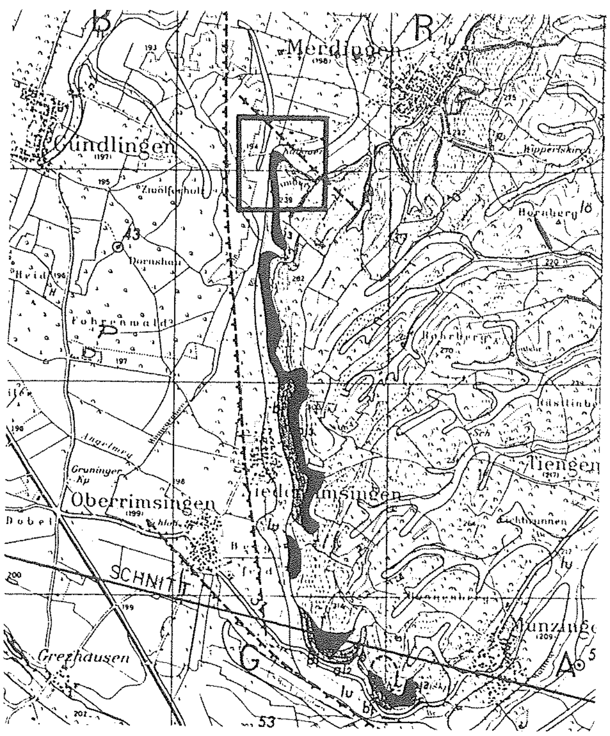

Fig. 19: Geological sketch of the area around Merdingen (black = Hauptrogenstein), positions of the Mathis quarry and cross-section are shown in Fig. 22 (SCHREINER 1974).

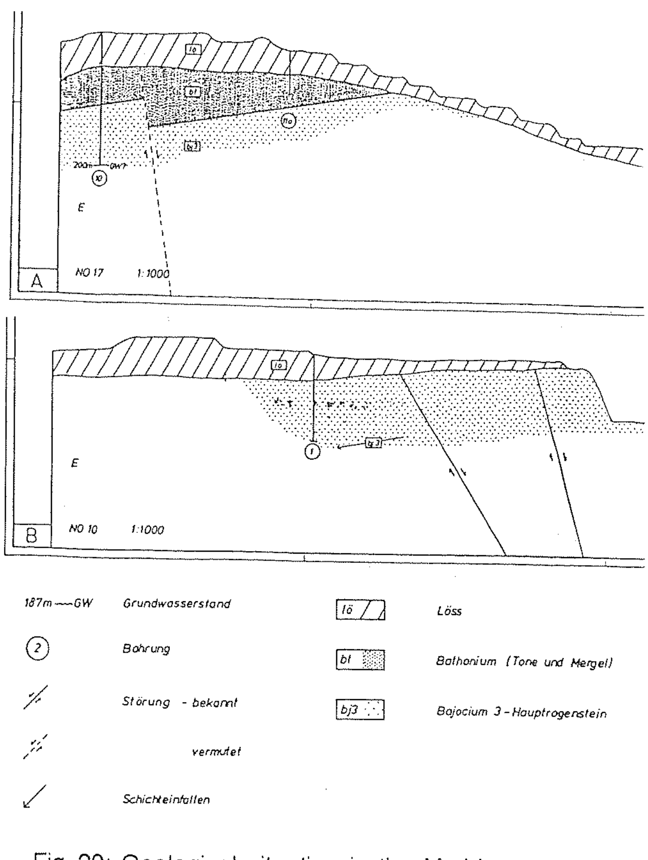

Fig. 20: Geological situation in the Mathis quarry near Merdingen. The Hauptrogenstein (bj3) is overlain locally by Bathonian beds (bt, A); from TRABOLD (1990).

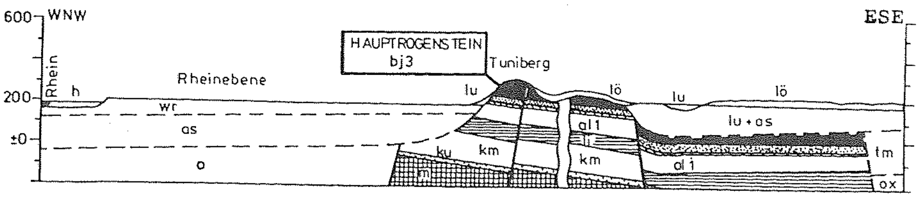

Fig. 21: WNW-ESE section through the Tuniberg near Minzingen and Merdingen (see Fig. 21) near the Mathis quarry. **h** = Holocene, **lu** = Löss, **wr** =Löss on Rhine gravel, **as** = Old Pleistocene gravel, **o** = Oligocene, not differentiated, **tm** = Tertiary , **ox** = Oxfordian, **bj3** = Hauptrogenstein, **bj** = blagdeni Beds, humphriesi Beds, sowerbyi Beds, **al2** = Aalenium, **al1** = Aaelnium (Opalinus Beds), **li** = Liassic undifferentiated, **km** = Middle Keuper, **ku** = Lower Keuper, **m** = Muschelkalk.

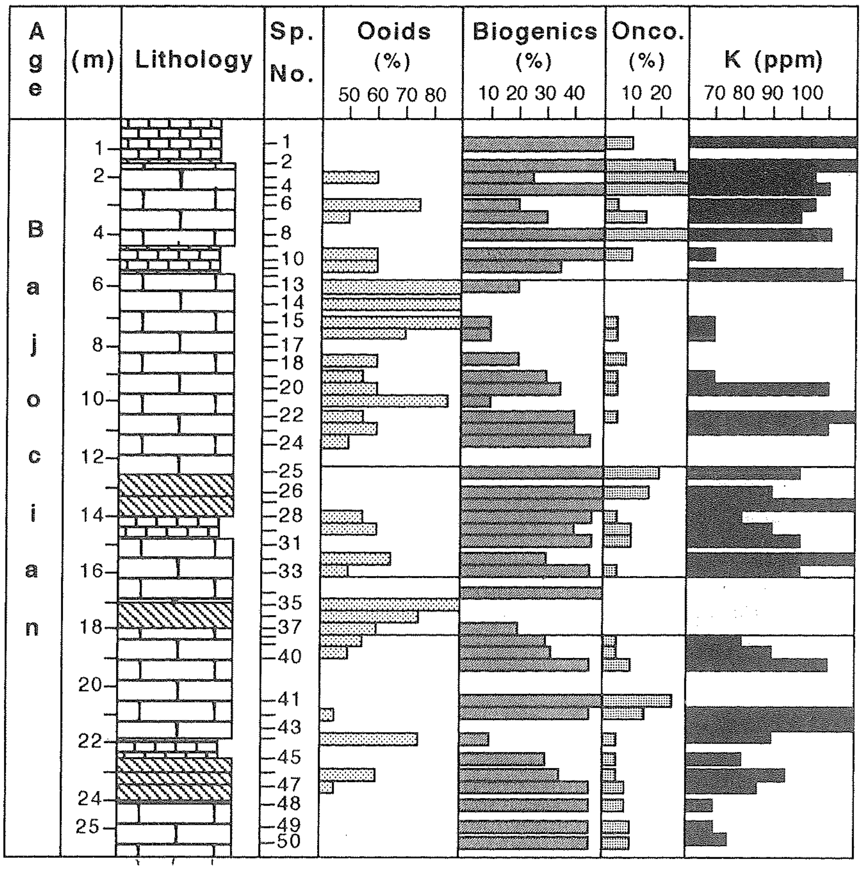

Fig. 22: Standard section of the Mathis quarry; uppermost Lower to Middle Hauptrogenstein (from Trabold (1990).

(meters to decameters) without predictable trends within this unit.

The main reservoir occurs in the middle and lower parts of the Hauptrogenstein. Only between Strassburg and Colmar porosity data (average 10 %) can be found (Fig. 2); highest porosities (average 15 %) southwards of Strassburg. North of Strassburg, where marl content increases, porosities of the oolitic limestone beds are between 1 - 5 %, typical for intensively cemented, dense bio-, oosparites (grainstones).

Fracturing is most important for the formation of reservoirs within the Hauptrogenstein. In the southern region fractures form a good reservoir rock, whereas the porosity of the rock itself is low. In the "Vorberg-zone", fractures generally are cemented by sparry calcite, whereas open fracture systems are found in the centre of the Rhinegraben. Only in the uppermost part of the sequence the fractures are filled by calcite cement.

Dolomitization can result in an improvement of the reservoir properties depending on the amount and type (idiomorphic - xenomorphic) of dolomite. With respect to dolomitization the geothermal gradient seems to be most important. A very high gradient is found around Mülhausen (> 5^0 C/100 m) in the area of the Staffelfeld oilfield. In areas of a lower or normal geothermal gradient the burial depth of the Hauptrogenstein seems to be important with respect to the presence of dolomite.

The **permeability** is generally low (0.1- 1 md) and thus, differs markedly from the good reservoir properties of the same formation in the Paris Basin where the Middle Jurassic oolites form an extraordinary reservoir rock with high porosities and permeabilities.

Tests were carried out in the uppermost part of the Hauptrogenstein which is intensively cemented. In the lower part of the section higher porosity/ permeability values were found indicating that these properties were strongly influenced by both primary facies, diagenesis and tectonics.

9.3 The Offenburg oilfield

The basic structure in the Offenburg oilfield is a longitudinal anticline striking NE-SW. The field is

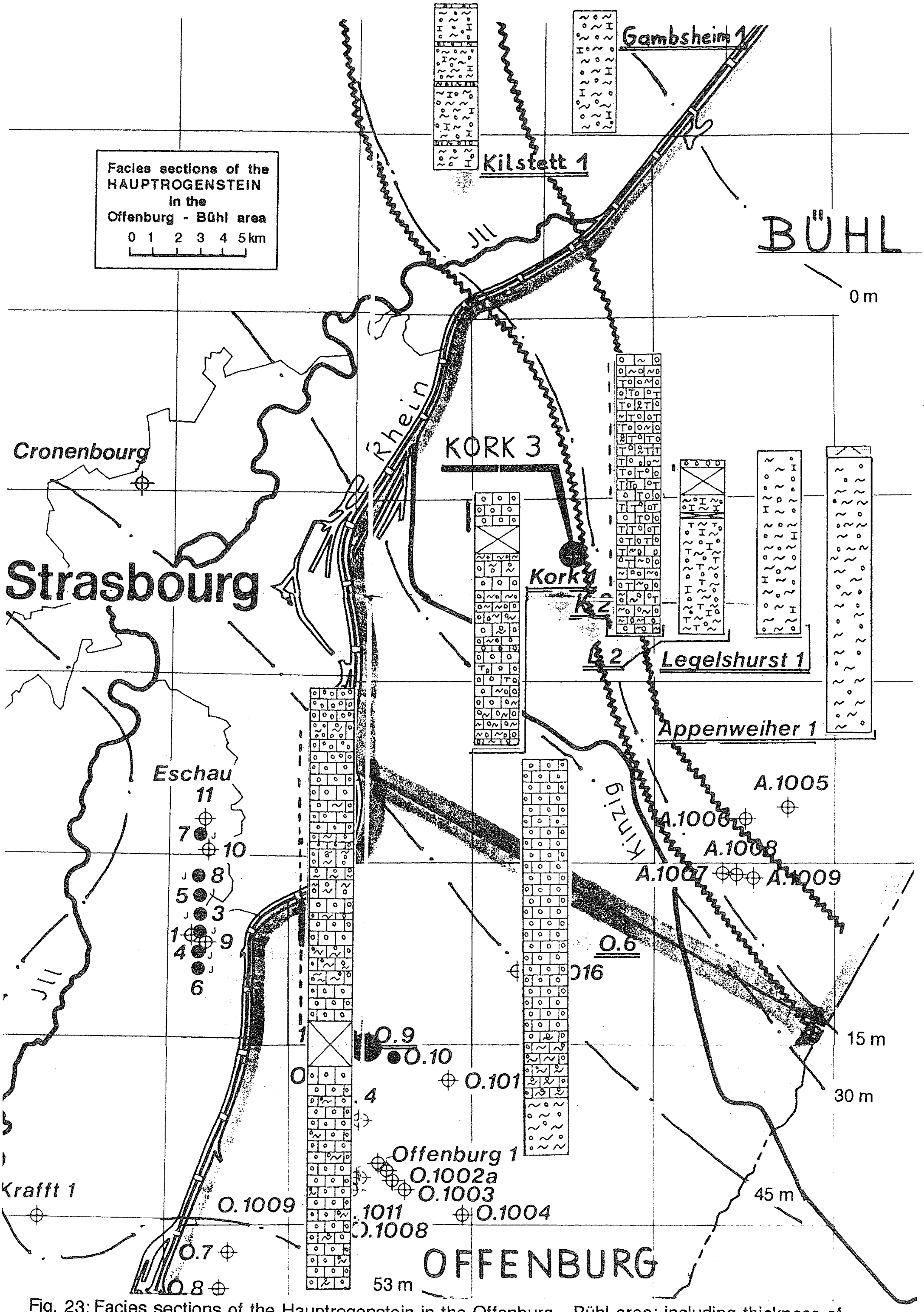

Fig. 23: Facies sections of the Hauptrogenstein in the Offenburg - Bühl area; including thickness of the Hauptrogenstein.

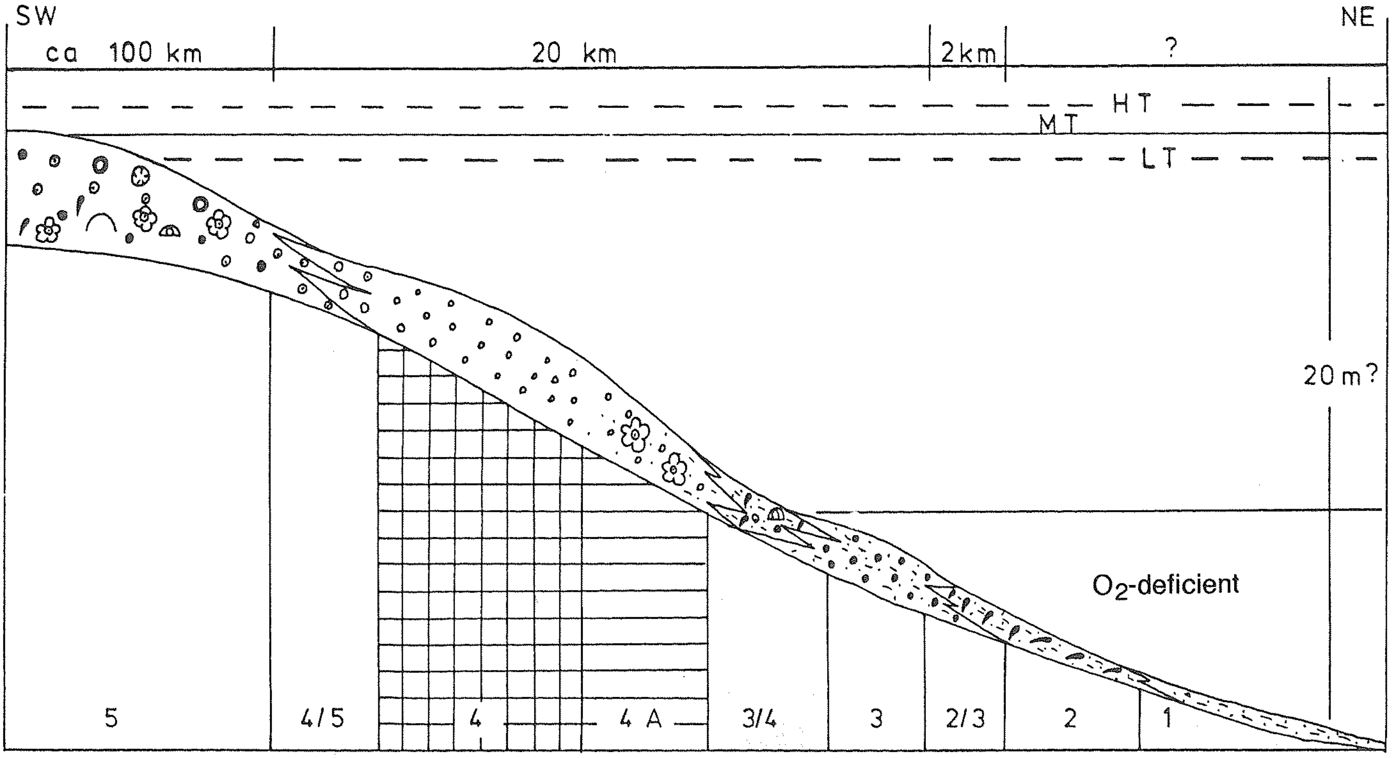

Fig. 24: Schematic section through the different facies belts interfingering at the N- and NE-slope of the Hauptrogenstein-platform. The highest porosity/permeability occur in the facies type 4 and 4a due to completely dissolved ooids (oomolds).

located where numerous, fault-bounded blocks form a culminating structure. This documents the importance of fracturing also in the northern area of the southern Rhine Graben (compare Fig. 2). Top of the reservoir is found between 1190 - 1250 m depth.

Production data of the Offenburg oilfield will be discussed on the base of the Offenburg 9 well (Fig. 23). In the years 1983 - 1987 about 9.000 t crude oil were produced in the Offenburg oilfield. The field was abandonned in 1993 after the production rates dropped successively as documented by the Offenburg 9 well (1983: 1.257 t, 1984: 4.067 t, 1985: 3.577 t, 1986: 242 t).

9.3.1 The Offenburg 9 well

In the Offenburg 9 well the Hauptrogenstein was encountered between 1374-1427 m (53 m thick; Fig. 23) and displays a characteristic log shape. The section mainly consists of oolitic limestones arranged in fining-upwards cycles each about 50 cm thick. They are commonly bounded by a thin zone of clay-flasers. The general composition of the allochems (ooids, oncoids, molluscs, echinoids) will be discussed in the field besides the lithologic development and petrophysical data. Porosity and permeability show increase values from top to bottom of the section, porosity ranging from 5-20 % and permeability from <0.1-10md. Generally the porosity in the Offenburg 9 well is composed of different pore types predominantly of (1) complete or partly oomolds, (2) fractures and microfractures, and (3) intercrystalline pores in dolomites.

The rock is traversed by abundant commonly open microfractures. Oilshows occurred in these fractures and within the rock itself. On the base of tests, a fractured reservoir with a "dual porosity system" was interpreted, with high permeability in fractures and low permeability in the matrix, because the isolated oomolds are separated by granular cements which fill the primary interparticle pores completely.

The study of microfacies and diagenesis revealed that the porosity system might be more complex because the porosity values strongly depend even on minor changes of the primary facies and composition of allochems.

Porosity and permeability show a relationship to the composition of allochems. In the lowermost part of the section where highest poroperm values were found large black-brown ooids occur, which also occur in other wells of the analyzed northern part of the oilfield (Fig. 24). The occurrence of these ooids may indicate oxygen-deficient bottom/pore waters because of the preservation of organic matter in the ooids. Detailed log and facies correlations from the oolite platform to the basinal facies in the north revealed a facies transition characterized by varying composition of the allochems (Figs. 23 and 24): facies belts oriented parallel to the platform margin were identified. On the base of log correlations and the interpretation of oxygen-deficient bottom waters a platform-basin transsect was constructed which

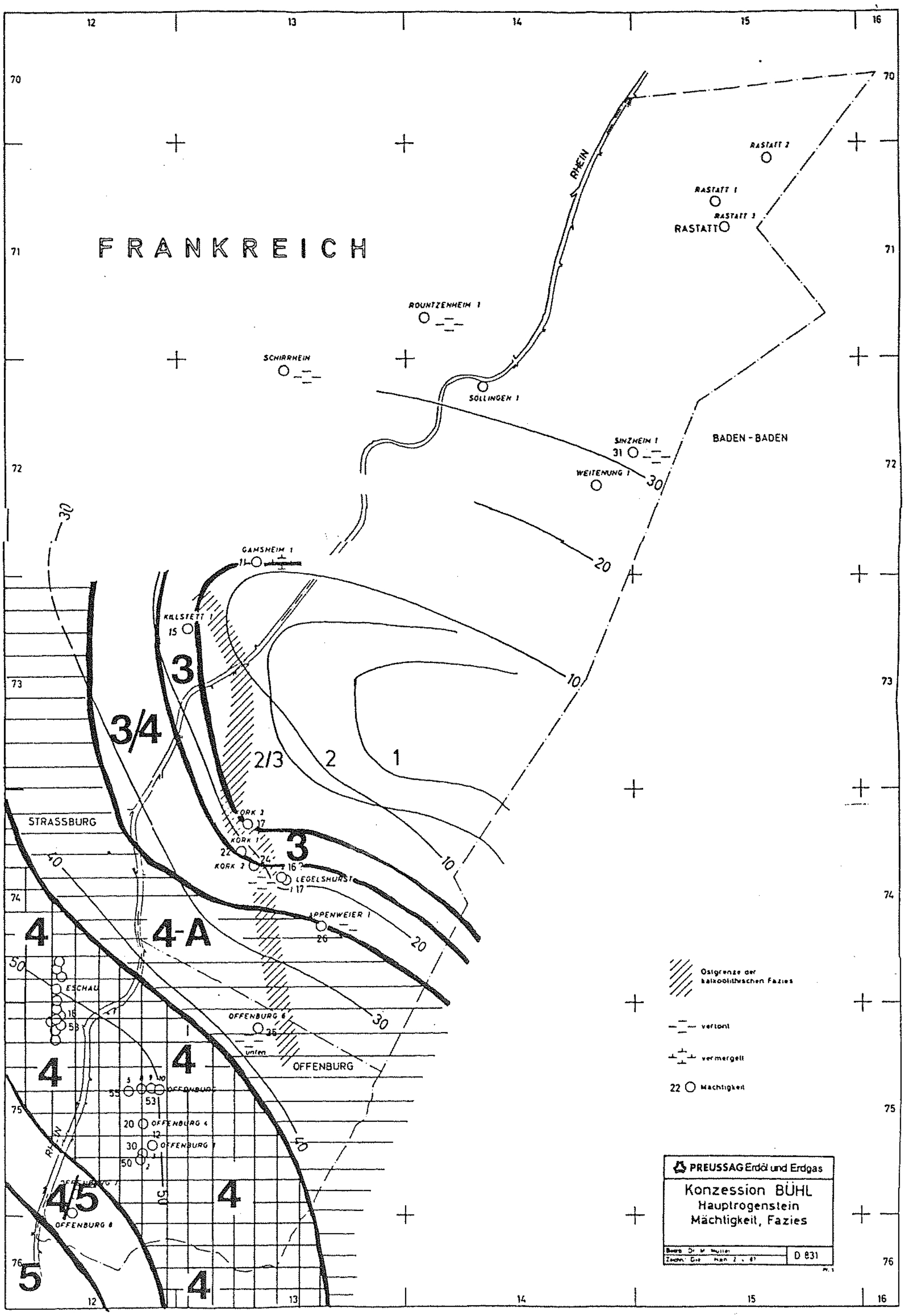

Fig. 25: Facies distribution in the Bühl oilfield showing position of the favourable facies belts 4 and 4 a, both with high oomoldic porosity.

shows good reservoir rock in facies belts 4 and 4a. This model will be discussed in comparison to the outcrops visited before and to the reservoir characteristics of the oilfields in the Paris Basin which show completely different porosity development in the Middle Jurassic oolites than in the Offenburg oilfield.

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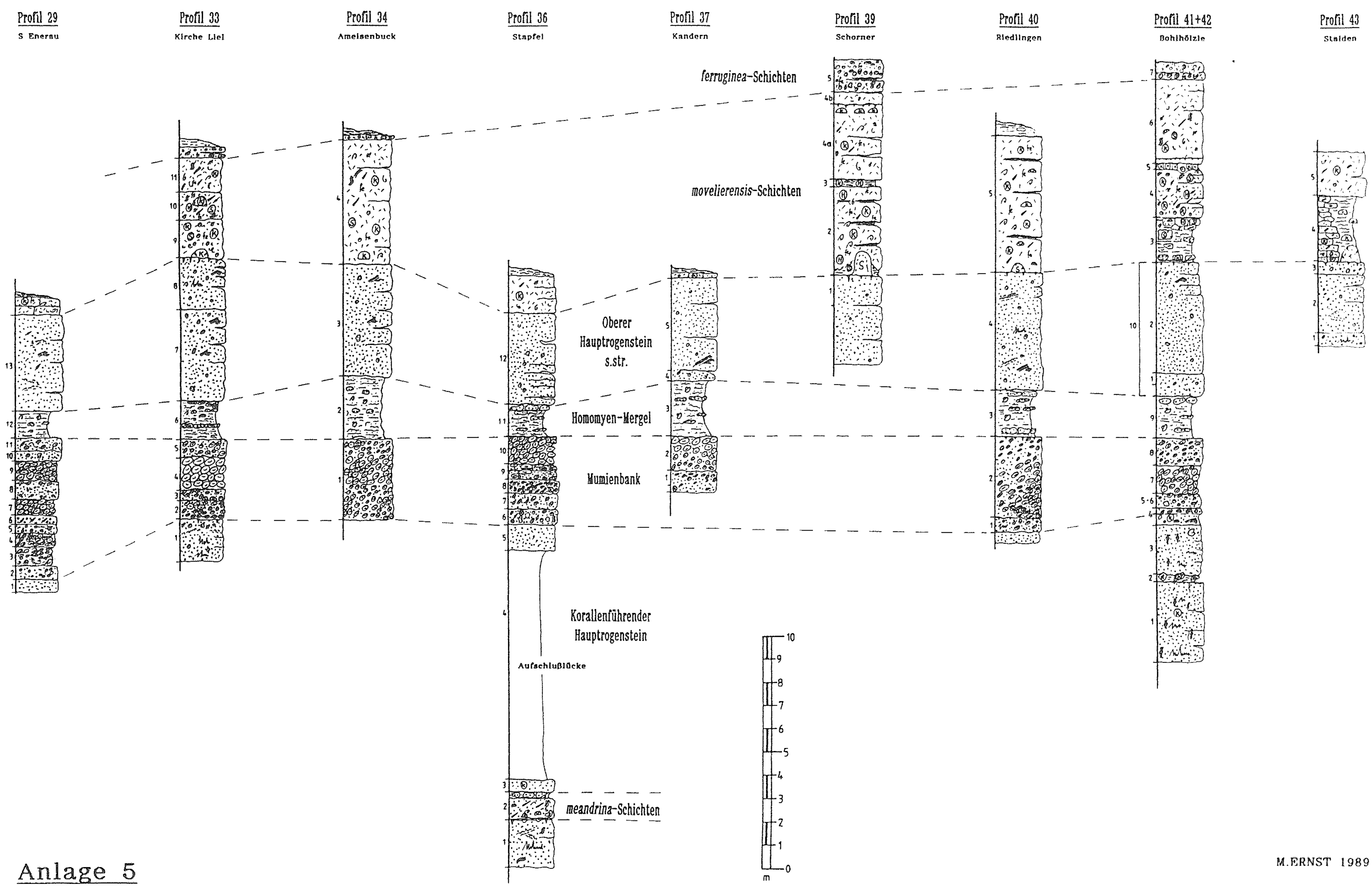
Fortsetzung der Detailprofile im Hauptrogenstein von Nord nach Süd auf Blatt Kandern



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