

SECOND · INTERNATIONAL
WORKSHOP · ON
AGGLUTINATED · FORAMINIFERA



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**2nd INTERNATIONAL WORKSHOP
ON AGGLUTINATED FORAMINIFERA**

ABSTRACTS

PROGRAM and EXCURSION GUIDE

Editor

F. RÖGL, Natural History Museum of Vienna

Vienna 1986

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For the organizers

Fred Rögl

**2nd INTERNATIONAL WORKSHOP
ON AGGLUTINATED FORAMINIFERA**

Part 1

ABSTRACTS

POLLUTION - INDUCED CHANGES IN ESTUARINE FORAMINIFERAL DISTRIBUTION IN THE OSLO FJORD

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The study area is Sandebukta, a branch of the Oslo Fjord (Norway) with a maximum depth of 70 m. Its water masses show estuarine stratification and receive pollutants (mainly organic matter). The distribution of the foraminiferal fauna displays essentially an estuarine pattern, but also reveals significant subrecent changes as demonstrated by means of 9 sediment cores supplemented by a larger number of sea bed surface samples.

The faunal changes have taken place during the last 100 years and are summarized as follows:

1. Increase in size of the total population shown by the sediment cores.
2. Reduction in the relative frequency of calcareous foraminifera upwards in the cores, so that the recent fauna of the inlet consists mainly of arenaceous forms.
3. Reduced faunal diversity.
4. Alterations in the species composition of populations, most pronounced in deeper waters.

Faunal comparisons with outer parts of the fjord system suggest that these changes are, at least partially, induced by pollution which has reduced the alkalinity and lowered the oxygen level. In addition, postem mortem destruction of foraminiferal tests is considered as a possible important modifying factor deserving further study.

CEMENT STRUCTURES OF SOME AGGLUTINATED FORAMINIFERS

BENDER, H., Geol. Inst. Univ. Tübingen, GFR

High resolution SEM and TEM studies of 15 species of agglutinated foraminifera raised in laboratory cultures show skeletons consisting of either calcareous or organic cement of various morphologies:

- (1) single strands up to $0.5\ \mu\text{m}$ in length interconnecting grains;
- (2) a form that gradually passes over from single strands into a fibrous mesh-work of strands within interstices of up to $2\ \mu\text{m}$ between the grains or
- (3) a foam-like mass filling gaps of $4\ \mu\text{m}$ in size.

Culture experiments on artificial, carbonate-free substrates demonstrate the presence of secreted calcitic cement in newly formed chambers. This settles a long lasting debate on the origin of calcareous cements in agglutinated foraminifera.

The agglutinated grains of organically as well as of calcareous cementing species are coated with an organic lining.

Examples are discussed.

CONSTRUCTIONAL ASPECTS IN TEST FORMATION OF SOME AGGLUTINATED FORAMINIFERA

BENDER, H. & HEMLEBEN, Ch.

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Taxonomy of foraminifera on the subordinal or superfamilial level is mainly based on their wall material and construction. The most evolved groups biomineralize their test by forming either calcite, aragonite, or high-magnesium calcite (miliolids). The first calcitic group (fusulinids) appeared in the fossil record during the Early Paleozoic. The agglutinated foraminifera evolved parallel to or even earlier (Late Precambrian ?) than the fusulinids and extend into the Recent. A typical feature of this group is the incorporation of foreign particles in their organic skeleton. In addition, various authors believe that some agglutinated species are capable of secreting a supplementary mineralized skeleton.

High resolution SEM and TEM studies on certain species raised in laboratory cultures show skeletons consisting of both calcareous cement and different types of organic cement.

Organic cements are organized either in single strands, which may gradually pass over into a fibrous meshwork of strands, or a foam-like mass. The agglutinated grains are coated with an organic envelope and have thus been somehow incorporated into the cytoplasm and transported to the site of construction. Similar observations were made on arenaceous species with a calcareous cement. These specimens, cultured on artificial carbonate-free substrates, demonstrated a secreted calcitic cement. The cement's ultrastructure resembles that of miliolid foraminifera, which belong to an entirely different suborder.

Similar results have been obtained from the fusulinid group (GREEN et al., 1980) and possibly from renalcids in Early Cambrian strata (RIDING & BRASIER, 1975).

The knowledge about calcite biomineralization in these different groups sheds new light on the early evolutionary development of calcification in foraminifera and will affect the classification and paleoecological application of agglutinated forms.

AGGLUTINATED FORAMINIFERA IN THE "SCAGLIA ROSSA" FORMATION (CENTRAL ITALY): GEOLOGICAL IMPLICATIONS

CATI, F. & BORSETTI, A.M.

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The study of the benthos content in the Upper Cretaceous Palirosa/Piobbico sequence (BORSETTI, 1962) has been reconsidered and extended to the Early Eocene. Due to the hardness of the rocks, thin sections were used. The percentage of the benthic foraminifera were therefore calculated not in weight or volume units, but in surface units (square centimeters).

At present we can note:

1. An abrupt drop of benthic foraminifera at the boundary Albian–Cenomanian;
2. Throughout the section calcareous and agglutinated benthic foraminifera are scattered and poorly diversified;
3. Shortly before the FAD of *Abathomphalus mayaroensis* (Upper Maastrichtian) large and rare agglutinated foraminifera appear and persist until the *Morozovella velascoensis* zone (Paleocene). These foraminifera are not easily recognizable in thin sections: *Sphaerammina* is present with certainty, *Haplophragmoides* and/or rotaliid-like forms only probably.

In all specimens the tests appear to be constituted of bioclastic granules. Benthic assemblages prevalently constituted of large agglutinated species are generally related to deep cold, oxygenated water masses (LOEBLICH and TAPPAN, 1964). According to STAINFORTH (1952) they are also related to highly turbid water.

The finding of these large agglutinated species in the Palirosa/Piobbico sequence suggests the following hypothesis:

1. During the Maastrichtian the bottom water of the deep Tethyan Sea became colder and more oxygenated; in other words, we suppose an early formation of oceanic water in this area at the end of the Cretaceous instead of at the beginning of the Cenozoic as generally accepted;
2. Large agglutinated species dominating the benthic assemblages may be related to tectonic activity documented in the area (COLACICCHI, 1984) and to the formation of deep-sea fans consisting of very fine calcareous material; this resulted in highly turbid water and furnished the bioclastic material necessary for the growth of the tests;
3. The peculiar benthic assemblages may be related to the concomitance of the two above events.

MORPHOGROUPS OF AGGLUTINATING FORAMINIFERA: THE
LIFE POSITION, FEEDING HABITS AND APPLICABILITY
IN PALEOECOLOGICAL STUDIES

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Data on the life positions and feedings habits of the agglutinating foraminifera have been collated. Analysis of results has led to recognition of a general relationship between feeding habit and test morphology. Four main "morphogroups" are described whose present day distributions are considered to be related to an appropriate food supply. A graphic method is outlined for portraying the relative abundance of the "morphogroups" in samples.

EARLY CRETACEOUS AGGLUTINATED FORAMINIFERA OF THE GRESTEIN KLIPPEN BELT, EASTERN ALPS (AUSTRIA)

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RÖGL, F., Naturhist. Museum Wien, Austria.

The Early Cretaceous limestone – marl rhythmites of the Upper Blassenstein member in the Gresten Klippen belt were studied with respect to their sedimentological development and micropaleontological content.

LITHOLOGY:

Grey mudstones mottled black or faintly laminated by bloturbation; carbonate content 80–90 %, insoluble quartz residue, clay minerals (mainly micas) and plagioclase. Average thickness of beds about 17 cm with smooth bedding planes. In thin sections: nannofossil micrites, rarely calcispheres (radiolaria), crinoid fragments (*Saccocoma*) and silt-size quartz grains. Occasional indistinct pelletisation due to bloturbation.

Intercalated pelites are black soft argillaceous marls or marls, approximately 5 cm thick. Carbonate content between 10 and 50 %. Insoluble residue of clay minerals (micas, chlorite, smectite), quartz, and plagioclase.

Two types of rhythmites can be distinguished:

Type A sequence:

distinct mudstone–pelite intercalations, e.g. section Nb, with sharp contacts and abrupt change in carbonate content. Bed thickness is constant; limestone–marl ratio about 3 to 4. Mudstones are burrowed; bioturbation in bedding planes causes faint lamination.

Type B sequence:

gradational contacts of limestones and marls, e.g. upper part of section Na. Fine intercalations of mudstones and black pelites are common, resulting in even to wavy lamination. Bioturbation less intensive.

BIOSTRATIGRAPHY:

Rich nannofossil assemblages with *Calccalathina oblongata*, *Crucellipsis cuvillieri*, and *Nannoconus steinmanni*. Age: Valanginian–Hauterivian, nanno zones CC3 to 4 of Sissingh. Samples are devoid of planktonic foraminifera but rich in radiolaria. Calcareous benthics with *Lenticulina eichenbergi*, *L. ouachensis*, *Epistomina caracolla* along with the nannoplankton restrict the age to the Hauterivian.

ECOLOGY:

The foraminifera are dominated by agglutinated forms. The fauna is dwarfed and dominated by distinct species in each sample. In the investigated sections the dominance of *Dorothia hauteriviana* versus *Ammobaculoides carpathicus* or *Bigenerina gracilis* is remarkable. Such phenomena are normally connected to special factors such as oxygen depletion.

The assemblages most similar to these are those described by Butt (1982) from the W African Atlantic margin off Morocco (DSDP Site 370). These were explained as stemming from deep water near the CCD with some degree of oxygen deficiency. The accompanying assemblage of *Ammodiscus*, *Glomospira*, *Reophax*, and *nodosarllids* is also similar in the two locations. In contrast, however, are the mid-shelf assemblages from the Agadir region (Morocco) where *Dorothia hauteriviana* occurs together with *Lenticulina elchenbergi*, *L. ouachensis*, *Epistomina caracolla*, and *Spirillina*.

Therefore the investigated rhythmites of the Upper Blassenstein member are interpreted by the foraminiferal fauna and the rich radiolaria content in a nannoplankton facies as being pelagic deep water sediments with black shale deposition in time of oxygen depletion. Transport of shallower deposits into the basin is indicated by the calcareous benthics.

The control of insoluble residue from both sediment types makes acidic residues useless for ecological interpretations. Complicated agglutinates such as *Dorothia* and partly also *Bigerina gracilis* are dissolved together with the calcareous fauna.

AGGLUTINATED FORAMINIFERA IN THE PANNONIAN (LATE MIOCENE) OF THE VIENNA BASIN

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The Vienna Basin shows a rapid change in facies during the Late Neogene from marine conditions in the Badenian to brackish facies in the Sarmatian and finally oligohaline facies in the Pannonian, when the salinity decreased to 7 ‰. Nearly all genera of foraminifera became extinct at the Sarmatian/Pannonian boundary. Only some kummerforms of agglutinates survived in deeper parts of the basin in the Early Pannonian.

Three different species of agglutinated foraminifera were found in boreholes in the Central Vienna Basin and also in the Pannonian Basin: *Miliammina subvelatina*, *Trochammina kibleri* and *Bathysiphon* together with *Silicopla-centina* (*Thecamoebian*). This appearance of endemic agglutinates in the Early Pannonian seems to be of stratigraphic importance throughout the Central Paratethys. It correlates with the mollusc zone A (according to PAPP, 1951) which is equivalent to the *Miliammina subvelatina*-*Trochammina kibleri*-zone (JIRIČEK & SVAGROVSKY, 1975).

References:

- PAPP, A. (1951): Das Pannon des Wiener Beckens.- Mitt. Geol. Ges., Wien, v. 39-41, 99-193, Wien.
- JIRIČEK, R. & SVAGROVSKY, J. (1975): Biozones of brachy- to oligo-haline molluscs of late Tertiary in the Central Paratethys.- in: CÍCHA, I. (ed.), Biozonal division of the Upper Tertiary Basins of the Eastern Alps and West Carpathians.- Geol. Survey, 45-56, Prague.

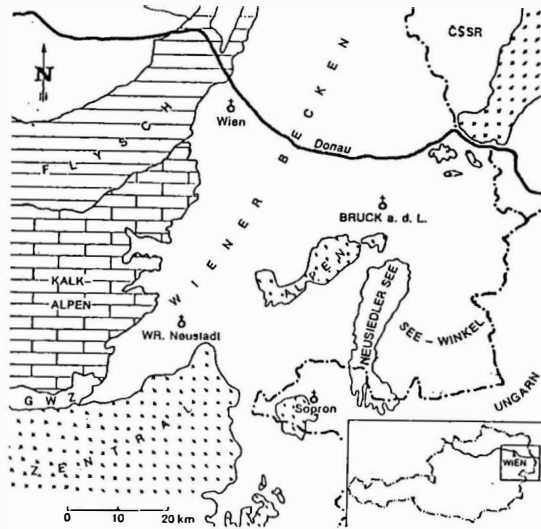


Fig. 1 : Location map of the Vienna Basin. "See-Winkel" is the Austrian part of the Pannonian Basin.

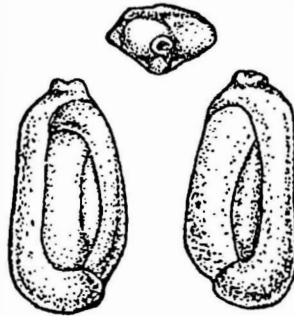


Fig. 2 : *Miliammina subvelatina* VENGILSKIJ; borehole KAGRAN 9, 915 m, eastern part of Vienna.

BATHYAL AGGLUTINATED FORAMINIFERAL ASSEMBLAGES FROM THE EARLY NEOGENE OF THE FALCÓN BASIN, VENEZUELA

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The Oligocene and earlier Miocene sedimentation in the Falcón Basin (northwestern Venezuela) is of deep water, bathyal, facies. The dark grey shales in the central part of the basin correspond to the Pecaya Formation, while the coeval sequence to the east, the lower part of the Agua Salada Group, is composed of brown clays and marls.

Both these units carry rich foraminiferal faunas of planktonic and calcareous benthic assemblages, with some agglutinated forms. At the top of Oligocene, within the *Globigerina ciperensis* Zone, the microfauna progressively deteriorates and disappears altogether. It is then replaced by agglutinated assemblages, with low diversity ones in the lower level and rather diversified ones, with over 15 species, in the upper part. No calcareous benthic forms are found in these assemblages, although some planktonics are observed, mainly as internal molds. The agglutinated assemblages occur everywhere in the basin at this stratigraphic level, involving distances of over 200 km, and mark an important basin-wide event related to a period of very rapid subsidence.

The calcareous foraminiferal microfaunas reappear in the earliest Miocene (*Globigerinoides primordius* Zone) in the Pecaya shales of central Falcón, but only in the *Globigerinatella insueta* Zone in Agua Salada (east Falcón). A hiatus between the Oligocene-Miocene boundary and the middle part of the Early Miocene is assumed for this region.

A second level of agglutinated assemblages of virtually the same taxonomic composition is found in the Agua Salada section at the Early-Middle Miocene boundary. This event is related to a deep prodelta environment. The deltaic sequence rapidly prograded over the area, building a few finger-like bodies of sand and silts surrounded by deeper water clays bearing the agglutinated microfaunas.

It is of interest to document the occurrence of these two levels of agglutinated foraminifera of very similar taxonomic composition within two widely different paleogeographic frameworks in the tropical Early Neogene of northern South America.

AGGLUTINATED FORAMINIFERA FROM THE CAMPANIAN AND
MAASTRICHTIAN OF THE LUBLIN AREA (EASTERN POLAND)

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This contribution presents new species of agglutinated foraminifera of the subfamily Telatynellinae, n. subfam., (Lituolidae) and the subfamily Varsovieninae, n. subfam. (Ataxophragmiidae). Described are all species of the genus *Spiroplectammina* Cushman, 1927 (Textulariidae), *Trochammina* Parker & Jones, 1859 (Trochamminidae), *Gaudryina* d'Orbigny, 1839, *Heterostomella* Reuss, 1866, *Tritaxia* Reuss, 1860, *Arenobulimina* Cushman, 1927, *Dorothia* Plummer, 1931, *Goesella* Cushman, 1933, *Plectina* Marsson, 1878, *Ataxophragmium* Reuss, 1860, *Orbignyna* v. Hagenow, 1842, *Voloshinovella* Loeblich & Tappan, 1964 (Ataxophragmiidae) of the Campanian and Maastrichtian of the Lublin area. Plates with photographs are included.

EARLY CRETACEOUS TO EOCENE AGGLUTINATED FORAMINIFERA IN THE INDIAN BASINS AND THEIR PALEOECOLOGICAL AND STRATIGRAPHIC SIGNIFICANCE

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Agglutinated benthic foraminiferal faunas of Early Cretaceous to Eocene age have been reported from the outcrop and in the subsurface in the Indian basins. The earliest assemblage of agglutinated foraminifera in the Raghavapuram shales (Early Cretaceous) in the Godavari Basin consists of *Ammobaculites* and *Haplophragmoides*. A similar assemblage has been reported from the Sriperumbudur beds in the Falar Basin. These assemblages are of low generic and species diversity with no planktonic forms. A mixed assemblage has been recorded in the basal Uttattur Group (Albian) in the Cauvery Basin; it contains agglutinated and calcareous foraminifera with smooth hedbergellids. Agglutinated genera present include *Glomospira*, *Haplophragmoides*, *Reophax* and *Ammodiscus*. Grey shales at Kallakkudy (Albian) contain varied agglutinated foraminifera (*Reophax*, *Spiroplectinata*, *Tritaxia*, *Trochammina*, *Verneuilina*, and others) with planktonic and benthonic forms such as *Pleurostomella* and *Lenticulina*. A prominent agglutinated foraminiferal assemblage is present in the greenish grey shale (Santonian - Campanian) in the wells of offshore Palk Bay Basin. Forms present in this section include *Glomospira*, *Ammodiscus*, *Bathysiphon*, *Haplophragmoides*, *Recurvoldes*, *Trochammina* and *Plectina*. In the wells of Krishna - Godavari Basin, shales of Campanian-Maastrichtian age contain agglutinated forms belonging to *Reophax*, *Bathysiphon*, *Ammobaculites*, *Ammodiscus*, *Gaudryina*, *Trochammina* and *Haplophragmoides* in addition to calcareous benthic and planktonic forms. Sediments of the Paleocene-Eocene section contain a mixed assemblage of calcareous benthic and planktonic as well as agglutinated forms including *Bathysiphon*, *Rzehakina*, *Dorothia*, *Glomospira*, *Saccammina*, *Textularia*, *Gaudryina*, *Spiroplectammina*, and *Cyclammina* (Eocene). The distribution of agglutinated foraminiferal faunas in different basins, the variation in their wall structure and test size, together with data from other groups of microfossils indicate that these assemblages have an extensive paleobathymetric distribution ranging from marginal marine to deep neritic conditions. Factors responsible for the observed distribution trend of these assemblages are suggested. Stratigraphically significant forms are described and illustrated in the present study.

EOCENE AGGLUTINATED FORAMINIFERA FROM THE CAMBAY BASIN, INDIA AND THEIR PALEOECOLOGICAL SIGNIFICANCE

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In the Cambay Basin, the Kalol Formation (Eocene) is chiefly a clastic sequence consisting of shale, sandstone, siltstone and coal. The agglutinated foraminiferal fauna has been studied from shale samples cored from wells in the upper part of this formation from Kalol and adjacent structures. The assemblage comprises specimens belonging to the genera *Haplophragmoides*, *Ammobaculites*, *Trochammina*, *Arenobullina*, *Karrerella*, *Verneulinoides*, and *Bolivinos*. The generic composition differs markedly from that of the flysch type "Rhabdammina fauna". The small to medium size, the light amber to dark gray color, the smoothly finished walls, the predominance of trochoid and multiserial forms in the assemblage, together with the rare occurrence of calcareous benthic forms in some samples indicate the deposition of these shales in a shallow inner neritic sea (0-30 m). Since the enclosed sediment consists of dark gray shale with abundant organic matter and pyrite, the environment was apparently under stagnant or slowly moving bottom water with small quantities of dissolved oxygen and high CO₂ content due to the decomposition of organic material. Such reducing conditions are ideally suited for the generation of hydrocarbons.

MODELS OF CENOZOIC FORAMINIFERAL STRATIGRAPHY, CENTRAL NORTH SEA

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As part of a long term investigation to better understand and apply agglutinated foraminifera taxonomy, paleoecology and stratigraphy in Paleogene deep marine basins, we are studying the North Sea. The central North Sea accumulated Tertiary terrigenous clastic sediments in excess of 3 km. Following widespread Danian, neritic, chalk deposition south of 60°N, the basin underwent rapid differential subsidence with a principally Paleogene depocentre in the north (Viking graben) and principally Oligocene-Miocene depocentre in the southern half of Central Graben. Mudstones predominate, with deep marine clastic fans in the early stage of subsidence; in the Ekofisk area post-Danian olistostromes occur.

The mudstones harbour a rich and diversified flysch-type agglutinated fauna with over 60 genera and 100 taxa. The stratigraphic distribution of this fauna delineates the principal depocentres, Paleogene in the north and as young as Oligocene-Miocene in the south. In a lateral sense, the fauna rapidly diversified and increases specimen abundance away from the shelf edges of the basins. Genera like *Cystamina*, *Hormosina*, *Rzehakina* and *Recurvoides* are more basinal taxa. Hydrodynamic sorting locally creates monotypic "turbidite" assemblages, reminiscent of the early invaders model. Basinal paleo-water depth was or exceeded several hundreds of meters.

The stratigraphic distribution of disappearances of 142 benthonic and some planktonic genera, including over 50 arenaceous ones in over 2000 cuttings, sidewall cores and core samples in 25 exploratory wells, was analyzed using the RASC (Ranking and Scaling), CASC (Correlation and Scaling in time) and DECORANA (Correspondence analysis) methods. For detailed regional studies two zonations are required, one emphasizing Paleogene agglutinated taxa when the North Sea was principally open to the north and a southern one with more Oligocene-Miocene calcareous taxa when the North Sea received more Atlantic influences. The generalized Cenozoic North Sea zonation uses the RASC thresholds $K_C = 8$ and $M_C = 4$, which means that zonal taxa occur in 8 or more wells and each pair of taxa in 4 or more wells. This leaves 44 out of 142 taxa, including 24 arenaceous ones.

The 8 zones are: *Subbotina pseudobulloides* zone - Danian; *Trochammina ruthven murrayi* zone - Thanetian/Selandian; *Alveolophragmium paupera* zone - Thanetian; *Subbotina patagonica* zone - Ypresian; *Cyclammina amplexans* zone - (Late) Eocene; *Rotaliatina buliminoides* zone - (Middle) Oligocene; *Globorotalia praescitula zealandica* zone - Early/Middle Miocene; *Cassidulina teretis* zone - Pliocene/Quaternary. Large, so-called interfossil

distances (using frequency of cross-over between events from well to well) between the zones correspond to the most likely position of log markers A through G as defined in the wells by Morton and Knox.

As a result we postulate regional hiatuses in Early Oligocene and Middle-Late Miocene time.

AGGLUTINATED FORAMINIFERAL ASSEMBLAGES IN THE LATE JURASSIC; ZONAL ASPECT

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There will be discussed a structure of shelf assemblages and peculiarities of their distribution according to paleoceanographic and paleoecologic conditions. A comparison of Subtethyan and Boreal associations is given.

BIOGEOGRAPHY AND BIOSTRATIGRAPHY OF SELECTED LATE
CRETACEOUS - EARLY TERTIARY AGGLUTINATED
FORAMINIFERA FROM WEST AFRICAN BASINS

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Sixty-five species of agglutinated foraminifera are illustrated and determined. The purpose of the study is to understand the relationship between the paleoenvironmental events and the agglutinated foraminifera distribution in the West African basins during Late Cretaceous to Early Tertiary times.

The studied material comes from Ivory Coast, Cameroon, Gabon and Congo-Angola basins.

The stratigraphic distribution of the studied species shows that the greatest number of the taxa are flysch-type or deep-water forms occurring in the Campanian-Maastrichtian in the Ivory Coast and Gabon basins. This is in response to the deep-water anoxic conditions prevailing in that area after the Campanian transgression.

The scarcity of species in the Middle Eocene, Late Eocene, and Oligocene is related to the regional Late Eocene regression. Agglutinated foraminifera with complex internal structures occur from the Oligocene to Middle Miocene in the Angola basin only.

SECRETED CALCITIC MATRIX IN FOSSIL AGGLUTINATED FORAMINIFERA?

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Forms of the subfamily Pfenderininae have been described with either a microgranular or an agglutinated wall structure. Representatives (Pfenderina, Kurnubia and Meyendorffina) investigated with SEM demonstrated an agglutinated structure composed of very small carbonate grains including coccoliths.

A representative form of the family Globotextulariidae, i. e., Pseudomarsionella, has a wall structure strongly reminiscent of that found in the Pfenderininae.

Two species of the genus Orbitolina were examined because their large size, general morphology, and presence of "cellules" reminiscent of alveolae in the epidermal region suggest that these forms had an algal symbiosis. By analogy with larger living foraminifera one might expect that the animals received help in the shell construction process from the algae. The walls of the two species studied, even the 3–5 μm thin cellular walls, were found to be constructed of agglutinated carbonate grains; some of these grains could be identified as coccoliths. In addition, grains up to 0,5 mm occurred in the region closest to the concave side of the shell.

Since recent agglutinated foraminifera with a primary secreted calcitic matrix occur in warm, carbonate-rich environments we studied forms from a parallel fossil environment – namely the Late Maastrichtian chalk in Denmark.

Representatives of two genera Orbignyna and Ataxophragmium were examined. The observations strongly point towards a primary calcitic cement which is, however, recrystallized and appears massive. These foraminifera therefore differ in structure from recent forms in which the secreted cement consists of units in the size range of 0,5 – 1,0 μm . The small size of the particles renders them particularly exposed to recrystallization.

Thus it is likely that primary secreted calcitic cement existed in fossil agglutinated foraminifera. It is, however, less common than anticipated; this may be due to the fact that many earlier works were based on light-microscopy alone.

EARLY MIOCENE AGGLUTINATED FORAMINIFERA FROM THE
BERMUDA ABYSSAL PLAIN; DSDP SITE 603

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Both DSDP Legs 93 and 95 attempted to drill the Jurassic basement at Site 603 in the Bermuda Abyssal Plain. There was a major hiatus recorded by each attempt at the site. This major lithological boundary between the underlying green radiolarian claystone (of Eocene age) and the overlying, yellow-brown, silt-rich claystone (of early Miocene age) is located at 603B-15-4, 46 cm. The Lower Miocene sediments contain abundant ichthyoliths but little else. A few samples have yielded well-preserved agglutinated foraminifera, including both simple tubes and planispirally-coiled members of the Lituolacea. Data on their mineralogy and form of their cementation will be presented.

THE GENUS ARENOBULIMINA, AND RELATED TAXA, IN THE LATE CRETACEOUS CHALKS OF THE UK

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This distinct group of genera and species is distributed throughout the Chalk facies of the UK. Several distinct lineages can be identified, and these can be related to major palaeoceanographic changes. As the sediment becomes more starved of detrital quartz higher in the succession the wall structure is modified and different strategies can be identified. Some groups begin to use other detrital material, including sponge spicules. The various species described can be used to identify a viable stratigraphy that can be integrated into an overall zonation based on benthic foraminifera.

A BATHYAL-TYPE AGGLUTINATED FORAMINIFERA ASSOCIATION
FROM A SANTONIAN HIPPURITID PATCHREEF-LAGOON
(AUSTRIA)

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Single small Hippurites patchreef complexes occur together with associated reef environments in the Late Cretaceous Hochmoos Beds (Santonian; *Dicarinella asymetrica* - zone) of the Gosau area (Salzkammergut, Austria). They usually contain typical shelf-sea benthic assemblages (calcareous algae, foraminifera, "micro"-gastropods; HÖFLING, 1985). The dark, silty, approximately 20 cm thick shales of the backreef lagoon of the Unterbrein patchreef complex (NE Rußbach) exhibit a peculiarity not usually found in the general palaeobathymetric situation: an abnormal fauna of arenaceous foraminifera with taxa which are known from flysch-type series of the Late Cretaceous and Palaeogene and from the bathyal of modern seas (e.g. HART, 1983).

Strongly represented are "simple", tubular morphotypes, especially *Bathysiphon* and *Reophax*. These are almost without exception agglutinated with idiomorphic pyrite crystals. Also present are *Dendrophrya*, *Ammodiscus* and *Glomospira*, some with pyrite-filled tests. They are associated with ataxophragmiids, nubeculariids, nodosariids, osangulariids and smooth-shelled ostracods which show no evidence of pyritization (post-mortem faunal mixture). The *Astrorhizidae*-*Hormosinidae* association of that type has been identified for the first time in an Alpine Late Cretaceous shallow marine depositional environment.

The high amount of pyrite indicates that a temporary anoxic situation with stagnant bottom water dominated in the lagoon. Special physico-chemical conditions (mainly linked to Eh/pH) were responsible for the subsequent biogeochemical reactions. These quite probably favoured the bacterially initiated formation of pyrite which collected in the mud of the lagoon floor.

The immigration of the bathyal-type agglutinants into this temporary, extreme biotope might possibly have been through the current transportation of small-sized specimens and/or intermediate stages of the foraminifera's life cycle (gamonts, schizonts) from the deeper regions of the sea. The high individual count suggests that the environment was particularly suitable for *Bathysiphon* and *Reophax*. According to MOORKENS (1976, 1984) modern tubular *Astrorhizidae* are also known to exist in H₂S-rich clayey mud.

The shales which overlie the whole patchreef complex contain "normal" foraminiferal faunas in typical shelf-sea assemblages.

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PALEOBATHYMETRY OF LOWER SELANDIAN (PALEOCENE)
"FLYSCH-TYPE" AGGLUTINATED FORAMINIFERA, VIKING
GRABEN, NORTH SEA

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This study deals with lower Selandian (Paleocene) "flysch-type" agglutinated foraminifera recovered from six wells in the UK and Norwegian Sectors, Viking Graben, North Sea. The wells are aligned in a transect perpendicular to the graben axis and represent a paleodepth gradient from the shelf edge to basin floor. Independent time control provided by a proprietary palynomorph zonation indicates the well samples are essentially isochronous.

This study (1) documents the changes in diversity, taxonomic composition and test morphology of the "flysch-type" assemblages with increasing paleowater depth; (2) compares and contrasts these changes with similar published data for modern deep-ocean agglutinated foraminifera; (3) presents plates of SEM photos.

FLYSCH-TYPE AGGLUTINATED FORAMINIFERA FROM THE LIZARD SPRINGS AND GUAYAGUAYARE FORMATIONS OF TRINIDAD

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Diverse flysch-type agglutinated foraminiferal assemblages (105 species belonging to 45 genera) have been identified in Maastrichtian to Early Eocene sediments of Guayaguayare and Lizard Springs Formation of Trinidad. These assemblages resemble flysch-type assemblages from Labrador, Poland, West Greenland, and the North Sea. Thirteen species documented by Cushman and Renz (1946) are synonymized with species in the Grzybowski collection of flysch-type foraminifera from Poland. The systematics of Cushman and Renz are accordingly revised and supplemented with additional species.

Factor analysis delineated three assemblages in Danian sediments of Well G-287. The first assemblage is dominated by the epibenthic tubular species *Dendrophrya excelsa* and correlates with the relative abundance of *Nuttalides truempyi* and sedimentological criteria suggesting redeposition and sorting from a deep, distal source. A second assemblage consists largely of small, finely agglutinated species, and is associated with bioturbated noncalcareous shales interpreted as being in situ. A third assemblage is comprised mainly of ataxophragmiids and litiolids and correlates with the abundance of *Stensioeina beccariiformis*. This is interpreted as indicating redeposition from a shallower, more proximal source. The distribution of species in the three factor assemblages is used to construct a paleobathymetric model of flysch-type agglutinated foraminifera in southern Trinidad, and this model is compared with the paleobathymetric distribution of flysch-type species in the Polish Carpathians.

Stratigraphic ranges are compiled for 82 common taxa in southern Trinidad. Of these, six possess isochronous datum levels in other regions of the North Atlantic or Tethys.

RESPONSE OF RECENT ABYSSAL AGGLUTINATED FORAMINIFERA TO PHYSICAL DISTURBANCE

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Biological theory predicts that the diversity of a benthic community is a function of the rates of displacement and the frequency of physical disturbance resulting in population reduction. Both observational and experimental techniques were employed to assess how physical environmental disturbance affects abyssal agglutinated foraminifera.

In the Western North Atlantic, large areas of the continental rise are periodically affected by strong bottom currents creating "benthic storms" which can erode and redeposit the surface layer of the sediment. At the High Energy Benthic Boundary Layer Experiment site, samples were collected to assess the effect of benthic storms on the faunal community. The diversity of the agglutinated foraminiferal assemblage was found to be reduced when compared to an assemblage from a more tranquil area of continental rise. The assemblage from the high-energy environment consisted mainly of primitive opportunists, and contained a greater proportion of species which utilize coarse material in the construction of the test wall.

In an experiment in the Panama Basin in which abyssal mud was artificially defaunated and benthic organisms allowed to recolonize, the agglutinated foraminiferal fauna had not completely recovered in terms of numbers or diversity after nine months. The most opportunistic forms in both the HEBBLE and Panama Basin recolonization experiments were species of *Reophax*. Surprisingly, epifaunal tubular forms such as *Rhizammina* were not found to be effective colonizers.

These results suggest a predictable response of agglutinated foraminiferal community structure to physical disturbance by strong bottom currents, and may serve to increase our understanding of the paleoecology of flysch-type agglutinated assemblages from Alpine regions.

FLYSCH-TYPE AGGLUTINATED FORAMINIFERA FROM ODP LEG 105, BAFFIN BAY AND LABRADOR SEA

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LEG 105 SHIPBOARD SCIENTIFIC PARTY

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A generalized model for the occurrence of flysch-type agglutinated foraminifera in Early Tertiary sediments relates them to hydrographic and sedimentological properties associated with restricted bottom water circulation and/or the rapid deposition of fine-grained clastic sediments, which lead to reducing substrates and high organic content (Gradstein and Berggren, 1981). Recent drilling at high-latitude sites on ODP Leg 105 has recovered diverse assemblages of flysch-type agglutinated foraminifera and provides a test of this model.

Site 645 in Baffin Bay contains agglutinated foraminiferal assemblages in dark clastic sediments of Miocene age. At this Site, preliminary shipboard evidence shows a relationship between the abundance of agglutinated foraminifera and changes in the amount and composition of organic matter preserved in the sediment. Agglutinated foraminiferal abundance may be interpreted as responding to changes in paleoproductivity in Baffin Bay.

Site 647 provides the first continuously-cored record of Eocene-Oligocene pelagic sediments in the southern Labrador Sea. At Site 647, assemblages of predominantly agglutinated foraminifera are replaced by a calcareous benthic assemblage in Late Eocene time. This faunal turnover is essentially complete by the Eocene/Oligocene boundary, and precedes the prominent regional seismic reflector R4. The stratigraphy of agglutinated foraminifera in Site 647 will be compared with existing zonations, and the nature of the Late Eocene faunal turnover will be presented and discussed in relation to paleoceanographic changes in Late Eocene to Early Oligocene time.

A COMPARISON OF LATE TRIASSIC AGGLUTINATED FORAMINIFERA OF THE WESTERN AND EASTERN END OF THE TETHYS

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In order to compare the Late Triassic agglutinated foraminifera from various parts of the Tethys, typical assemblages from the most western regions, e.g., from Hallstatt Limestones of the Northern Calcareous Alps as well as from Late Triassic Reef Limestones of the Kuta-Formation in Papua New Guinea from the most eastern region were taken as examples for the whole realm. The remarkable result is that also within this benthonic group the majority of taxa correspond with each other within the realm. The represented agglutinated foraminifera are distributed throughout the entire Late Triassic. In addition to the Triassic taxa the assemblage also contains some representatives described for the first time from the Paleozoic and Cretaceous.

PATTERNS OF AGGLUTINATION OF ARENACEOUS FORAMINIFERA

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The hypothesis is developed that agglutinated foraminifera follow genetically fixed patterns of agglutination where the levels of constancy in relation to a certain pattern (so-called factors) are specific for distinct species and also attain supraspecific taxonomic value.

Several distinct "factors of constancy" can be discriminated (although more may exist):

The constancy of a species with regard to certain principles of

- wall construction or to a certain
- chemical composition of the cement,

and the constancy of a species in selecting agglutinated material

- in relation to chemical composition,
- in relation to morphology,
- in relation to grain size.

Each of these factors may occur within a species on different levels from nil to extreme in uncorrelated combinations. The levels of one factor can be described as the ability of a species to deviate from a preferred (or fixed) mode of agglutination.

The combination of defined levels of each factor may have descriptive value for the interpretation of biocoenoses beyond the characterization of distinct species. The level of constancy frequently is correlated to the stability of the biotope. Thus, species with high levels of constancy in one or several factors will increase in frequency in stable biotopes like the deep-sea. Species with low levels of constancy to any factor will abound in biotopes with low stability such as nearshore environments. Homoeomorph species from different biotopes with distinct factor level will have to be treated as distinct species or subspecies unless co-occurrence in the same biotope can be verified.

Examples for this hypothesis are given from various sources and consequences for systematics and taxonomy are discussed.

DISTRIBUTION OF AGGLUTINATED FORAMINIFERA IN DEPTH
PROFILES OF SOUTHERN OCEAN (KERGUELEN PLATEAU AREA),

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Recent to subrecent benthonic agglutinated foraminifera from four areas of the Southern Ocean around the Kerguelen Plateau are investigated with regard to depth distribution and agglutination patterns. Strong differences exist between the agglutinated faunas from diatomaceous sediments west of the plateau and glacial marine sediments from the slope of the Antarctic Continent. The fauna of two areas east and northeast of the plateau have an intermediate position. Major ecological influences are seen in the effect of sedimentological factors, in the saturation level of calcium carbonate, and in the nutrient condition of the biotope. Since these factors are functions of the geographic position and are related to water masses, the main differences between deep-sea faunas are primarily induced by the overall situation of an oceanic area rather than by depth or oceanographic factors like temperature or salinity.

CAMPANIAN TO PALEOCENE AGGLUTINATED FORAMINIFERA
FROM FRESHWATER-INFLUENCED MARGINAL MARINE (DELTAIC)
SEDIMENTS OF SOUTHERN EGYPT.

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The following problems will be discussed:

- Description of different low diversity associations of agglutinated foraminifera of near-shore deltaic environments from the southern basin margin of Upper-Nile Basin (Western Desert, S Egypt).
- First presentation of Ammoastuta-assemblages from N Africa.
- Comparison of the Ammoastuta-assemblages with those of recent Mississippi Delta ("Ammoastutetum ineptae" of HILTERMANN & TÜXEN, 1976).
- Deduction of the (mixohaline) salinity conditions at the time of deposition.
- Demonstration of the environmental restriction of the mixohaline foraminifera.
- Discussion on the effects of syndimentary or early diagenetic decalcification on the possibilities of interpretation of oryktocoenosis (= relict assemblages).

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LATE OLIGOCENE TO EARLY MIOCENE AGGLUTINATED FORAMINIFERA OF THE MOLASSE BASIN IN UPPER AUSTRIA

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The stratigraphical and regional distribution of agglutinated foraminiferal assemblages was studied in the Molasse Basin – the Alpine foredeep – in Upper Austria. Throughout the Oligocene–Early Miocene a change in the faunal composition is observed which is connected with the basin development and facies distribution. In the Oligocene, the Molasse Basin underwent a time of strong deepening with slumpings and turbiditic sedimentation; a gradual shallowing occurred in the Early Miocene. The material originated predominantly from deep drill sites. Generally the number of species and individuals decreases gradually from the Oligocene to the Miocene. The relative abundance of the different agglutinated foraminifera, however, shows individual tendencies – e.g., there is an opposite trend in the abundance of *Bathysiphon taurinensis* (decreases from the Oligocene to the Miocene), while *B. filiformis* increases.

The Lower Puchkirchen Formation is characterized by a great amount of forms such as *Bathysiphon taurinensis*, *Cyclammina tenuissima*, *C. acutidorsata*, *Haplophragmoides* div. sp., *Rhabdammina* div. sp., and *Glomospira charoides*.

In the Upper Puchkirchen Formation *Bathysiphon filiformis*, *B. taurinensis*, *Cyclammina tenuissima*, *Haplophragmoides* div. sp., *Cribrostomoides subglobosus*, and *Karrerella* sp. are dominant. The main forms in the Hall Formation are *Bathysiphon filiformis*, *Ammodiscus incertus*, *Cribrostomoides subglobosus*, and *Valvulina flexilis*.

AVAILABILITY OF DISSOLVED SILICA AND IRON, AND
APPROPRIATE PHYSICOCHEMICAL CONDITIONS FOR TEST-
CEMENT SECRETION AND PRESERVATION, AS PROBABLE
ECOLOGICAL PARAMETERS FOR THE OCCURRENCE OF THE
"PRIMITIVE" AND SOME OTHER AGGLUTINATED FORAMINIFERA

MOORKENS, Th. L.

From a review of numerous published data on present-day occurrences of agglutinants in foraminiferal assemblages, it appears that the "primitive" (i.e. the non-septate Ammodiscacea, Astrorhizida) and some other agglutinants, belonging to the (multilocular) Lituolacea, preferably live below watermasses (or as infauna in interstitial waters e.g. of deep-sea red clays) which are considerably richer in dissolved silica and iron-hydroxides than average ocean surface waters.

This observation is confirmed by the study of "agglutinated foraminifera-facies" in the fossil record. My own observations are mainly based on Mesozoic-Cenozoic microfaunas from NW Europe (North Sea and adjacent areas), but they are also corroborated by numerous literature data on other areas. Indeed, foraminiferal assemblages consisting predominantly of above mentioned agglutinated forms are known to often occur in red or brown stained deposits containing authigenic minerals of precipitated iron-hydroxides and -oxides (or their diagenetic derivatives) such as limonite, hematite, goethite, pyrite, marcasite, and possibly glauconite, or in organic-rich deposits in which relatively high concentrations of adsorbed metals can occur. Generally the sediments of "agglutinated foram-facies" are siliceous (often with preservation of silica-walled microfossils) and they are often poor in carbonates, but some are connected to deep-water red limestones (Scaglia rossa).

Since the above mentioned agglutinated foraminiferal groups are mainly those which are known to store silica and/or iron-oxides in their test-cement, it is thought that this strong coincidence of these foraminifera and of iron-rich/siliceous deposits is not fortuitous but that there may be a direct causal link: In order to build their test (1) the availability of these two materials in the dissolved state and (2) appropriate physicochemical conditions for them to be secreted/precipitated as test-cement, may be important ecological and preservational parameters for the environmental distribution of the agglutinants.

The physicochemical conditions governing iron and silica dissolution/precipitation are reviewed. In "normal" sea water (= average surface, well circulated, ocean waters) the two materials are very poorly represented as trace elements.

Dissolved silica is always undersaturated in seawater, (as most of it is taken up by diatoms, radiolaria, silicoflagellates and siliceous sponges); however it is known to be somewhat better (but generally still undersaturated) repre-

sented in:

- (a) the deep ocean waters where it is more or less continuously replenished by volcanic/hydrothermal, and where it occurs also in the interstitial waters of the "red clays",
- (b) bottom and interstitial waters of diatom-rich sediments of the shallower arctic and antarctic cold waters,
- (c) "upwelling" waters, as derived from the deep sea, and the organic rich deposits they overlie,
- (d) "outwelling" fresh- to brackish river-waters, mixing with sea water (flocculation/colloids) in lagoonal, estuarine and prodeltic environments.

Indeed silica dissolution and precipitation is strongly dependent on the pH conditions and it is practically the reverse of carbonate dissolution/precipitation.

Dissolved iron also is to be considered as a trace element in "normal" sea water, as in these higher pH-Eh conditions, its solubility product is very low. However, in lower pH conditions more dissolved iron can be present and it can be transported as ions, or also as chelates, in organic molecules in the following environments:

- (a) the deep-sea "red/brown clays", where iron-oxides are known to precipitate near the sediment-water interface. Deeper down in the "pH minimum zone" of the surficial sediments it may be remobilized, and can move upwards with the interstitial waters to the sediment-water interface where it is again precipitated.
- (b) some other cold water masses (arctic/antarctic) or their derivatives such as the "upwelling waters", acidic/nutrient-rich waters which often can transport higher iron concentrations, owing to their lower pH (ionic iron) and organic matter complexes (adsorbed iron).
- (c) river waters (having a lower pH) often carry considerably higher ionic iron concentrations (or adsorbed to humic components).

From the above it appears that precisely these water which generally contain somewhat higher silica and iron concentrations often coincide with environments preferred by the above mentioned agglutinated foraminifera. They comprise both oxidative low-pH environments (e.g. deep sea-red clay environment), and disaerobic ones (low-oxygen, organic-rich environments) occurring under semistagnant water masses.

As a working hypothesis it is postulated that the availability of dissolved Fe and Si (and the physicochemical plexus linked to their dissolution or precipitation) may be directly linked to the occurrence of those agglutinated foraminifera.

In order to check this hypothesis it is recommended that in future ecological and paleoecological studies attention be paid to the concentration of these two materials.

Moreover it is thought that similar physicochemical conditions occurring in the subsurface (mainly the pH and Eh conditions are meant) may be responsible for the post-mortem changes (early diagenesis) within foraminiferal assemblages, especially in changing the agglut. versus calcareous benthic (A/CB) foram. ratio:

- (a) Dissolution of calcium carbonate in low-pH, CO₂-rich waters decreases the amount of planktonics and calcareous benthics versus agglutinants (examples: deep-sea "red clays" occurring below CCD, and stagnant organic-rich environments in the shallower realms). It may lead to the typical "agglutinated foraminifera facies".
- (b) Disaggregation of the chitinous organic membrane and/or of silica and iron-oxide cements (pH-linked) may decrease the number of agglutinants versus calcareous foraminifera (examples: Recent/Quaternary agglutinants in surficial deposits of the deeper parts of Baltic sea; recent Globulinspira faunal patches in Gulf of Mexico which are not preserved in the subsurface). It may lead to foraminiferal assemblages consisting predominantly or entirely of calcareous planktonic and benthic foraminifera (Rotallina) and those agglutinated foraminifera which include calcareous cements.

In this paper an extensive bibliography is given for all above discussed case-histories and their geochemical characteristics.

LATE CRETACEOUS DEEP-WATER AGGLUTINATED FORAMINIFERA
FROM THE NORTHERN APENNINES

MORLOTTI, E.

Inst. Geol. Univ. Parma, Italy

Deep-water agglutinated foraminifera from the Solignano and Monte Cassio Flysch (northern Appennines) were studied. Calcareous nannofossil data indicate that the Solignano Flysch is entirely Early Maastrichtian in age, whereas the base of Monte Cassio Flysch spans the Late Campanian–Early Maastrichtian interval; both formations are widely considered to have been deposited near or below the carbonate compensation depth.

Forty-seven layers in the Solignano Flysch and twenty layers in the Monte Cassio Flysch, interpreted as possible hemipelagic deposits, were sampled; all the agglutinated foraminifera in 10g of dried residue were sorted and classified. The micropaleontological analysis led to the identification of sixty-four and thirty-seven species respectively, belonging to the families Astrorhizidae, Ammodiscidae, Hormosinidae, Lituolidae, and Textulariidae.

The first two families are by far the most represented: *Batysiphon brosgel*, *Rhabdammina cylindrica*, *R. latissima*, *R. robusta*, and *Rhabdammina indivisa* are always present and abundant, whereas *Batysiphon vltta*, *Dendrophyra excelsa*, *Trochamminoides conglobatus*, *T. coronatus*, and *Kalamopsis grzybowskii* are fairly common. A single massive occurrence (12% and 49% of the total assemblage) of *Rhabdammina discreta* was observed in both sequences.

A striking inverse correlation was found between the total faunistic abundance and the calcium carbonate content of the samples; the highest abundances (and highest specific diversities) closely match the lowest carbonate values (from 0% to 6%). This suggests that undersaturation not only allowed, but also favoured the life and numerical growth of agglutinated deep-water foraminifera assemblages.

This observation is by no means an assumption, but rather only a tentative working hypothesis to be tested through further analyses of coeval deep-water sequences.

AGGLUTINATED FORAMINIFERA FROM THE UPPER PART OF
THE "DOGGER-SANDSTEIN" (AALENIAN/BAJOCIAN) OF THE
FRANCONIAN ALB (NORTHERN BAVARIA, GERMANY)

MUNK, Ch., Inst. Paläont., Univ. Erlangen, GFR.

The sediments of the "Doggersandstein" of the Franconian Alb form a sequence of mostly fine-grained, yellowish sandstones with intercalations of iron-oolitic seams, calcareous sandstones and clays. The main source area of the sediments was the Bohemian Massif. The sedimentary area was subdivided into small local basins and swells. The "Doggersandstein" sequences represent a marginal shelf environment. The fossil content is generally poor.

A more clayey sedimentation took place in some regions in the upper parts of the "Doggersandstein" (Hauptrotelhorizont, boundary Aalenian/Bajocian). Only this upper part contains foraminifera. The benthic foraminiferal assemblages consist predominantly (with only rare calcareous elements) or exclusively of agglutinated forms. The generic and species diversity of the agglutinated assemblages is very low (about 7 genera with 8 species), although abundance of individuals may be very high in some sections. The assemblages are dominated by genera with simple wall structures (Tolypammina, Ammodiscus, Ammoverrella, Reophax, Trochammina, Haplophragmoides, Ammobaculites).

FORAMINIFERAL DISTRIBUTION IN MIDDLE JURASSIC TO
EARLY CRETACEOUS DEPOSITS IN SPITSBERGEN

NAGY, J., Inst. Geol., Univ. Oslo, Sweden.

BÄCKSTRÖM, S., Saga Petroleum, Hørvik, Norway.

LØFALDLI, M., Arabian Gulf Explor. Comp., Benghazi, Libya.

Three sections covering the Janusfjellet Formation (Bathonian to Hauterivi-
an) in central Spitsbergen have been analysed for foraminifera. The forma-
tion consists generally of dark to black shales. The faunal sequence is subdiv-
ided into 11 assemblages representing a preliminary biostratigraphical
framework. The assemblages consist mostly of agglutinated species; the
most common genera are *Haplophragmoides*, *Trochammina*, *Glomospira*, and
Bathysphion.

The black shale facies developed in the lower part of the formation has
TOC values commonly between 3 and 8% and contains the low diversity
Haplophragmoides-*Trochammina* assemblage. The upper part of the forma-
tion has a low to intermediate TOC content (mostly > 2.5%) associated with
increased faunal diversities and contains locally significant amounts of cal-
careous foraminifera. Fauna and lithology suggest normal marine to deep
shelf and delta-influenced shelf conditions for these deposits.

THE FOSSIL FORAMINIFERA OF THE TERTIARY BASIN OF
VIENNA. REVISION OF THE MONOGRAPH BY ALCIDE
D'ORBIGNY (1846)

PAPP, A., Int. Paläont. Univ. Wien, Austria (post mortem)
SCHMID, M.E., Geol. Survey of Austria, Vienna.

Alcide d'Orbigny's work on the fossil foraminifera of the Vienna Basin Miocene was one of the most important early publications in micropaleontology. The original material was collected by J. v. Hauer in the outcrops around Vienna and sent to d'Orbigny for determination and description. He mentioned that this was the richest fauna of foraminifera ever found in any country.

The foraminifera are described from the marine Middle Miocene of Vienna Basin (Badenian stage), mainly from the near-shore facies at Nußdorf and Grinzing as well as from the deeper water clay near Baden. Additional material comes from the endemic development of the Sarmatian, but also from Bultur (Romania) and Tarnopol (Ukraine).

According to the facies development, only shallow water forms of agglutinated foraminifera are described:

Ammobaculites agglutinans
Martiniella communis
Gaudryina mayeriana
Spiroplectinella carinata
Bigenerina agglutinans
Textularia div. sp.

The revision of the 228 species provides new descriptions in parallel columns in both German and English, and is accompanied by more than one hundred plates of SEM micrographs and reprints of original figures.

MONDAY, JUNE 23		TUESDAY, JUNE 24	
"Agglutinated foraminifera - biology, morphology, taxonomy"		"Recent and fossil ecology"	
09.00	Opening Chairman: F.M. GRADSTEIN	08.30-09.00	Chairman: H.J. HANSEN SCHRÖDER, C.
09.30-09.50	HEMLEBEN, Ch. (BENDER & HEMLEBEN)	09.00-09.20	KAMINSKI, M.A. & GRASSLE, J.F.
09.50-10.10	BENDER, H.	09.20-09.40	ALVE, E. & NAGY, J.
10.10-10.30	LINDENBERG, H.G.	09.40-10.00	SANCHEZ ARIZA, M.
	Break		Break
	Chairman: J.E. WHITTAKER		Chairman: Th.L. MOORKENS
11.00-11.20	HANSEN, H.J.	10.30-10.50	KAMINSKI, M.A. & al.
11.20-11.40	HART, M.B.	10.50-11.10	JONES, G.
11.40-12.00	MOORKENS, Th. L.	11.10-11.30	HAMAOU, M. & al.
12.00-12.20	WEIDICH, K.F.	11.30-11.50	DECKER, K. & RÖGL, F.
		11.50-12.10	GRIGELIS, A.
		12.10-12.30	KRISTAN-TOLLMANN, E.
14.00-18.00	Microscope Session at the Institute of Paleontology Universitätsstraße 7/II 1010 WIEN I	14.00-18.00	Microscope Session at the Institute of Paleontology Universitätsstraße 7/II 1010 WIEN I
		19.00	Reception in the main hall of the Museum of Natural History

WEDNESDAY, JUNE 25		THURSDAY, JUNE 26	
"Application in regional geology and stratigraphy"		EXCURSION A	
08.30-09.00	Chairman: H.G. LINDENBERG GRADSTEIN, F.M. et al.	07.45	Vienna Woods and Vienna Basin. Departure from Maria Theresien Platz
09.00-09.20	GAMERO, M.L.		
09.20-09.40	CATI, F. & BORSETTI, A.M.		
09.40-10.00	MORLOTTI, E.		
Break		FRIDAY, JUNE 27	
Chairman: W.A. BERGGREN		EXCURSION B	
10.30-10.50	LUGER, P.	07.45	Molasse Basin and Margin of the Eastern Alps. Departure from the Maria-Theresien Platz
10.50-11.10	GOVINDAN, A. & BHANDARI, A.		
11.10-11.30	GAWOR-BIEDOWA, E.		
11.30-11.50	SZTEJN, J.		
11.50-12.10	NAGY, J. & al.		
12.10-12.30	MUNK, Ch.		
		SATURDAY, JUNE 27	
14.00-16.00	Discussion of the POSTER SESSION. Museum of Natural History	07.45	Departure in Salzburg from Hotel Hofwirt
16.30-17.30	Closure of the 2nd IWAF		

THE SUPERFAMILY LITUOLACEA IN THE MIDDLE AND LATE
CRETACEOUS OF SE POLAND

PERYT, D.

Zakład Paleobiol., Pol. Akad. Nauk., Warszawa, Poland.

This study presents the main results of an investigation on the species of the Superfamily Lituolacea from the Middle and Late Cretaceous epicontinental sea of SE Poland. Twenty-nine species of the families Textulariidae, Trochamminidae, Ataxophragmiidae and Pavonitidae are identified.

Species of the family Ataxophragmiidae turned out to be the most important element of the agglutinated assemblages. The stratigraphic distribution of these species is controlled by associated planktonic foraminifera index-forms. The principal species are considered in terms of their taxonomy, evolution, and biostratigraphic value.

SOME INTERESTING TYPES OF AGGLUTINATED FORAMINIFERA IN THE COLLECTION OF THE NATURAL HISTORY MUSEUM IN VIENNA

RÖGL, F., Naturhist. Museum Wien, Austria

The foraminiferal collection of the Natural History Museum in Vienna goes back over 200 years with first acquisitions of nummulites and ammonites. The first important type collection was that of Fichtel & Moll (1798). In later years comparative types of descriptions were donated by d'Orbigny & Hauer (1846), Reuss (1845), Stache (1866), Hantken (1868) and Neugeboren (1861). The main part of the well-preserved material was deposited by Karrer, who worked here as a free scientist. The second important part in the collection was the material described by Reuss. His collection was sold to the museum by his daughter in 1891. It contains 4003 nos. of Tertiary and 1839 nos. of Cretaceous and older foraminifera, as well as his ostracods. Altogether, 3212 types may be found in this collection. Unfortunately the catalogue for this collection was lost, and only vials with numbers of single species and assemblages in an unsystematic order are at hand today.

Additional important collections include those from the Austrian Novara Expedition (1857-1859), e.g. New Zealand faunas, and from the Austrian-Hungarian Northpole Expedition described by Brady (1881). Brady also donated the largest collection of comparative specimens of the Challenger Expedition outside the British Museum.

From this material a few species are re-examined and revised:

- Operculina cretacea* REUSS, 1845
- Cornuspira hoernesii* KARRER, 1861
- Trochammina proteus* KARRER, 1865
- Haplophragmium crassum* REUSS, 1867
- Rhabdogonium minutum* REUSS, 1867
- Verneullina cretacea* KARRER, 1870
- Gaudryina crassa* KARRER, 1870
- Plecanium roschildi* KARRER, 1870
- Stylolina lapugyensis* KARRER, 1877

AGGLUTINATED FORAMINIFERAL ASSEMBLAGES IN THE MIDDLE MIOCENE OF THE VIENNA BASIN

RUPP, Ch., Inst. f. Paläont., Univ. Vienna, Austria
 FUCHS, R.,
 SCHREIBER, O., ÖMV-AG, Vienna, Austria.

In a study proposed by the Austrian Mineral Oil Company (ÖMV-AG) concerning the paleoecology of benthic foraminifera of the middle Badenian (Middle Miocene) of the Vienna Basin (Matzen Oilfield) and adjacent areas (Walbersdorf, Burgenland), the agglutinated foraminifera proved to be of ecological significance.

An R-mode clustering analyses (species cluster; reallocation clustering analyses based on an unweighted Pair Grouping Method using averages - SNEATH & SOKAL, 1973) of the total benthic fauna (50 species groups, based on generic level and/or observed co-occurrences) revealed several clusters composed mainly or exclusively of agglutinated foraminifera.

One cluster is built up of the species groups: *Pelosina* + filiform agglutinated foraminifera and *Textularia earlandi* + *Reophax nanus*. Both *T. earlandi* and *R. nanus* are found today in greater numbers in or near areas with higher freshwater influx (lagoons, estuaries, or deltas). Thus CULVER & BUZAS (1983) designated *T. earlandi* as indicative for the Mississippi Mouth Facies. In Matzen area these foraminifera were abundant in a similar facies (Prodelta, indicated by the total fauna and sporadically high numbers of allochthonous thecamoebians).

Another cluster of agglutinated foraminifera consists of three groups of species: *Ammoscalaria* (*A. tenulmargo*) + *Ammomarginulina*, *Trochammina* + ?*Trifarina* and *eggerella* (mainly *E. scabra*). Most of these foraminifera are euryhaline and often found in areas with high numbers in front of river-mouth systems (Mississippi delta, Rhone delta) and probably prefer nutrient-rich biotopes. These agglutinated foraminifera also fit to the picture of a delta-influenced shelf area such as that present in the Matzen oilfield.

The genera *Saccammina*, *Reophax* (excl. *R. nanus*), *Haplophragmoides* + *Cribrostomoides* + *Alveolophragmium* + *Discammina* and *Heterolepa* build up the next cluster. Most are stenohaline; the agglutinated foraminifera such as *Reophax*, *Cribrostomoides* or *Discammina* are considered to prefer lower temperatures. This association was mainly found in sediments of the outer neritic and to a lesser degree in middle neritic sediments of the Matzen area. Genera such as *Textularia* (excl. *T. earlandi*) and *Bilgenerina* + *Gaudryina* + *Karrerella* + *Cylichnocyclus* were grouped into one cluster dominated by typical calcareous shelf-foraminifera (*Quinqueloculina*, *Reussella*, *Elphidium*, *Hanzawala*, *Nonion* and others).

The genera *Spiroplectammina* + *Semivulvulina* + *Martinotiella* were assigned to a cluster of calcareous foraminifera mainly found in bathyal depths (*Cibicides*, *Angulogerina*, *Uvigerina*, *Pullenia*, *Sphaeroidina* and others).

The agglutinated *Miliammina fusca* was linked with the genus *Haynesina* to one cluster. Both are found today as euryhaline elements of Inner neritic and are often found together in hyposaline environments. With the exception of *Ammonia* and *Aubignyna* this cluster is rather isolated from the other species groups.

STUDY OF THE RECENT AGGLUTINATED FORAMINIFERA FROM
THE MOTRIL-NERJA LITTORAL REGION, SPAIN

SANCHEZ ARIZA, M.d.C.

Dept. Zool. Colegio Univ. Jaén, Spain.

Eight recent agglutinated foraminifera species from the Motril-Nerja littoral region of Spain are studied. They belong to the genus *Iridia*?, *Reophax*, *Spiroplectammina*, *Textularia*, *Bigenerina*, *Trochammina*, and *Eggerella*?. Their characteristics, distribution, and the mathematical distance $d_{i,k}$ between each pair of species in relation with the total recent benthic foraminifera of the zone and with depth are studied. $d_{i,k}$ is determined from the relative frequencies in percent. The constancy and abundance indices are also evaluated.

ENVIRONMENTAL ASSOCIATIONS OF BAFFIN ISLAND FJORD AGGLUTINATED FORAMINIFERA ASSEMBLAGES

SCHAFFER, Ch.T. & COLE, F.E.

Atlantic Geoscience Centre, Dartmouth, Nova Scotia, Canada.

The total population of foraminifera (agglutinated plus calcareous) observed in the modern sediments of 10 arctic fjords (67–800 m water depth) located along the east coast of Baffin Island averages 54 species of which about 85% are agglutinated forms. *Textularia earlandi* is the dominant species in five of the fjords located north of latitude 68°N. *Spiroplectammina bifurcata* and *Trochammina nana* dominate in four fjords south of latitude 70°N. The percentage of agglutinated specimens is poorly correlated with % silt ($r = 0.31$, $P = 0.05$) and water depth ($r = 0.33$, $P = 0.05$). *Reophax arctica* and *S. bifurcata* percentages show an inverse relationship to bottom water temperature. The percentage distribution of *Trochammina nana* is comparable generally to that of *Textularia earlandi* and tends to be highest in the deep (400–800 m) basins that are characteristic of these fjords.

Common factor analysis (R-mode) was run on a matrix of nine environmental variables and 36 agglutinated species that have mean abundances of $>0.1\%$ in the 63 sample suite. Several distinctive fjord basin settings and one fjord sill environment were identified: the indigenous assemblages of the nine most abundant species appear to be controlled by a combination of one or more substrate texture and watermass characteristics. The distribution of *Recurvoides turbinatus* is positively correlated to the total agglutinated specimen percentage ($r = 0.37$, $P = 0.05$) and could reflect a species interrelationship. This association is further supported by the relatively high correlation ($r = 0.49$, $P = 0.05$) of *R. turbinatus* (total percentages) and the concentration of living agglutinated specimens per cc of wet sediment.

DEEP-WATER AGGLUTINATED FORAMINIFERA IN THE
NORTHWEST ATLANTIC

SCHRÖDER, C.

Dept. Geol. Dalhousie Univ., Halifax, Nova Scotia, Canada.

Recent deep-water benthic foraminifera were analysed from 25 box-cores taken on the Continental Rise off Nova Scotia, the Southern Bermuda Rise, and Nares Abyssal Plain. The samples cover a depth range from 2225 m to 5779 m. Approximately 265 species including 104 agglutinated taxa (related to 10 families) were identified. The agglutinated taxonomy stresses morphotype variability as a function of sediment-type. Classical deep-water collections by H.B. Brady, E. Heron-Allen, A. Earland, and J.A. Cushman served as taxonomic model and were critically reexamined. The percentage of agglutinated foraminifera is increasing progressively with depth. Contour currents strongly influence the nature of substrate which in turn influences the composition of the foraminiferal community. The region below the axis of the Western Boundary Undercurrent (WBUC, 2700-4000 m) is subject to winnowing processes which results in an increased foraminiferal number and a high species diversity. Fragile agglutinated species such as *Rhizammina algaeformis* seem to prefer zones without major current activity and consequently dominate on the upper Nova Scotia Rise (2200-2500 m) above the zone of WBUC and in abyssal regions. The middle rise agglutinated assemblage, living on a coarse grained substrate, is characterized by coarse grained taxa such as *Hyperammina* sp.1, *Rhabdammina* sp. and *Astrorhiza crassatina* and complemented by species with robust, spherical tests such as *Cribrostomoides subglobosus*, *Recurvoides scitulus*, and *Trochammina* cf. *globigeriniformis*. Agglutinated species such as *Reophax scorpiurus*, *Reophax bilocularis*, *Psammosphaera fusca*, and *Lagenammina tubulata* are non-selective in their choice of wall material. These species reflect the sediment substrate, resulting in a large intraspecific variability. The agglutinated assemblage on the Nares Abyssal Plain is characterized by a fragile network of delicate species of the family Komokiacea. Other common abyssal species are *Adercotryma glomerata*, *Nodellum membranaceum*, *Ammomarginulina foliacea*, and *Cystammina galeata*. Results suggest that agglutinated foraminifera are more likely controlled by the substrate than by watermasses. Depth ranges, particularly of non-selective taxa, are extended at the lower limit by comparing with published data.

The vertical change in sediment in the upper 30 cm is compared with changes in the agglutinated fauna. The effects of selective preservation, chemical solubility of the ferruginous compound in the cement of various species and shifts through transport and reworking processes are reflected in the vertical distribution of the agglutinated assemblages. Based on test construction and depth distribution pattern agglutinated species are ranked into three major classes reflecting fossilization potential.

LATE EARLY CRETACEOUS AGGLUTINATED FORAMINIFERA
OF THE POLISH LOWLANDS

SZTEJN, J.

Inst. Geol., Warszawa, Poland

This contribution provides information on the paleogeographical implication of selected agglutinated species of foraminifera from the Polish Lowlands. Plates are included.

ON THE VARIABILITY OF SOME RECENT AND FOSSIL "CLAVULINA" SPECIES

WEIDICH, K.F.

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A Recent foraminiferal fauna yielded a rich assemblage of "Clavullnas". Most forms can be assigned to the species *diformis* d'Orbigny, *mexicana* Cushman, and *tricarinata* d'Orbigny. A large number of intermediate forms between these three "species" could be found.

In fossil microfaunas, "Clavulina" species are abundant in both samples and literature (e.g., Upper Cretaceous, Lower Tertiary). These all need revision because, considering a certain variability, several "species" fall into synonymy.

Although we do not know the causes for such high variability, this phenomenon again leads to a discussion of the species concept in foraminiferology.

We should remember the conservative view on foraminifera as did our colleagues at the end of the 19th century.

2nd INTERNATIONAL WORKSHOP
ON AGGLUTINATED FORAMINIFERA

Part 2

EXCURSION GUIDE
to the 2nd IWAF Excursion in Austria 1986

by

F. RÖGL, R. FUCHS, W. SCHNABEL,
P. SEIFERT & L. WAGNER

SHORT INTRODUCTION TO THE GEOLOGY OF AUSTRIA

F. Röggl, Naturhist. Museum Vienna.

LANDSCAPE

The Austrian landscape is of great variety but dominated by the long W-E stretching mountain range of the Eastern Alps. The western and central parts show glaciation locally and have peaks exceeding 3000m. The highest mountain, the Großglockner with 3797m, lies in the Hohe Tauern. The height of the mountains decreases to the east, and the Alps turn to a NE direction, continuing in the Carpathians. The lowlands of the Alpine foredeep extend to the north and surround the hilly triangle of the Bohemian Massif.

Intramountainous basins, particularly the Vienna and the Styrian Basin, are sunken in the Alpine belt. The main river system of the Danube drains Central Europe into the Black Sea. Only a small western part of Austria is connected to the Atlantic by the Rhine.

TECTONIC UNITS (Figure 1-2)

The northern part of Austria belongs to the Bohemian Massif, a deeply eroded relic of the Variscan mountain system. Metamorphic rocks and granites of Precambrian and Paleozoic age prevail. Since the Permian, erosion has taken place. This unit continues to the south on the subsurface as the basement of the Molasse Zone. It developed into the Alpine foredeep since the Late Eocene and consists of clastic marine and fluvial sediments up to 4000 m in thickness. Discontinuous Mesozoic (Jurassic-Cretaceous) and very rare Late Paleozoic sediments are preserved as erosional relics on top of the crystalline basement. The southern parts of the Molasse are strongly disturbed by the overthrust of the Alps in the Neogene.

The Helvetic Zone: borders in continuation of the Western Alps as a narrow strip the northern margin of the Eastern Alps. Further to the east it is overthrust, appearing only in windows and in the form of the Gresten Klippen belt. The facies and stratigraphical range change from west to east.

The Flysch Zone: to the south comprises a complex of sandstones, marls and clays with turbiditic sedimentation, partly below the CCD. It is overthrust on the Helvetic Zone. To the west it continues in the Western Alps and to the east in the Carpathians as far as the Ukraine. It is termed the Rheno-Danubian Flysch. This zone is considered as the younger (E. Cretaceous to Eocene), sheared-off sedimentary cover of the Penninic Zone.

The Penninic System: of the Western Alps continues below higher tectonical units of the Eastern Alps, appearing in large windows along the central axis of the Alps. The most prominent among these is the so-called Tauern Window. Generations of "nappists" and "autochthonists" fought over this structure. The Penninic Zone comprises a crystalline (Precambrian? and E. Paleozoic) basement, the "Central Gneiss", and a cover of Late Paleozoic to Mesozoic metasediments. All series underwent Alpine metamorphism.

The Austro-Alpine System: represents an Internally complicated and Imbricated nappe system thrust from the south and superimposed on all above-mentioned zones. Two or three (Upper-, Middle?-, Lower-Austro-Alpine) tectonical subunits have a crystalline basement and a distinct Paleozoic-Mesozoic sedimentary cover. The Northern Calcareous Alps form a Mesozoic limestone belt more then 500 km long and up to 50 km wide along the northern flank of the Alpine range (and contain more than 6000 registrated caves). In the south they are connected with a unit of Paleozoic rocks, the "Grauwackenzone", dipping north under the Calcareous Alps. These units belong to the Upper Austro-Alpine subsystem. The Grauwackenzone and the crystalline basement together with the Lower and Middle Austro-Alpine form the "Central Zone" of the Eastern Alps.

The Southern Alps: are separated from the Austro-Alpine system by the "Periadriatic Lineament-fault". They exhibit a Paleozoic to Mesozoic sedimentary sequence and continue in the Dinarides.

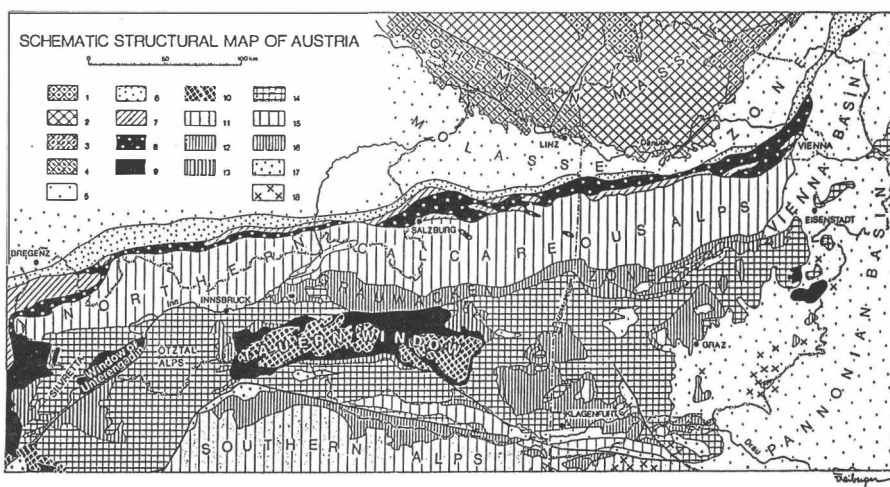


Fig. 1: Schematic structural map of Austria (after P. BECK-MANNAGETTA & A. MATURA, 1980). 1—4 = Bohemian Massif; 1 = Post-Variscan sedimentary cover; 2 = Moldanubian Zone; 3 = Moravian Zone; 4 = Bavarian Zone; 5 = Tertiary basins; 6 = Subalpine Molasse; 7 = Helvetic and Klippen Zone; 8 = Flysch Zone; 9 = Metasedimentary rocks of the Penninic Zone; 10 = Crystalline basement of the Penninic Zone; 11—14 = Austro-Alpine Unit; 11 = Permomesozoic in North-Alpine facies; 12 = Palaeozoic; 13 = Permomesozoic in Central Alpine facies; 14 = Crystalline basement ("Altkristallin"); 15 = Permomesozoic of the Southern Alps; 16 = Palaeozoic of the Southern Alps; 17 = Periadriatic intrusive masses; 18 = Neogene andesites and basalts. Cross-section see fig. 2.

(from JANOSCHEK & MATURA, 1980)

Intramountain basins developed during the Neogene in the Alpine-Carpathian nappes. The most well known (due to extensive oil and gas exploration) is the Vienna Basin. It is an asymmetrically E-SE dipping, downfaulted in these nappes and filled by more than 5000 m of marine and lacustrine Neogene sediments. The autochthonous sequence of the Molasse Basin has been drilled in the deep well Zistersdorf ÜT1 at a depth of 7100 m, below the Alpine nappes (Ringhofer, 1986). A second large Neogene Basin is the Styrian Basin in the SE, a bay-like extension of the Pannonian Basin. Within the Alps, small basins containing lignite formations of Early to Middle Miocene age are developed.

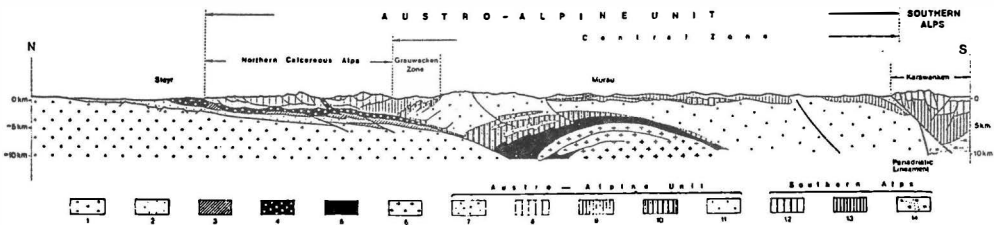


Fig. 2: Schematic cross-section of the Eastern Alps along the line Linz - Klagenfurt (modified after S. PREY, 1976; for exact position of the cross-section see fig. 1). 1 = Extra-Alpine basement of the Bohemian Massif; 2 = Molasse Zone and intra-Alpine Tertiary (post-upper-Eocene); 3 = Helvetic Zone and Klippen Zone; 4 = Flysch Zone; 5 = Metasedimentary rocks of the Penninic Zone; 6 = Crystalline basement of the Penninic Zone; 7-11 = Austro-Alpine Unit: 7 = Gosau Formation; 8 = Permomesozoic (unmetamorphic) in North-Alpine facies; 9 = Palaeozoic (low-grade metamorphic); 10 = Permomesozoic (low-grade metamorphic) in Central Alpine facies; 11 = Crystalline basement ("Altkristallin"); 12-14 = Southern Alps: 12 = Permomesozoic; 13 = Palaeozoic; 14 = Crystalline basement.

(from JANOSCHEK & MATURA, 1980)

PALEOGEOGRAPHIC DEVELOPMENT SINCE JURASSIC TIME:

The aim of this excursion program is to demonstrate agglutinated foraminifera in the Thetys and Parathetys realm. These forms are strongly connected with clastic sedimentation in the Flysch and Molasse basins, where the richest assemblages occur in the Late Cretaceous to Eocene and Late Oligocene respectively. A reconstruction of Alpine basins development is given by Faupl (1978), based on the ideas of Oberhauser (1968) and plate tectonic models of Frisch (1977). The evolution of Molasse Basin is discussed by Wagner (this paper).

Lias-Dogger: Fig. 3-5

In the Jurassic a marine transgression extended to the north on the European platform, starting with paralic coal facies in the Gresten Beds. The Penninic geosyncline began to develop as a separate ocean basin. The rifting was accompanied by coarse clastic sedimentation. The large Austro-Alpine Triassic carbonate platform with its southern fringing reefs subsided to pelagic sedimentation depths. It is bordered by submarine scarp breccias in the north.

Early Cretaceous: Fig. 6–8

The rifting shifted from the southern to the northern Penninic zone. The basin was a continuation of the Valais-trough of the Western Alps. In this basin the Rheno–Danubian Flysch Zone was developed. The different basins were separated by long W–E trending sills. The southern margin of the European platform (Helvetic Zone) subsided with concurrent calcareous and radiolaria–limestone sedimentation.

Late Cretaceous: Fig. 9

In Mid-Cretaceous time the southern Penninic trough was subducted continuously. This resulted in an elevation of the northern part of the Austro-Alpine plate with continental crust and Penninic ophiolites, the so-called "Rumunian-sill". Connected with the pre-Gosavian overthrusts, sedimentation ceased in the area of the Calcareous Alps but started again in the Coniacian with shallow water deposits in the Lower Gosau formation. In the Campanian this area was formed into flysch troughs by the continuing subduction in the Penninic system. The Austro-Alpine nappes continued to thrust northwards.

Paleogene: Fig. 10

In the Flysch Zone and Gosau basins, sedimentation continued until the Eocene. In the southern parts of the Helvetic Zone (Ultrahelvetic), sedimentation took place partly below the CCD. The Helvetic shelf rose in the Paleocene but subsided again in the Middle Eocene and was again subjected to pelagic sedimentation. In the Late Eocene, the area of the Alpine foredeep – the Molasse Basin – was incorporated into the realm of the Helvetic sea.

From the Oligocene onwards a new system developed in Central and Eastern Europe: the Oligocene–Miocene Paratethys (Rögl & Steininger, 1983). At the end of the Early Miocene the sea withdrew from the Alpine foredeep, the latter becoming filled by fluvial sediments. Intramontane basins developed, and in the Late Neogene the rising Alps formed the modern landscape.

General geological informations:

Janoschek & Matura, 1980
 Matura & Summesberger, 1980
 Oberhauser, 1980
 Tollmann, 1976, 1977, 1985

Fig. 3

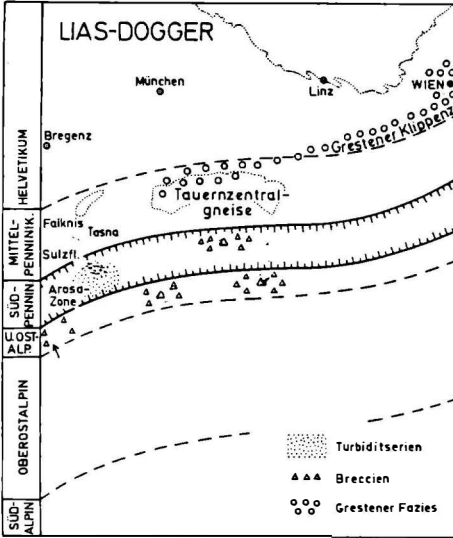


Fig. 4

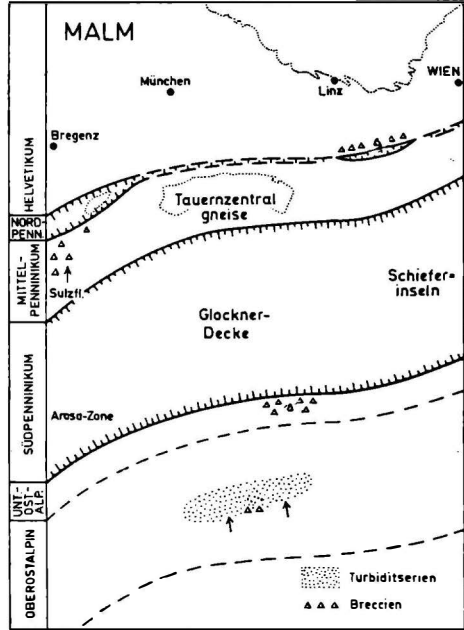


Fig. 5

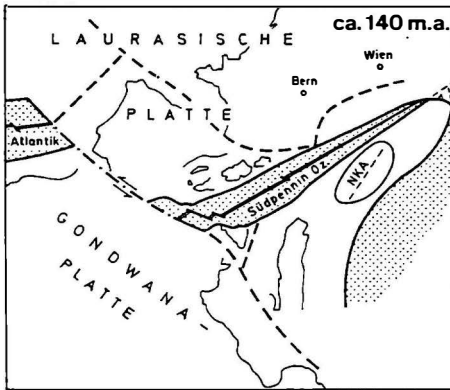
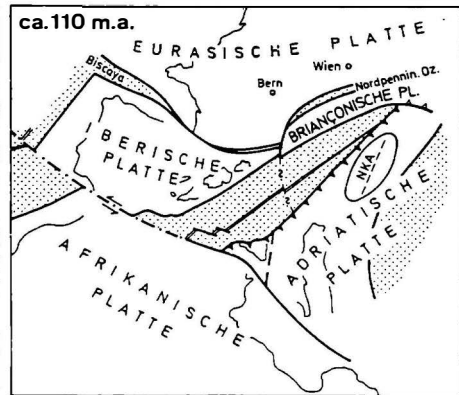


Fig. 6



Figs. 3 - 10: Paleogeographic evolution of the Eastern Alps in context to the plate tectonics of the Western Mediterranean (figs. 3 - 4, 7 - 10 from Faupl, 1978; figs. 5 - 6 from Frisch, 1977; NKA = Northern Calcareous Alps).

Fig. 7

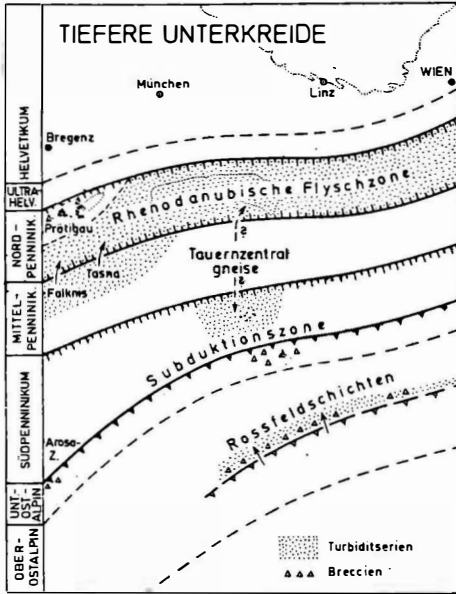


Fig. 8

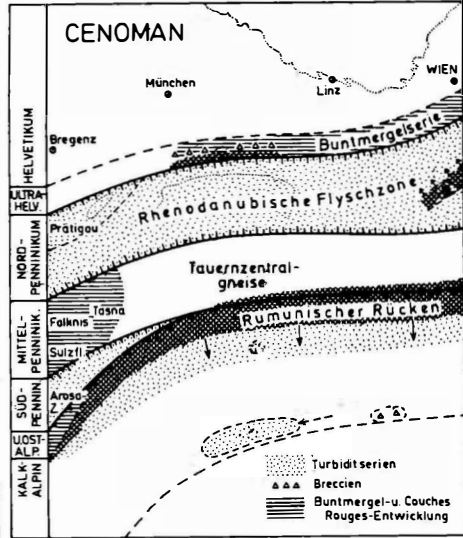


Fig. 9

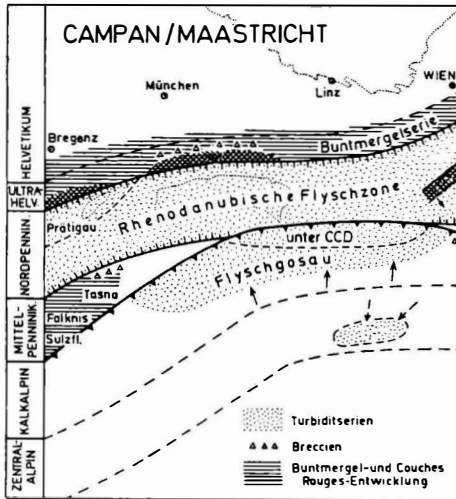
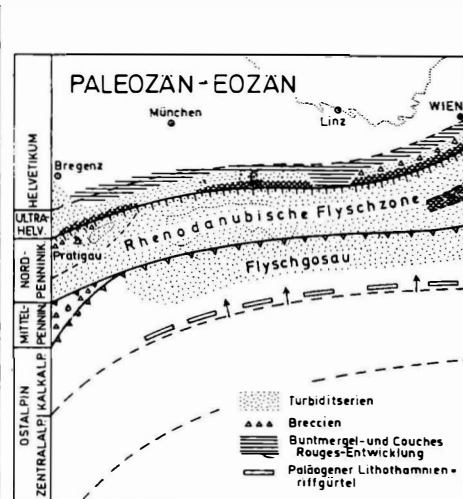


Fig. 10



EXKURSION A, June 26, 1986
Vienna Woods and Vienna Basin

Route: Vienna (Maria Theresien Platz) - Sievering - Höhenstraße, Kahlenberg - Klosterneuburg - ÖMV AG gas field Höfleln - Hagenbachklamm - Dopplerhütte - ÖMV AG deep well Maurerbach 1 - Dammbach quarry - high way A1/A21 - Alland - Helenental - Baden Sooss - Vienna.

STOP 1:

- * Wien XIX., Sievering, north of Sieveringer Straße, old quarry Gspöttgraben West.
- * Flysch Zone, Sievering Beds, Late Maastrichtian
- * References: Faupl & al., 1970
Kern, 1977
Plöchinger & Prey, 1974 (point I/1)

A succession of sandstones (1-7 m thick), clays, and marls presents the entire range of flysch phenomena such as graded bedding, load casts, ripple marks, and trace fossils. The outcrop was studied in detail by Faupl & al. The agglutinated fauna (see fig 11) comprises typical Late Cretaceous - Paleogene assemblages of large forms dominated by Psammosiphonella, Dendrophrya, and Recurvoides. Among the larger foraminifera, Orbitoides and Lepidorbitoides are re-deposited. Some reworking of globotruncanas was observed.

The road continues along the Erbsenbach in Sievering Beds and approaches the basis of the Kahlenberg Nappe with Mid-Cretaceous sediments.

STOP 2:

- * Wien XIX., Sievering, valley of the Erbsenbach, 1,5 km NW of the village. Stop at the road bridge, pathway along the eastern bank of the Erbsenbach for 500 m; outcrop at the small bridge on the western bank.
- * Flysch Zone, basal Kahlenberg Nappe, Gault Flysch, Mid-Cretaceous.
- * References: Plöchinger & Prey, 1974 (point VI/2)

Black-grey, greenish grey and light grey laminated clays and claystones with thin layers of fine-grained sandstones, dipping steeply N-NNW. Only agglutinated assemblages with Reophax minutus, Plectorecurvoides alternans, Dorothisia filiformis, and Trochammina globigeriniformis. Common pyritized radiolaria.

The Höhenstraße continues in Kahlenberg Beds (Santon-Campan) with grey marls and sandstone layers. No good outcrops.

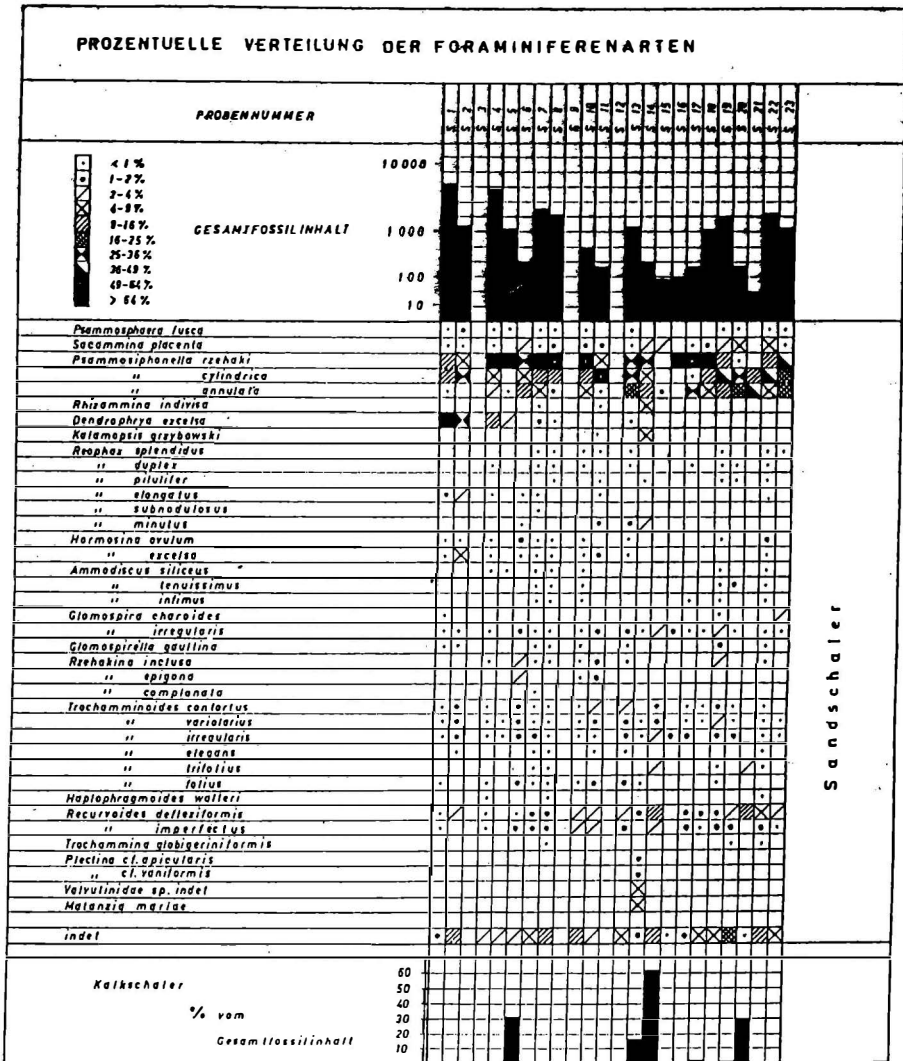


Fig. 11: Sievering, Gspöttgraben West, Assemblages and frequencies of agglutinated foraminifera (Faupl & al., 1970).

Kahlenberg, terrace of the hotel: sight seeing point with best view of Vienna. East of the Flysch Zone the Vienna Basin opens on both sides of the Danube. Under a good visibility the eastern border with the Leithagebirge and Smaller Carpathians can be observed. The coastline of the Middle Miocene sea formed a flat terrace along the foothills of the Kahlenberg. To the S and SW, Vienna is surrounded by Pleistocene terraces.

Route descends to Klosterneuburg, the capital of the Babenbergs (1106–1156) with a monastery dating from that period. The main building is in a baroque style emulating the Escorial. The road to Tulln crosses the Greifenstein Nappe of the Flysch Zone. Based on microfossils, the Greifenstein Beds belong to the youngest flysch sediments (Middle Eocene) but are poor in foraminifera.

THE GAS FIELD HÖFLEIN

P. Seifert, ÖMV-AG, Vienna

Höflein 1 found natural gas with an underlying liquid phase of hydrocarbons. Eleven other exploration drillings defined the limits of the field. It has an extension of nearly 12 km² between the villages Hadersfeld and Höflein and the river Danube, northwest of Vienna.

The gas-bearing reservoir at a depth of 2750 m is the "Doloquarz-arenitserie" on top of the Dogger sequence. This sediment consists of sandy dolomites with porous chert layers. The whole Mesozoic sequence is structured by post-Jurassic faults with a NE-SW trend (see fig 12). Therefore the gas-bearing column in the exploration drilling varies between 20 and 70 m. Höflein is the first gas field with an economic value which was found in the Autochthonous Mesozoic below the overthrust belts of the Alps.

References: Grün, 1984

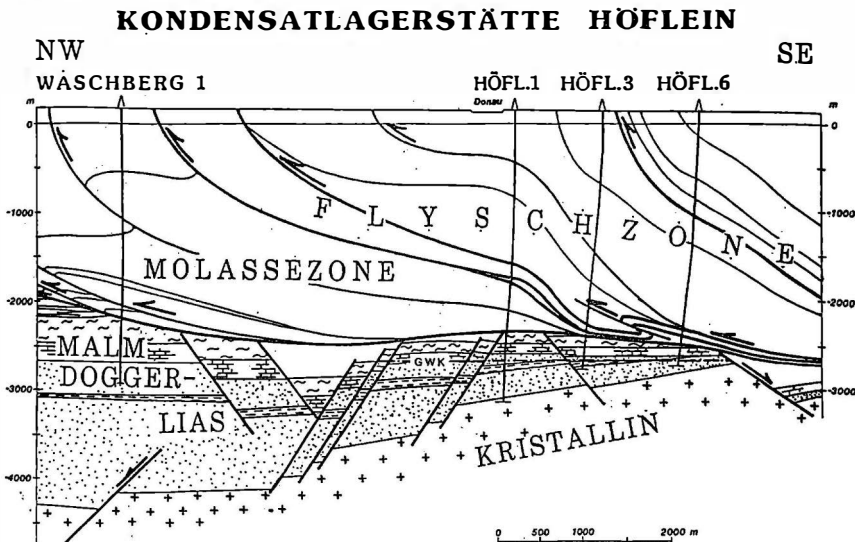


Fig. 12: Geological section of the ÖMV-AG gas field Höflein

AUTOR: Dr. W. Grün
1984 09

Drill Site HÖFLEIN 1:

During 1983 the exploration drilling Höflein 1 was drilled at the river Danube north of Vienna. It was to examine the stratigraphy of this area and reach the high zone of the Autochthonous Mesozoic which was identified by reflexion seismic measurements. The Flysch Zone in the area of Höflein consists of two overthrust nappes of Paleocene to Early Cretaceous age. The sediments consist of turbidite sequences with alternate bedding of sandstones to calcareous sandstones and marlstones with claystone intercalations. Calcareous sandstones, light brown pelagic limestones, and black claystones represent the basal part of the flysch sediments (Early Cretaceous).

A thin series of red and green marlstones of Eocene age is overthrust by the Flysch. "Sandstreifenschlier", the thin bedded series of calcareous sandstones and marlstones of the Molasse zone, was found between 1950 and 2500 m. From a depth of 2504 m Höflein 1 drilled through the sequences of the autochthonous Mesozoic: Grey marlstones and light brown limestones of Malmian age, sandy dolomites, black claystones and grey sandstones of Dogger and Lias age. The Paleozoic crystalline basement of the Bohemian Massif was reached at 3245 m depth.

Stratigraphy:

0 - 25 m	Quaternary
25 - 1900 m	Flysch
	25 - 620 m Late Cretaceous
	620 - 940 m Eocene-Paleocene
	1740 - 1900 m Early Cretaceous
1900 - 1951 m	Helvetic nappe ("Buntmergelserie") Eocene
1951 - 2504 m	Subalpine Molasse - Early Miocene (Ottománylan-Eggenburgian)
2504 - 3245 m	Autochthonous Mesozoic
	2504 - 2733 m Malm Marlstones + Limestones
	2733 - 2943 m Dogger Dolomites, Claystones, Sandstones
	2943 - 3245 m Dogger-Lias Sandstones
3245 - 3298 m	Crystalline Paleozoic

STOP 3:

- * Hagenbachklamm, gorge S of St. Andrä, eastern wall of the creek, 100 m S of the entrance. Mapping point no. 114 of Brix.
- * Flysch Zone, Greifenstein Nappe, Alltengbach Beds, Maastrichtian.
- * References: Brix, 1961, 1970
Grün, 1970

Not very well exposed outcrop, yet important due to its rich fauna. Grey to

dark-grey soft marls are interbedded in a sequence of sandstone. The following species are described by Grün: *Psammosphaera fusca*, *Saccamina placenta*, *Psammosiphonella* div. sp., *Kalamopsis grzybowskii*, *Reophax duplex*, *Ammodiscus infimus*, *Glomospira irregularis*, *Glomospirella gaultina*, *Rzehakina* div. sp., *Trochamminoides* div. sp., *Recurvoidea*, and *Plectina*.

The road follows the overthrust of the Flysch Zone on the disturbed Molasse to the W, ascending again from Königstetten to the summit of the Flysch at the Dopplerhütte.

STOP 4:

- * Old quarry at the Dopplerhütte.
- * Flysch Zone, northern border zone of the Greifenstein Nappe, Wolf-passing Beds ("Neokomflysch"), Early Cretaceous.
- * References: Bertle, 1970
Brix, 1961
Plöschinger & Prey, 1974 (point 1/5)

Calcareous flysch development with 30 to 50 cm thick limestone layers and thin intercalations of black-grey and grey clays. The limestones contain considerable quartz sands and show graded bedding. Chert nodules are common in the upper part. The sequence is folded and strongly dipping. The microfauna is poor, consisting mainly of radiolaria, a number of hedbergellids, trochollinas and certain rotaliids. The nannoflora, with *Nannoconus stelmani* and *Zeughrabdodus embergeri* allows this formation to be dated as Early Cretaceous.

Dopplerhütte: parking lot, sight-seeing point. From this vantage point one can see the Molasse Basin north and south of the Danube, and in far NW the Bohemian Massif is visible. The lower hillsides are formed by silty clays and conglomerates of the disturbed Molasse. At this site the Alpine range bends to a NE Carpathian direction. The Flysch Zone is transformed to the W, north of the Danube by a fault where the Danube has entered the Vienna Basin since Pliocene times. From here the excursion returns through the Flysch Zone nappes and passes the deep well Mauerbach 1.

DRILL SITE MAUERBACH 1a:

R. Fuchs, ÖMV-AG, Vienna.

The exploration drilling Mauerbach 1a (drilled in 1964 by the ÖMV-AG, the Austrian National Oil and Gas Company) is situated 3.5 km south of the northern margin of the Flysch Zone, south of the front of the Alpine thrust fold belt. The borehole demonstrates the nappe structure of the Flysch (mainly Late Cretaceous and Early Tertiary turbidite sandstones intercalating with argillaceous and calcareous layers) and its overlapping on the Molasse Zone.

The borehole reached a depth of 3487.3 m in the Paleozoic crystalline of the Bohemian Massif (fig. 13).

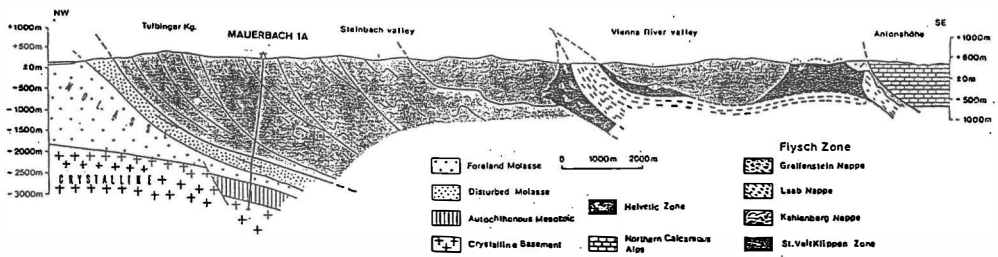


Fig. 13: Cross-section of the Flysch Zone with the drilling Mauerbach 1a. The borehole sank through the so-called "Greifensteiner Nappe" (Flysch), reached Disturbed and Autochthonous Mesozoic and ended in the Crystalline of the Bohemian Massif (after S. PREY in W. DEL-NEGRO, 1977)

DRILL SITE MAUERBACH 1a:

Stratigraphy:

0	-	6 m	Quaternary
6	-	2364 m	Flysch (Early Cretaceous–Early Tertiary; scaly structure)
6	-	346 m	Early Eocene
346	-	443 m	Late Cretaceous
443	-	619 m	Early Eocene
619	-	818 m	Late Cretaceous
818	-	892 m	Danian
892	-	933 m	Late Cretaceous (Maastrichtian)
933	-	1008 m	Danian
1008	-	1612 m	Campanian & Maastrichtian
1612	-	2192 m	Late Cretaceous & Paleocene
2192	-	2364 m	Early Cretaceous

- 2364 - 3038 m Subalpine Molasse (Neogene)
 Disturbed Molasse:
 2364 - 2438 m Eggenburgian scaly
 2438 - 2486 m Egerian (=Oligo-Miocene) structure
 Autochthonous Molasse:
 2486 - 2993 m Eggenburgian
 2993 - 3038 m Egerian
- 3038 - 3457 m Autochthonous Mesozoic
 shales and sandstones (Dogger and Lias)
- 3457 - 3487,3 m Crystalline (Paleozoic)

Another drilling, Berndorf 1, about 35 km south of Mauerbach, penetrated two alpine limestone nappes as well as Flysch and encountered Molasse (Egerian) at a depth of 5910 m (R. FUCHS et al., 1980; G. WACHTEL & G. WESSELY, 1981). This was another excellent demonstration for the nappe structure of the Northern Calcareous Alps and the Flysch Zone.

References: Del Negro, 1977
 Fuchs, R. & al., 1980
 Wachtel & Wessely, 1981

Near the overthrust of the Kahlenberg Nappe we pass the former Carthusian monastery Mauerbach and approach the valley of the Wien river (Wienfluß) at Purkersdorf.

STOP 5:

- * Old quarry in the Dambach valley, 3 km W of Purkersdorf, 300 m S of the Wien river (Wienfluß).
- * Flysch Zone, Kahlenberg Nappe, lower Kahlenberg Beds, Campanian.
- * References: Plöchlner & Prey, 1974 (point I/6)

Typically developed sequences of alternating grey to blue-grey limestones and sandstones (0.5 - 1 m thick) with grey marl and clay intercalations. Sandstone with graded bedding, load casts, sole marks, trace fossils at the lower surface of the beds. Marls commonly burrowed. Beds dipping 20-30° NE.

The microfauna is represented by large, tubiform agglutinates, e.g. *Dendrophya*, and rare *Rzehakina epigona*; double-keeled globotruncanas occur. (Campanian age based on nannoplankton determination by H. Stradner).

The route follows the highway A1 from Pressbaum to Steinhäusl where representative outcrops in the flysch have been investigated at construction sites by the Flysch group (Grün & al., 1964, 1972). The road also crosses Alt-lengbach and Greifenstein Beds. Highway A21 from Steinhäusl to Alland again traverses all Flysch nappes (Greifenstein-, Kahlenberg-, Laab-Nappe). Shortly before Alland, to overthrust of the Northern Calcareous Alps on the

Flysch Zone is crossed. Without a stop the excursion continues along the Schwechat river valley to Baden. The Alps end here with steep down faulting to the Vienna Basin.

STOP 6:

- * Baden - Sooss, brickyard, clay pit SE of the Southern Railway.
- * Vienna Basin, Middle Miocene, Badenian stage (type locality), Upper Lagenidae zone, Baden-clay.
- * References: d'Orbigny, 1846
Papp & Steininger, 1978
Papp & Schmid, 1985

In the western part of the clay pit, marine, blue-grey, silty Baden-clays (Badener Tegel) are exposed. It is the only existing outcrop in this area providing foraminifera material corresponding to the large number of species described by d'Orbigny. The assemblages are very rich in lagenids and planktonic foraminifera. Agglutinated species characteristic of a shelf sea environment are: *Textularia* div. sp., *Spiroplectinella carinata*, and *Martinotella communis*.

In the eastern part of the clay pit, one of the steep faults of the basin margin shows down thrust olive-green Sarmatian clays. The reduced salinity resulted in a poor microfauna with small nonionids, elphidiids and ostracods.

EXCURSION B, June 27 - 28 , 1986

Molasse Basin and Margin of the Eastern Alps.

Route: 1st day: Vienna (Maria Theresien Platz) - Wachau - Melk - Vorchdorf - Pettenbach - Gmunden - Mondsee - Salzburg,
2nd day: Salzburg - St. Pankraz - Mattsee - Steyr - Großraming/Pechgraben - Waidhofen - Amstetten - Vienna.

The route follows highway A22 and S3 along the northern bank of the Danube in a western direction. First, the gate of the Danube through the Flysch Zone of the Vienna Woods is passed along a transform fault between Kahlenberg and Blsamberg. The small Neogene Korneuburg Basin in the north is down faulted in the Flysch nappes. To the west, Flysch (on top the castle Kreuzenstein, 19th century) rests on the disturbed Molasse of the Waschberg Zone; cliffs of L. Jurassic to Eocene age under an Oligo-Miocene sedimentary cover. The road passes the Molasse Zone and then enters the Bohemian Massif near Krems.

Krems is a well-preserved medieval town surrounded by terraces of vineyards cut into the Pleistocene loess; south of the Danube the hills are crowned by the Benedictine abbey Göttweig. It was rebuilt in the baroque style (1750-60) in form of a royal tent of a Turkish sultan in remembrance of the victories over the Turkish army.

From Krems to Melk the lovely scenery of the Wachau represents an old erosional structure; marine Miocene deposits are preserved near Spitz. At Dürnstein, Richard Lionheart was imprisoned by the Babenbergs in order to extort a huge ransom from Britain. A memorial pays tribute to him and his loyal minstrel Blondel. At the western entrance of the Wachau lies Melk - another Benedictine abbey and the largest baroque monastery in Austria.

On highway A1 we cross the southern spurs of the Bohemian Massif in which relics of an Oligocene-Early Miocene sedimentary cover are preserved. Sedimentation started with parallel brown coal formations in the E./M. Oligocene. In this area the Molasse Basin is constricted to a width of a few kilometers by the approaching Alpine front. At Linz the basin opens into the western Molasse. At Vorchdorf the excursion turns to the south to Pettenbach in order to visit the core-deposit of the RAG for demonstration of the Molasse Basin sedimentation.

STOP 1:

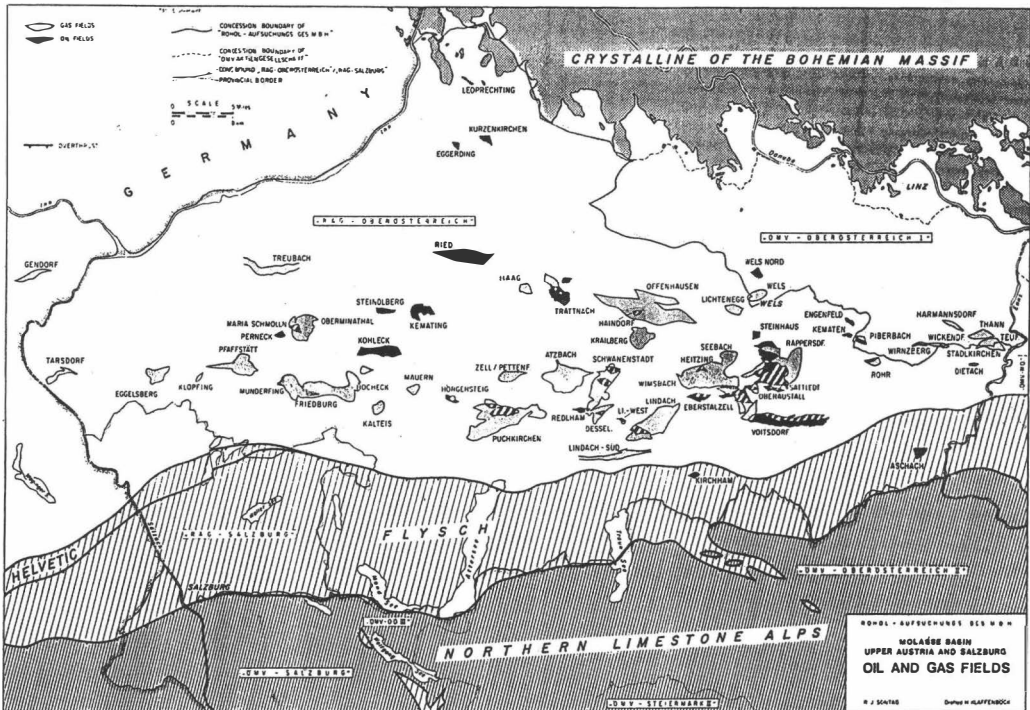
- * Pettenbach, core-deposit of Rohöl-Aufsuchungs GmbH (RAG)

THE MOLLASSE BASIN IN UPPER AUSTRIA.

L. Wagner, Rohöl-Aufsuchungs Gesellschaft mbH, Vienna.

The Molasse Basin is the second most important gas and oil region in Austria besides the main region of the Vienna Basin (fig 14). Production began more than 80 years ago in the natural gas fields near the town Wels. Pro-spection for gas was not successful until after world war II, when in 1956 the first RAG deep well of Puchkirchen 1 was drilled. It struck oil at 2578 m.

Figure 14



Introduction:

The "Molasse Zone" of Upper Austria and Salzburg forms part of the Alpine-Carpathian Cenozoic foredeep, the Molasse Basin, which extends from France through Switzerland, Germany and Austria to Czechoslovakia. In Upper Austria and Salzburg, this basin contains Late Eocene to Quaternary sediments which were deposited unconformably on Mesozoic series overlying the crystalline basement of the southern extension of the Bohemian Massif.

PLEISTOCENE	QUATERNARY		TERRACES AND HORAINES	0 - 300	
PLIOCENE	UPP. PIOCENE		MAL-BEARING		
MIOCENE	PAHNNIAN SARMATIAN BADENIAN CARPATHIAN		FRESH-WATER MOLASSE	0 - 300	
	OTTNANGIEN "HELVETIAN" OF GERMAN MOLASSE	INNER- FORMAT.	ONCOPHORA GROUP GLAUCONITIC GROUP RODALIA SCHLIER ROBULUS SCHLIER	0 - 300	
	EGGENBURGIAN "BURDIGALIAN" OF GERMAN MOLASSE	HALL FORMAT.	HALL SCHLIER BASAL GROUP (Siltstones, Sandst. etc.)	0 - 800	
OLIGOCENE	AQUITAINEAN OF GERMAN MOLASSE	UPPER PUCHKIRCHEN FORMAT.	N: PELITIC FACIES S: A 1 TONGUES A 2 OF A 3a COARSE A 3b CLASTICS A 4	0 - 1050	
	EGERIEN				
	CHATTIAN OF GERMAN MOLASSE	LOWER PUCHKIRCHEN FORMAT.	N: PELITIC FACIES S: TONGUES OF COARSE CLASTICS → (Leoprechting)	0 - 1000	
	RUPELLIAN			N: PELITIC FACIES SW: SHALES AND SANDST.	0 - 450
				Possible gas Detach 1 BANDED MARL	0 - 50
			BRIGHT MARLY LST.	0 - 15	
LATORFIAN		FISH-BEARING SHALES	0 - 30		
EOCENE	UPPER EOCENE		N: SANDSTONE H: LITHOTHAMN. S: LITHIOTHAMN. LST. CERITHIUM BEDS DISCOCYCLINA(D) LIMNIC BEGS A. GLOBIGERINA(6) SHALES SANDSTONE	0 - 120	
UPPER CRETACEOUS	CAMPANIAN SANTONIAN CONIACIAN UPP. TURONIAN LOW. TURONIAN CENOBIANIAN		NW: SANDST. NE: SANDST. GLOBOTRUNCANA SHALES AND MARLS GLAUCONITIC SANDSTONE QUARTZ-SANDSTONE & CLAU: SST.	0 - 1000	
JURASSIC	MALM		CARBONATIC GROUP	0 - 400	
	JURASSIC BASAL SERIES		CHERT DOLOMITE (Hndf) SST., CONGL., CLAY-ST., COAL	0 - 40	
PERMO-TRIASSIC			PERWANG-TERRESTRIC	0 - 230	
CRYSTALLINE OF THE BOHEM. MASSIF			GRANITES AND GNEISSES		

LEGEND: ☼ GAS, PROVED ● OIL, PROVED
☼ GAS, PROSPECTIVE ⊕ OIL, PROSPECTIVE

G 15 544

Fig. 15: Stratigraphic Table of the Molasse Zone in Upper Austria and Salzburg

The Cenozoic Molasse Basin of Upper Austria and Salzburg has the geometry of an asymmetrical, south dipping, 30 to 55 km wide trough. Its northern margin is formed by the outcropping basement of the Bohemian Massif whilst its southern margin corresponds to the Alpine thrust front. In this basin the thickness of Cenozoic series ranges from a few meters along its northern margin to over 3000 m along the Alpine deformation front.

During the Oligocene and Early Miocene phases of the Alpine orogeny the southern parts of the Molasse Basin were overridden by the Alpine nappe system. Seismic reflection and well data indicate that the autochthonous foreland basement, with its Mesozoic and partial Cenozoic cover, extends for a considerable distance under the Alpine nappes.

Sedimentary sequences: (fig 15)

Late Paleozoic:	Late Carbonian–Permian, fluvial braided stream sandstones with coal layers; floodplain siltstones and shales Flora: reworked Stephanian. Spores corroded.
Mesozoic:	
Dogger:	Transgressive sequence. fluvial braided stream sandstones with coal layers, marsh and shallow marine sandstones, dolomite with chert nodules and quartz grains, glauconitic limestones. Flora: Bathonian–Bajocian Spores. Fauna: Lumachelles, corroded ammonites, belemnites, echinoids, sponges, corals.
Malm:	shallow marine–shelf limestones and dolomites – algal and sponge banks and bioherms, oolites and grain stone banks, coral reefs, lagoonal limestones, breccias.
Purbeckian:	regressive sequence – freshwater influenced tidal flats. Tight fine crystalline dolomites, cherty limestones, stromatolites, breccias. Flora: Algae, Characea Tectonics: uplifting of central swell zone, erosion and karstification
Early Cretaceous:	restricted to south of the central swell zone – marine glauconitic sandstones, shale. Flora: Berriasian/Hauterivian nannoflora
Cenomanian:	transgressive sequence "Schutzfelsschichten"; Karstfilling, fluvial braided stream sandstones, glauconitic sandstone – poorly preserved beach sands; bulk of Cenomanian: burrowed and laminated glauconitic sandstone – storm-dominated shelf deposits.
Early Turonian:	offshore glauconitic clay and glauconitic sandstone– storm deposits

GEOLOGICAL CROSS SECTION THROUGH THE WESTERN PART OF THE MOLASSE ZONE OF UPPER AUSTRIA

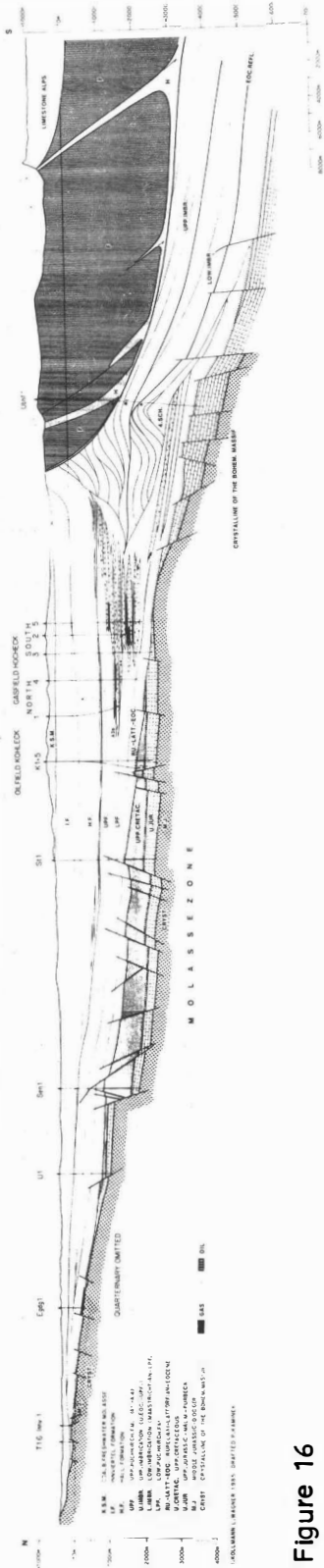


Figure 16

Late Turonian to Late Campanian: offshore clays.
Restricted to the easternmost part of the upper Austrian Cretaceous basin from late Cenomanian to early Turonian marine storm deposits and shales. Beginning late Turonian fluvio-deltaic clastic fan deposits.

Late Campanian: north of swell zone – shallow marine conglomerates and sandstones; south of swell zone – shale.
Tectonics: uplift, dissection of the Cretaceous basin by NW-SE and NNW-SSE trending faults, and uniform tilting to the east, extensive erosion.

Tertiary:

Eocene: Transgressive sequence. North of central swell zone: Limnic beds: channel sandstones of meandering rivers cut into floodplain clays (Characea), coal layers. Certhium beds: fossiliferous shales and sandstones from intertidal channels. Lithothamnium limestone: red algal limestone and shallow marine sandstones.

South of central swell zone: marine sandstones, Lithothamnium limestone, Discocyclus shale, Nummulite limestone and limestone with Uvigerina and Globigerina.
Tectonics: subsidence (maximum rate of change)

Latdorfian: Dark organic rich fish-bearing limestone and shale. Immature source rock

Rupelian: Light marly limestone – deep marine nanno ooze.
Banded marl – soft sediment deformed shale with thin intercalations of nanno ooze. "Shale stage" – deep marine shale-hemipelagites and distal parts of turbidites.

In the area around Salzburg: intercalations of sandstones and conglomerates from turbidites.

In the north, shallow marine sandstones were deposited directly on top of the Crystalline.

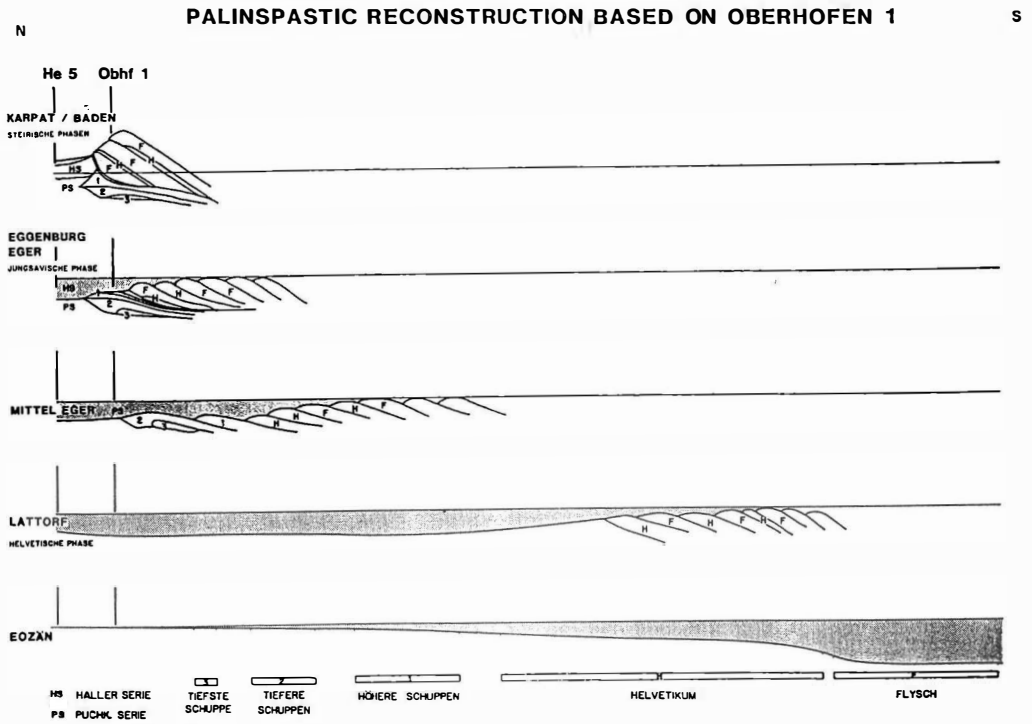
Egerian: "Lower und Upper Puchkirchen Formation" – deep marine shale, conglomerates and sandstones – turbidites. The "Linzer Sande" in the N – shallow marine sandstones resting on the Crystalline of the Bohemian Massif.

Tectonics: Submarine erosion, Flysch nappes reached approximate present position.

Eggenburgian-Hall Formation: shale, sandy and sandstone intercalations from turbidites – slope and basin deposits.

Ottangian – Innviertler Formation: shallowing sequence from basin deposits with turbidites to tidal flats – shale and sandstones.

Figure 17



Productive formations:

Oil and associated gas:

Middle Jurassic	sandstone
Middle Jurassic	limestones with chert
Cretaceous–Cenomanian	sandstones
Cretaceous–Santonian	sandstones only in the E
Eocene	sandstones and limestones

Heavy oil:

Rupellan to Egerian	shallow marine sandstones in the north
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Bacterial gas:

Egerian	turbidite sandstones
Eggenburgian	turbidite sandstones

Palaeogeographic reconstruction: (fig 17):

The well Oberhofen 1, drilled in 1981/1982, encountered Late Eocene sediments seven times, indicating a variety of tectonic units.

Geologic range of separate units:

Autochthonous:	Malm–Early Egerian
Lower Molasse imbrications:	Eocene–Early Egerian
Upper Molasse imbrications:	Eocene–Latest Egerian
Helvetic Zone:	Santonian–Late Eocene
Flysch Zone:	Neokomian–Late Eocene

Water depth continuously increased to the south. Greatest water depth in Flysch, lowest water depth in the Molasse. Reconstruction of Eocene reflections from the seismic lines indicates a distance of at least 200 km between Molasse Late–Eocene and Flysch Late–Eocene.

Eocene:

Subduction effective on the Molasse Zone from Eocene time on. The subduction zone was situated at the Central Alps and pulled the basement of the foreland to the south, resulting in extensive E–W striking extensional faulting. Nappes and imbrications piled up due to the subduction in the S. The weight of the N–ward moving nappes caused progressively northern parts to subside and to be involved in the extensional tectonic activity.

The following reconstructions are based on the maturity profile, stratigraphic and dip angles:

Latdofian– Earliest Rupelian:

Helvetic Zone and Flysch were imbricated far in the S in a NNE–SSW direction and coalified in their entirety as a whole package.

Egerian:

Molasse imbrications (lower and upper units) arrived at about their present position. Sediments from Late Egerian were then deposited on top of these imbrications.

Egerian–Eggenburgian:

Movement of imbrications ceased during this time. Only basin/slope sediments with turbiditic sands were preserved. Shelf and beach sediments were totally removed in Salzburg and Upper Austria. The so-called Hall transgression was caused by the shortening of the Hall Formation trough by the Egerian imbrications. These events rearranged the sea current system which resulted in Upper Puchkirchen erosion.

Karpatian:

Flysch and Helvetic Zones were internally further overthrust and uplifted. The southern parts of the Hall and Innviertel Formation were then compressed and tilted.

We follow the foothills of the Alps to the west where a series of N–S stretching lakes indicates the force of Pleistocene glaciers; these lakes are sealed to the N by end-moraines. The northern front of the Alps is formed by the Flysch Zone. The northern tectonic unit – the Helvetic Zone – is exposed only at a few small sites at the northern rim or is imbricated and present in the form of windows. The Northern Calcareous Alps end with steep northern walls. A very impressive cliff forms the Traunstein near Gmunden on the Traunsee.

STOP 2:

- * Gmunden, Gmundner Berg, southern flank of Pinsdorf Berg, near the summit; quarry of the Hatschek cement plant.
- * Flysch Zone, Mübbsandsteinführende Oberkreide (friable sandstone series), Late Cretaceous.

The formation of the "friable sandstone series" is exposed with steeply S dipping beds and shows a rhythmic change of sandstones, limestones, marls, and clays. Sole marks and trace fossils are common. Characteristic are the sandy micaceous friable parts. The clay layers contain agglutinated assemblages with large forms of *Psammosiphonella*, *Trochamminoides*, *Recurvoides*, and rare *Rzehakina* (compare Prey, 1951, and Cicha & al., 1968, p. 37).

On highway A1 we approach lake Attersee and Nussdorf from the W. A small country road crosses the hills in the direction of Mondsee (Nussdorf – Limberg – Lichtenbuch – Radau – road to Mondsee).

STOP 3:

- * Upper Dexelbach creek WSW of Limberg, near the bridge at the fork of the creek.
- * Flysch Zone, "Neokomflysch", Early Cretaceous.

Typical Early Cretaceous flysch is exposed along the creek. Light grey marly limestones, with bioturbation, and layered (30–50 cm) and intercalated by dark grey and black shales, have a well preserved pyritized radiolaria fauna. Agglutinated foraminifera (e.g. *Haplophragmoides*, *Glomospira*, *Dorothyia*) are rare.

Route Mondsee – Salzburg on highway A1.

Salzburg, the capital of the former principality of the archbishop, was deemed by Alexander von Humboldt to be one of the three most beautiful towns in the world. It still has its special beauty. The "Festung", a medieval castle, towers over an arrangement of churches and small cosy streets. The cathedral is the most important Renaissance building north of the Alps. In baroque time Salzburg was a cultural centre in which most famous Austrian artists and many Italians worked for the archbishop. It is not happenstance, that Wolfgang Amadeus Mozart came from this town.

The second day is devoted predominantly to the Helvetic Zone. Hagn (1960) divided the Helvetic Zone into W-E stretching parallel facies belts.

STOP 4:

- * St. Pankraz am Haunsberg, 18 km N of Salzburg, quartz-sand quarry.
- * Helvetic-Zone, Südhelvetikum, Roterz – Mittelschichten – Schwarzerz – Fossilsschichten, Early to Middle Eocene.
- * References: Aberer & Braumüller, 1958
Gohrbandt, 1963 a,b
Traub, 1938, 1953
Vogeltanz, 1970

The lithologic sequence is directly comparable with the series of Kressenberg, Bavaria (compare Hagn, 1960). Because of their rich fossil content the outcrops around the Haunsberg have been the subject of great interest. In the quarry the shallow water facies of the Südhelvetikum is exposed. Today this consists mainly of "Roterz", a limonitic nummulite-sandstone (Early Eocene), and the yellowish white "Mittelschichten" (decalcified quartz sands with rare alveolines). The "Schwarzerz" is an oolitic iron ore with nummulites and asslinas, outcropping only in the old parts of the quarry. The "Mittelschichten" are doubled by a thrust, and only a thin grey layer, mainly the "Fossilsschicht", marks the thrust plane. The Middle Eocene "Fossilsschicht" is separated from the quartz sands by a sedimentary gap. It is a marly glauconitic condensed horizon with an enormous amount of fossils: nummulites, discocyclinas, gastropod casts, bivalves, nautilids, echinoderms, corals, and crabs. The "Stockletten" – a light grey to yellowish soft pelagic marl (late M. to L. Eocene) – is not exposed in this outcrop.

STOP 5:

- * Fraham–Eisenharting, 1 km N of Seeham at the lake Obertrumer See, old overgrown quarry. Mapping point of Gohrbandt (1963).
- * Helvetic Zone, Nordhelvetikum. Stockletten, Late Eocene.

In the Nordhelvetikum, sedimentation started after a gap (E. Maastrichtian – M. Eocene) with Assilina-marls: the Adelholzen Beds. A deepening of the basin caused pelagic sedimentation of the "Stockletten". Bioclastic limestone layers, mainly calcareous algae, originated from gravity slidings. The marls contain abundant globigerinas (*G. eocaena*, *G. gortanii*) and rich benthic fauna comparable with Guembel's (1868) description and the excursion point Katzenloch in Bavaria (Hagn, 1981).

A nearby RAG drillsite, CF Nussdorf 6, showed the transition from the Eocene calcareous pelagic facies to the E. Oligocene clay facies with pyritic preservation and stagnant *Bulimina* facies (*B. sculptilis*, *B. cf. pupoides*). Nannoplankton determinations by C. Müller (Paris) demonstrate NP 19 to 20 in the drill site and NP 18 in the outcrop.

The overthrust of the Helvetic Zone on the Molasse was exposed only 60–80 m to the N.

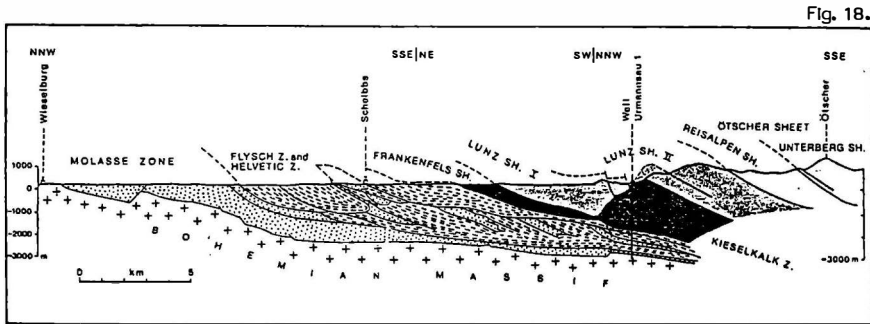
The route continues to Mattsee, Seekirchen, and over highway A1 along the Alps to Enns. Along the Enns river we drive south, crossing the Flysch, and enter the Northern Calcareous Alps.

GEOLOGY OF THE NORTHERN MARGIN OF THE EASTERN ALPS, SECTION BETWEEN THE RIVERS ENNS AND TRAISEN (EASTERMOST UPPER AUSTRIA – WESTERN LOWER AUSTRIA).

W. Schnabel, Geol. Survey of Austria, Vienna.

Similar to the structure of the whole northern border of the Eastern Alps, this part is also dominated by the three main tectonic units: the Helvetic Zone, the Flysch Zone (=Reno–Danubian Flysch) and the northern tectonic elements of the Northern Calcareous Alps. Special features within this section are the Klippen–Zone and the exposures of the Inner Alpine Molasse within the Alpine system. It is expected that the reason for these remarkable structures in this particular area is the south spur of the Bohemian Massif reaching beneath the Alpine body with only a thin cover of autochthonous Molasse. It is overthrust by the Alpine nappe system composed of:

highest	Ötscher sheet	}	Northern Calcareous Alps
	Lunz sheet		
	Frankenfels sheet		
	Cenoman–Randschuppe		
	Reno–Danubian Flysch		
	Helvetic Zone		
lowest	Inner Alpine Molasse		



Cross-section through the Molasse Zone, the Ultrahelvetice Zone, the Flysch Zone, and the Northern Calcareous Alps in the area of the window of Rogatsboden and the well Urmannsau 1. Demonstrated are the submerging Foreland Molasse, the thrustlices of the Sub-Alpine Molasse within the Ultrahelvetice Zone, the Flysch Zone, the internal structures of the Northern Calcareous Alps, and the location of the well Urmannsau 1

(from JANOSCHEK & MATURA, 1960)

Due to the generally flat south dipping overthrusts this sequence of nappes is exposed not only in the northern front part, but also in a considerable number of tectonic windows and "semi-windows" as for instance:

the window of Rogatsboden-Schelbbs and Texing: Molasse beds together with units of the Helvetic Zone exposed within the Flysch-Zone

the window of Brettli: Flysch-Zone with "Klippen" exposed within the Frankenfels sheet of the Calcareous Alps

the window of Urmannsau: the Frankenfels sheet exposed under the Lunz sheet

The well Urmannsau 1, situated in the window of Urmannsau, drilled through 1900 m rocks of the Frankenfels sheet before penetrating Flysch with "Klippen", Helvetic Zone and disturbed Molasse and finally reaching the crystalline basement at a depth of 3015 m (fig 18).

The "KLIPPENZONE" is a highly deformed, folded and imbricated zone and has fault contact with all adjacent units. Therefore the original position in the sedimentation area has not always been clear. It includes the Helvetic Zone (=Gresten Klippen-Zone), but also parts of the Rheno-Danubian Flysch with remnants of its primary basement (SCHNABEL, 1979). The Klippen-Zone is characterized by the occurrence of the Jurassic/Early Cretaceous "Klippen" surrounded by younger soft rocks, termed "Klippenhülle" (i.e. Klippen cover, see also Helvetic Zone and Rheno-Danubian Flysch).

The INNER ALPINE MOLASSE of Late Eocene to Oligocene age occurs in several windows within the Flysch Zone, imbricated with the Buntmergelserie of the Helvetic Zone.

The HELVETIC ZONE as the paleogeographic external unit of the Alps is in this sector entirely included in the Klippen-Zone. The Helvetic "Klippen" are essentially represented by the Liassic Gresten Beds (arkose, siltstone, marls, coal beds), Posidonia marls, siliceous limestones, radiolarites and Aptychus

Limestone of the Malmian and Neokomian. The "cover" is the Buntmergelse-rie (Variegated marl serels) of the upper part of the Early Cretaceous to Middle Eocene, representing the Southern Ultrahelvetic Realm. Its deposits under the CCD contain a rich fauna of agglutinated foraminifera. The original basement of the Helvetic Klippen can be assumed to consist of crystalline rocks comparable with the Bohemian Massif, as shown by dislodged slices of granite exposed in this area. The largest of these outcrops became a monument for the famous geologist LEOPOLD VON BUCH (1774-1852).

The RHENO-DANUBIAN FLYSCH in that area comprises Neokomian to Paleocene age. The younger formations (i.e. Campanian Zementsmergelerde and Maastrichtian to Paleocene Altengbacher Schichten) form the main unit of the Flysch Zone, a nappe which has entirely overridden the Helvetic Zone from here to the east. The older series (Neokomian Flysch, Gaultflysch, variegated shales and siliceous flysch of Cenomanian to Santonian age) are included in the Klippen Zone. They are in close contact to Jurassic "Klippen" of deep sea deposits (radiolarians, Aptychus limestone) and ophiolites, which can be considered to be remnants of the previous Flysch basement (SCHNABEL, 1979).

The NORTHERN CALCAREOUS ALPS are preserved by the so-called fore-Alpine nappe system (Frankenfels, Lunz and Ötscher sheet) and dislodged slices of the Cenoman-Randschuppe. In the area of the River Enns they form one of the most interesting features of the Northern Calcareous Alps, the Weyerer Bögen Structure, where the continuously east-west trending belts are obviously disturbed.

(Parts of this article are taken from Janoschek & Matura, 1980).

STOP 6:

- * Pechgraben W of Grossraming, old quarry at the 2nd Pechgraben-gorge.
- * Northern Calcareous Alps, Ternberg-Frankenfels Nappe, Vilser Kalk - Ammergau Beds - Schrammbach Beds, Dogger to Early Cretaceous.
- * References: Holzer, 1968, 1969
Kristan-Tollmann, 1962
Rosenberg, 1964

This outcrop presents a steep NNE dipping sequence of layered limestones. The SW part consists of reddish and grey-green recrystallized "crinoid" limestone, the Vilser Kalk. A fault causes a gap below the red calpionella limestones (Ammergau Beds), which has layers measuring 2-33 cm, totalling 8.7 m in thickness. An agglutinated fauna of the insoluble residue was described from this site by Holzer. *Tolypammina*, *Glomospira*, and *Trochammina* dominate. The higher sequence is not well exposed. The Schrammbach Beds (Aptychus limestones) are grey to grey-green mottled limestones and are overlain by grey marls (Albian).

STOP 7:

- * Leopold von Buch memorial, Steinbauergraben, an eastern side branch of the Pechgraben.
- * Helvetic Zone, southern Ultrahelvetikum, Buntmergelserie.
- * References: Faupl, 1975
Lögters, 1937
Matura & Summesberger, 1980

The memorial is part of a huge granite mass, a sheared off basement cliff resembling red granites in the Moravian Zone of the Bohemian Massif. The accompanying soft marls and clays are strongly faulted and imbricated into a kind of tectonic breccia. Lithology and ages vary within a range of only a few meters. This area is therefore well suited for collecting different samples. This formation, the "Buntmergel-Serie" (variegated marl formation), is part of the Ultrahelvetetic subunit, the southernmost part of the European plate. The sediments are rich in agglutinated foraminifera, which are partly deposited below the CCD. The time range spans from Late Aptian to Eocene.

Leopold von Buch (1774–1853), one of the fathers of European geology, was honored here by the society of German natural and medical scientists.

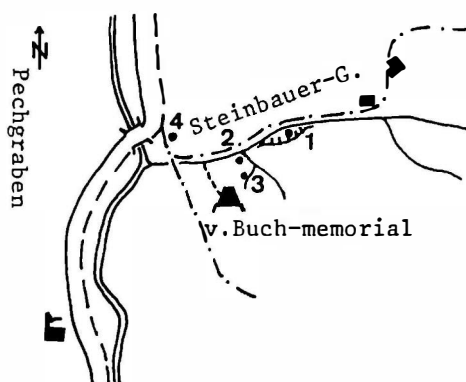


Fig. 19: Outcrops of the Buntmergelserie near the v. Buch memorial.

POINT 7/1: Early Eocene, dark grey to black clays with layers of fine-grained glauconitic sandstones. Very rich in agglutinated foraminifera, e.g. tubiformes, *Glomospira*, *Recurvoides*, occasionally rich occurrences of *Cyclammina ampectens*.

Planktonics: *Globorotalia aragonensis*, *G. marginodentata*, *Globigerina li-naperta*.

POINT 7/2: Early/Middle Cenomanian, layered light grey biotubated calcareous marls with soft clayey intercalations. Very rich in planktonic foraminifera, only few benthics, some calcified radiolaria.

Planktonics: *Rotalipora appenninica*, *Rt. reicheli*.

POINT 7/3: Early Middle Eocene, reddish-grey marls with rich but recrystallized planktonic fauna; agglutinated forms are common, e.g. *Recurvodes*, rare *Cyclamina amplexans*.

Planktonics: *Globorotalia caucasica*, *Acarinina bullbrooki*. According to nanoplankton (det. H. Stradner, Zone NP 14).

POINT 7/4: outcrop near the parking lot (entrance of the valley). Early Campanian, reddish to light grey laminated marls and silty clays with rich planktonic fauna and large agglutinates. Tubiform species, *Tritaxia*, and *Dorothia* are common.

Planktonics: *Globotruncana elevata*, *Gt. fornicata*, *Gt. linneiana*.

The route follows the road to Maria Neustift and turns toward Waidhofen an der Ybbs.

STOP 8:

- * Waidhofen an der Ybbs, suburb Zell, northern bank of the Ybbs river near the electric power station.
- * Helvetic Zone, Gresten Klippen belt, Jurassic to Early Cretaceous.
- * References: Trauth, 1954.
Schnabel, 1970

Aptychus limestone with intercalations of argillaceous marls (Arzberg Beds), Tithonian to Neocomian;

radolarite, Early Malmian;

Zell Beds, sandy to silty, marly clays, Dogger;

The outcrop at the river bank exposes a sequence extremely folded and dissected by faults. Thereby it gives an impressive example of the Klippen belt tectonics.

The excursion turns back to Vienna, crossing the Molasse Basin and the Vienna Woods along highway A1.

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ÖMV Aktiengesellschaft

When the first oil was produced in Austria in 1934, it was owned in the main by foreign companies. Originally, these owners were Swiss-Austrian, Anglo-American and French, but later became German and then Russian until 1955. At the time of the Russian withdrawal in 1955 ÖMV Aktiengesellschaft was established as the national oil company, and the state became the owner of its crude oil. ÖMV is the second largest industrial enterprise in Austria and is a fully integrated oil, gas and petrochemical company owned by the Republic of Austria with a share capital of AS 2 billion.

ÖMV therefore profits from having more than 50 years of experience in the Austrian oil and gas fields, and at the end of 1985 had approximately 7000 employees. Turnover during this same year amounted to roughly AS 62 billion.

ÖMV operated rigs drill more than 80 000 meters (262 480 ft) per year and have reached depths below 8 500 meters (27 900 ft). The annual domestic production of ÖMV amounts to approximately 850 000 tons (18 000 BPD) of crude oil and 700 million cubic meters (24,7 billion SCF) of natural gas from 1 500 (1 300 oil and 200 gas) wells. More than 35% of its crude production comes from secondary recovery techniques.

As well as domestic production, the company participates in hydrocarbon exploration and production activities in Tunisia, Libya, Egypt, Canada and Denmark.

ÖMV is by far Austria's most important crude oil importer, via the TAL - AWP Pipeline System from Trieste, and operates one of the most modern and complex refineries in Europe. This is situated at Schwechat near Vienna, has an annual crude oil throughput of 10 million tons (200 000 BPD) and supplies more than 70% of the oil product consumption of Austria including feed stock supplies to

PETROCHEMIE DANUBIA GmbH, a wholly owned subsidiary which produces polyethylene and polypropylene. ÖMV has 1.8 million cubic meters (12,6 million bbl) of storage capacity for crude oil and products in its two tankfarms outside the refinery.

ÖMV is the primary importer and seller of natural gas in Austria to the tune of 4,0 billion m³/year (141 billion SCF) and also plays an important role in the European gas transportation system. It owns and operates the Trans-Austria-Gas Pipeline (TAG) and the West-Austria-Gas Pipeline (WAG) through which 14,5 billion m³/year (512 billion SCF) of natural gas from the USSR are transmitted to France (via West Germany), Italy and Yugoslavia, and with more than 2,0 billion cubic meters (71 billion SCF) of underground storage capacity ÖMV is able to meet fluctuations in seasonal demand.

ÖMV operates at an advanced level of technology and makes use of its own research and development laboratories, engineering department, computer software facilities and its specialized design manufacture and construction division for plant and equipment used in the oil and natural gas industry.

Its engineering activities also cover the construction of certain refinery plants, the design and construction of pipelines and district heating systems, consulting and engineering services, as well as the setting up of training programmes at all levels for the requirements of oil and gas industry personnel.





ROHÖL - AUFSUCHUNGS
GESELLSCHAFT

Contributes to cover Austria's
energy needs of crude oil
and natural gas

Founded in 1935, RAG struck oil with its second well "RAG 2" in 1937 in the Zistersdorf area. In the course of its long history, RAG has produced approximately 11,9 million tons (88,1 million barrels) of crude oil and sold 10 billion std cubic metres (372,4 billion cubic feet) of natural gas. Current production flows out of 34 oilfields and 36 gas fields.

PERFORMANCE DATA (1985)

Seismic data have been gathered in the Salzburg, Upper Austrian and Styrian area by one vibroseis seismic crew.

A total of 485 km (303 miles) of seismic lines were shot.

For one part of the year, an additional hammer seismic crew made vibroseis surveys in shallow areas, supporting the seismic crew with short distance lines.

22 wells were completed with a total depth of 48,067 metres (160 224 ft). Oil and / or gas was found in 15 wells; 6 wells were dry. 1 well is an injection well.

Crude oil production was 268,713 tons, (approx. 2 million barrels) equivalent of 23 p.c. of national production.

Natural gas production was 464,7 million std. cubic metres, (17,305 billion cubic feet) equivalent of 38 p.c. of national production.

Sales of natural gas in Upper Austria covered more than 38 p.c. of province's need of natural gas (together with gas imports, corresponding figure is above 40 p.c.).

Investments in exploration and production amounted to 482 million Austrian Shillings.

At year end 1985 maintained in Kremsmünster, Upper Austria crude oil stocks of 178,300 tons (1,301 million barrels). This is stored for RAG owner group affiliates Mobil Oil Austria AG and Shell Austria AG, and is in accordance with the Compulsory Crude Storage and Reports Act.