# B7 Facies development and coralline algae in the Vienna and Eisenstadt Basins (Miocene)

Werner E. PILLER
Vienna

## Geological setting

The Vienna Basin is of rhombohedral shape, strikes roughly southwest - northeast, is 200 km long and up to 55km wide, and extends from Gloggnitz (Lower Austria) in the SSW to Napajedl in Czekia in the NNE. The western border is bound to the south by the morphological eastern margin of the Northern Alps (represented by several Alpine tectonical units: Greywacke Zone, Northern Calcareous Alps, Flysch Zone) and to the north by the Waschberg Zone In the east it is bordered in the south by the hills of the Rosaliengebirge and the Leithagebirge, and in the north by the Little Carpathian Mountains; all three mountain ranges are part of the Alpine-Carpathian Central Zone

The basement of the basin is also composed of the above-mentioned Alpine-Carpathian nappes. The Neogene sediment filling of the basin reaches a thickness of up to 6000m. It is part of the Paratethys (Central Paratethys), with an evolution separated from that of the Mediterranean. This is also expressed by different biostratigraphic stages (e.g., RÖGL & STEININGER 1983; SENES & STEININGER 1985; STEININGER et al. 1988; BALDI 1989; STEININGER et al. 1990; fig. 1).

The *en enchelon* fault pattern within the basin and the sigmoidal shape of the fault system, for example, point to a formation as a pull-apart basin along a northeast-striking, left-slip fault zone (ROYDEN 1988; WESSELY 1988). Basin extension and sedimentation began in Karpatian time as supposed by STEININGER et al. (1986, p. 295), but was restricted to the northern part (north of the Danube). Only during the Badenian also the southern part was included and the final shape of the basin was reached. The various fault structures created a complex pattern of horsts and troughs. Especially at the western border of the basin, relatively uplifted blocks occur; these are separated from the deep depressions located in the east along major faults (e.g. Mistelbach block along the Steinberg fault in the northern, Mödling block along the Leopoldsdorf fault in the southern basin fig. 2). This differentiation, together with rapid changes between trans- and regressions (RÖGL & STEININGER 1983), caused deposition of various sediments depending on distance from land and on position of the particular blocks.

The pre-Badenian sediment filling was highly terrigenous, coarse in marginal positions and more pelitic in the deeper parts. For the first time during the Badenian, a fully marine sedimentation in the whole basin occurred. These sediments consist not only of clastics but also carbonates were deposited. This facial development with local coral reefs and widespread coralline algal limestones is restricted to the Badenian. During the Sarmatian, a reduction in salinity already started leading to non-marine and subsequently continental conditions in the Pannonian-Pontian (compare chapter A5).

The Eisenstadt Basin has a triangular shape and is bordered in the east by the Ruster Höhenzug, in the north by the Leithagebirge, in the west by the Rosaliengebirge, and in the south by the Brennberg (see fig.1 in chapter A5). Its maximum dimensions are approx. 20

by 20 kilometers. It is connected to the Vienna Basin by the "Wiener Neustädter Pforte"; the subsurface separation from the Vienna Basin is represented by the continuation between the Rosalien- and Leithagebirge. Its tectonic and sedimentary history is very similar to that of the southern Vienna Basin and therefore it is considered as a subbasin of the former.

## Facial development during the Badenian

Conditions for carbonate sedimentation and growth of coral buildups were favourable only during the Badenian stage. Therefore, the development and facial distribution for this period should be discussed in more detail. Because of similar development and direct connection, the Vienna and Eisenstadt Basin will be described together.

The general biostratigraphic classification (PAPP et al. 1978; fig. 1) into Lower Badenian (Lower and Upper Lagenid Zone), Middle Badenian (*Spiroplectammina* Zone) and Upper Badenian (*Bulimina-Bolivina* Zone, *Rotalia* Zone) is based on typical foraminiferal assemblages, reflecting in fact an ecostratigraphical sequence. Besides these assemblages, planktonic foraminifers and certain benthic groups are also of special importance, e.g. uvigerinids, bolivinids, and some species of the larger foraminfer *Heterostegina* (e.g., STEININGER 1977; PAPP, CICHA & CTYROKA 1978; PAPP et al. 1978; PAPP & SCHMID 1978; PAPP 1978). The sediments of the lowermost Badenian (Lower Lagenid Zone) are confined to the northern Vienna Basin.

During the Upper Lagenid Zone, sedimentation is fully developed in the entire basin. At the same time marine sedimentation starts in the Eisenstadt Basin.The facial development roughly reflects a distinction between marginal and central facies:

* The basinal facies is characterized by the Baden Tegel, a marl with variable sand and clay content. Intercalated into the marls are sandy layers. This material is transported from marginal sources. These marls and sandy interbeddings are highly fossiliferous, containing an extremely rich micro- (foraminifers, ostracods) and macrofauna (especially mollusks, but also fish teeth; comp. PAPP et al. 1978), well documented since the 19th century (e.g. D'ORBIGNY 1846; REUSS 1849; KARRER 1861; HÖRNES 1856, 1870; HÖRNES & AUINGER 1879). The depositional depth of this fine-clastic material can be interpreted as being not deeper than 50 - 100m (PAPP & STEININGER in: PAPP et al. 1978: 140) or 100 - 200m (TOLLMANN 1985: 500). Although subsidence of the basin during the Badenian was very rapid, this relatively shallow-ater depth can be explained by a high sedimentation rate leading to a sediment accumulation of approx. 1500 m in the central basin during the Badenian (e.g. WESSELY 1988: 342). In the Eisenstadt Basin thickness of the Baden Tegel is distinctly less.

* A much more complex facies pattern is developed along the basin margins in dependence on the hinterland and coastal morphology. In general, the western border of the southern Vienna Basin is highly influenced by the clastic sediment influx from the Northern Alps. Around the Leithagebirge, which represented an island, a chain of islands or a shoal during the Badenian, and along the Ruster Höhenzug, autochthonous carbonate sediments dominate

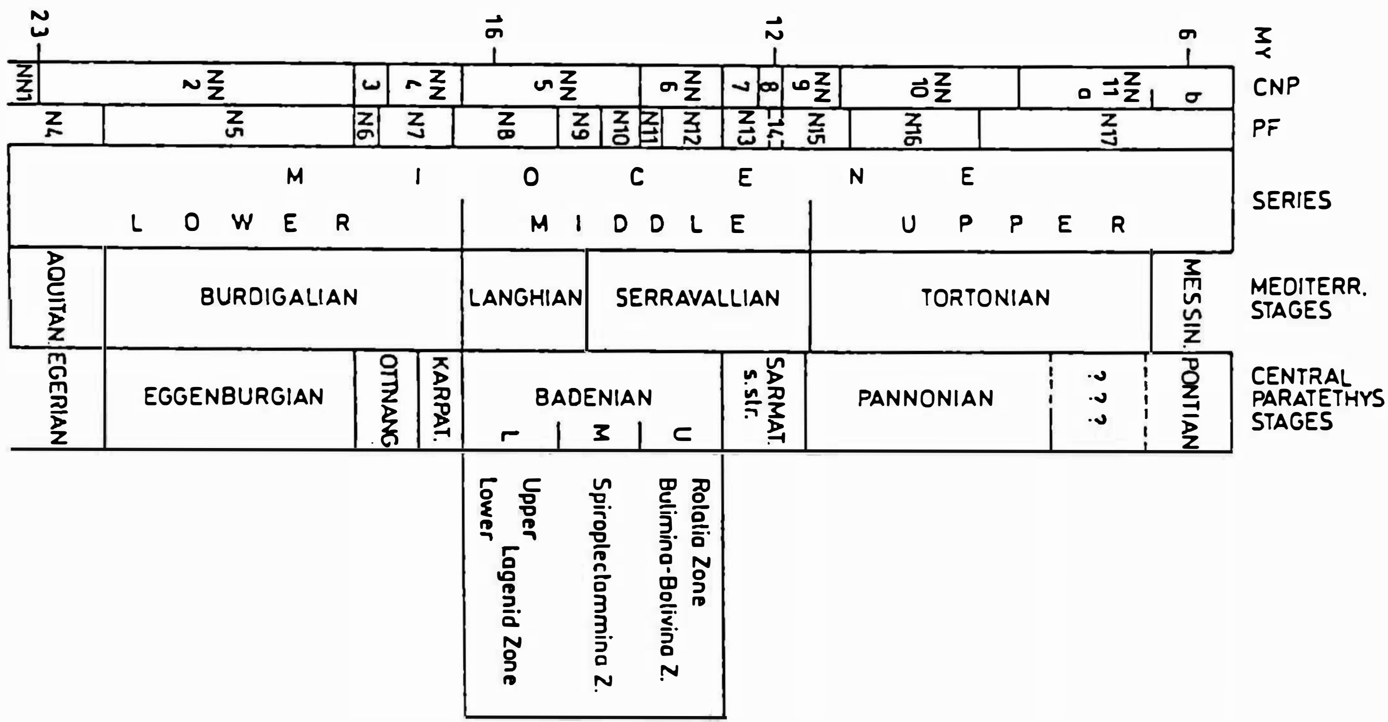
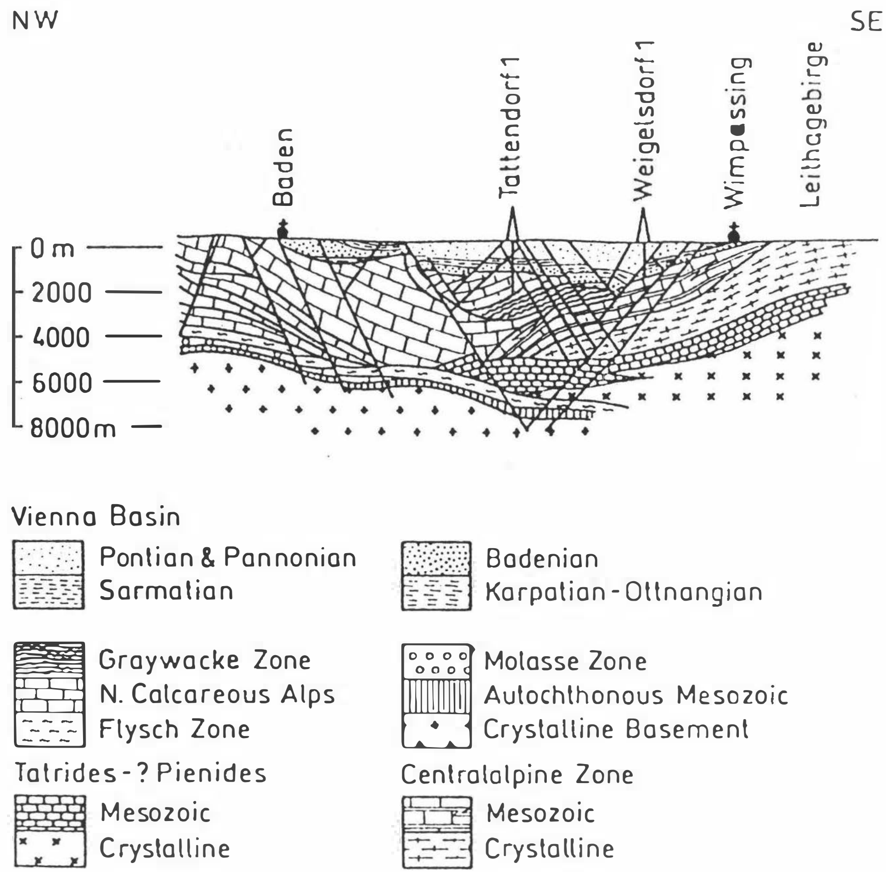



Fig. 1: Correlation chart of the Miocene of the Mediterranien and the Central Paratethys (after STEININGER et al. 1990). CNP: Calcareous Nannoplankton Zones; PF Planktonic Foraminiferal Zones.

Fig. 2: Geological section through the Vienna Basin (after WESSELY 1983: pl 3; modified).



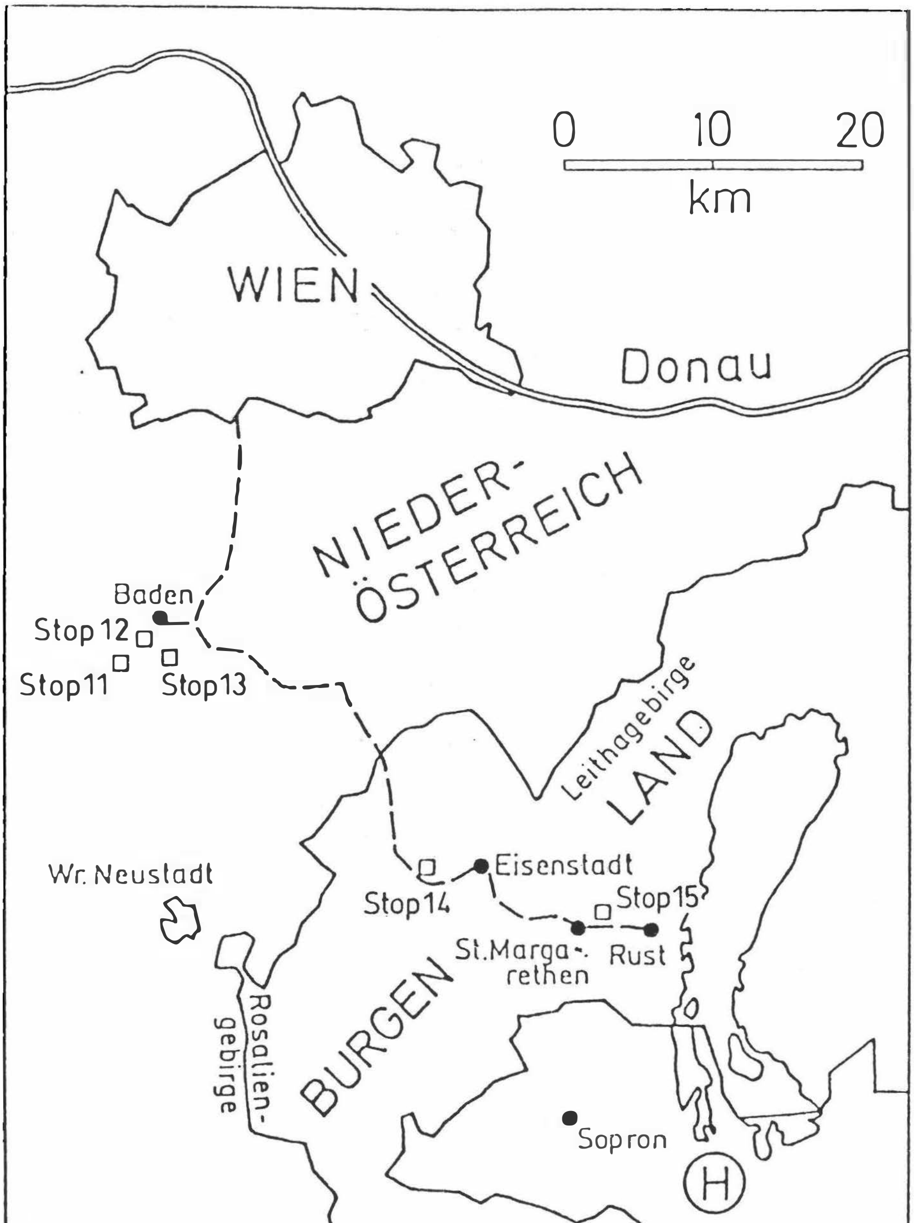



**Fig. 3:** Excursion route across the Vienna and Eisenstadt Basin with Stop locations

irrespective of sometimes thick basal transgressive sediments).

The coastal development along the western margin shows strong fluvial influx at some locations, expressed by thick conglomerates dominated by material derived from the Northern Calcareous Alps as well as the Flysch Zone [Baden (Vöslau) Conglomerate; comp. BRIX & PLÖCHINGER 1988]. In some places, steep rocky shores with large boulders are also preserved (e.g.W' Sooß, see Stop 11), while wide coastal or marginal areas are covered by sands (Gainfarn Sands) with a rich and excellently preserved fauna. These sands interfinger with the Baden Tegel.

The most widespread facies unit along the Leithagebirge and the Ruster Höhenzug as well as at certain sites along the western margins of the Vienna Basin (e.g.around Wöllersdorf) is the Leitha Limestone (compare chapter A5). This unit is characterized by the occurrence of coralline algae in various growth forms, representing rhodolite facies or a maërl type. Coral buildups of limited size are developed only locally. Such buildups are rare along the western margin of the Vienna Basin due to the high terrigenous input and represent only small patch reefs (comp. Stop 11). Along the Ruster Höhenzug no significant coral settlement is developed (or preserved); organic buildups are predominantly made up of bivalve beds accompanied, in some places, by corals (comp. DULLO 1983: 37). The best developed coral buildups are present at the southern tip of the Leithagebirge, where the limestones reach the greatest spatial extent and the thickest sequences (about 50m). Here, due to the island position, no major terrigenous influx restricted coral growth. On the contrary, it can be assumed that water currents or relatively strong waves with ample food supply favoured their growth at the southern tip of the Leithagebirge.

## Stop 11

**Locality**

Roadcut Sooß-Lindkogel

**Topography**

Outcrop along the forest road from Sooß to Sooßer Lindkogel (fig. 4); Map: ÖK 1:50.000, Sheet 76 Wiener Neustadt.

**Stratum**

Leitha Limestone (overlying Hauptdolomite).

**Age**

Upper Lagenid Zone (BRIX & PLÖCHINGER 1988) - *Bulimina-Bolivina* Zone (?); underlying Hauptdolomite (Late Triassic).

**Description**

a) The outcrop along the roadcut shows - from west to east - a bedded dolomite, mainly composed of laminated beds reflecting algal stromatolites. These beds dip at an angle of approx. 40° towards E - NE and represent Late Triassic Hauptdolomite.

This regularly bedded dolomite is interrupted to the east by a breccia of large dolomite boulders (up to $m^3$ size) interspersed with gravel; a fine-grained matrix is, in general, lacking. All constituents of the breccia are very angular to subangular; one of the large components contains a megalodontid bivalve.

Most of the larger fragments are intensively bored by chemically boring bivalves. Because of the large dimensions some of the bore-holes can probably be attributed to *Lithophaga antillarum* D'ORBIGNY 1842 (comp. KLEEMANN 1980). Others were produced by a

*Gastrochaena* species, probably related to *G. gigantea* DESHAYES 1830 (PILLER & KLEEMANN 1991; PILLER & VAVRA 1991). The larger boulders are bored exclusively on the exposed surfaces, showing that the large fragments were not turned over after being deposited.

A few decameters eastward, a monomictic breccia is present with angular to subrounded dolomite components reaching a size up to more than 10cm. These finer-grained breccias are bedded on a decimeter scale and the beds dip between 10 - 20° towards the east. Further to the east, or above these breccias, the roundness of the components increases in some beds and they represent, partly polymictic, conglomerates. These finer-grained breccias and conglomerates show a clear increase in fossil content from west to east. At first only very thin crusts of coralline algae are developed around the components; they become thicker to the east and the crusts also develop protuberances representing rhodoliths or macroids with large nuclei (pl. 1,figs. 1-2). Additional encrusters besides coralline algae include acervulinid foraminifers, serpulids and bryozoans. Between the components, bryozoans, larger foraminifera (*Amphistegina, Heterostegina*), calcitic bivalves (oysters, pectinids), and echinid fragments are present; coral fragments are rare.

b) A few hundred meters downhill along the road a very small outcrop of Leitha Limestone is visible; it represents a limestone composed of branch fragments of coralline algae (maërl type); small rhodoliths occasionally occur, in which the corallines are intergrown with acervulinid foraminifers.

c) A more massive limestone outcrop (at the moment very poor) is present further downhill (between the first and second turn of the road coming from Sooß). This fully cemented limestone is composed of larger coral heads (mainly *Porites*) encrusted by thin coralline algal crusts, serpulids, bryozoans, and sessile foraminifers. Between the coral heads bivalve moulds are abundant and echinoids occur.

**Algal flora**

a)The coralline algae of the breccias form only very thin crusts (mainly ‹1mm), are badly preserved and have not been identified up till now; however, at least *Lithothamnion, Mesophyllum* and *Spongites* have been detected. These thin crusts are intergrown predominantly with sessile foraminifers (mainly acervulinids), sometimes also with serpulids and bryozoans. In the conglomerates crusts become thicker (up to ›5mm) and protuberances are developed. The flora consists of *Lithothamnion* sp., *Palaeothamnium archaeotypum* CONTI, *Mesophyllum* div. sp., *Lithophyllum* sp., *Spongites anguineum* (CONTI), *Spongites duplex* (MASLOV), *Titanoderma* cf. *nataliae* (MASLOV), *Lithoporella* sp. Also fragments of geniculate coralline algae are present.

b) The maërl-type is dominated by *"Lithothamnium ramosissimum* (GUEMBEL) CONTI", *"Lithophyllum ramosissimum* (REUSS) CONTI", *Spongites albanense* (LEMOINE) and also several lamellate *Lithophyllum* species. The rhodoliths or macroids are predominantly built by acervulinid foraminifers and coralline algae are often of minor importance.

c) The patch reef is dominated by crustose coralline algae (encrusting corals, molluscs, etc.), e.g., *Lithothamnion* sp.,

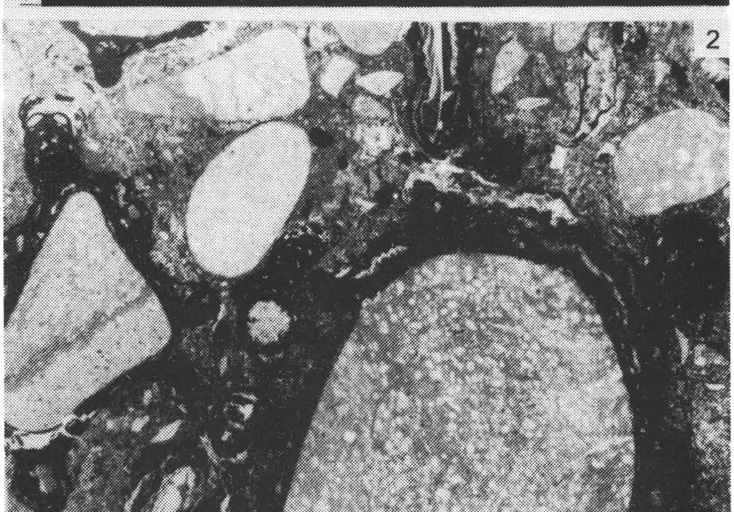


**Plate 1**

**Fig. 1:** Baden Conglomerate, showing well rounding components of the Northern Calcareous Alps encrusted by coralline algal and foraminiferal crusts. - Road cut Sooß -Soosßer Lindkogel (Stop 11a); polished slab;

**Fig. 2:** Thin section of the Baden Conglomerate of fig. 1. - S 81/3/3; magnification: x21.6

*Mesophyllum* sp., *Spongites duplex* (MASLOV).

**Environment**

The westernmost outcrop (a) can be interpreted as steep rocky shore of the Badenian Sea, with Late Triassic Hauptdolomite as coast-forming rock. Just in front a zone with larger boulders, fallen down from the wall, was developed. Water energy must be interpreted as having been moderate because both larger boulders and smaller gravel are angular.

The bedded monomictic dolomite breccias east of these coastal boulders also reflect reworking of nearly autochthonous material by a higher degree of rounding, the polymictic conglomerates point to a (fluvial) transport of various lithologic units from the hinterland. These beds dip with a narrow angle towards the basin.

The coralline algal debris limestone of maërl type (b) reflects autochthonous carbonate production with only little terrigenous influx and moderate energy conditions. The area characterized by coral heads (c) can be interpreted as a small coral patchreef.

Generally the outcrops can be reconstructed as having been located in a shallow-water coastal environment with a gentle morphology bordered by a steep rocky shore. This morphology, documented by some elevations of dolomites inside the Badenian sediments, and the probable fluvial influence produced the variety of facies: directly reworked dolomites at the shore; polymictic conglomerates transported into the marine environment by a river and being subsequently intensively incrusted by coralline algal crusts; coralline algal debris sediments, perhaps deposited in small depressions, in areas protected from terrigenous influence; small coral patches on minor topographic elevations.

**References**

BRIX & PLÖCHINGER 1988; KLEEMANN 1980; PILLER & KLEEMANN 1991; PILLER & VAVRA 1991

## Stop 12

**Locality**

Baden-Rauchstallbrunngraben

**Topography**

Abondoned quarries south of the road Baden - Gasthof Jägerhaus (fig. 4). The locality consists of 2 quarry areas (upper and lower quarry) which are connected by a small path; Map: ÖK 1:50.000, Sheet 76 Wiener Neustadt.

**Stratum**

Baden Conglomerate, Leitha Limestone, "Bryozoan marl".

**Age**

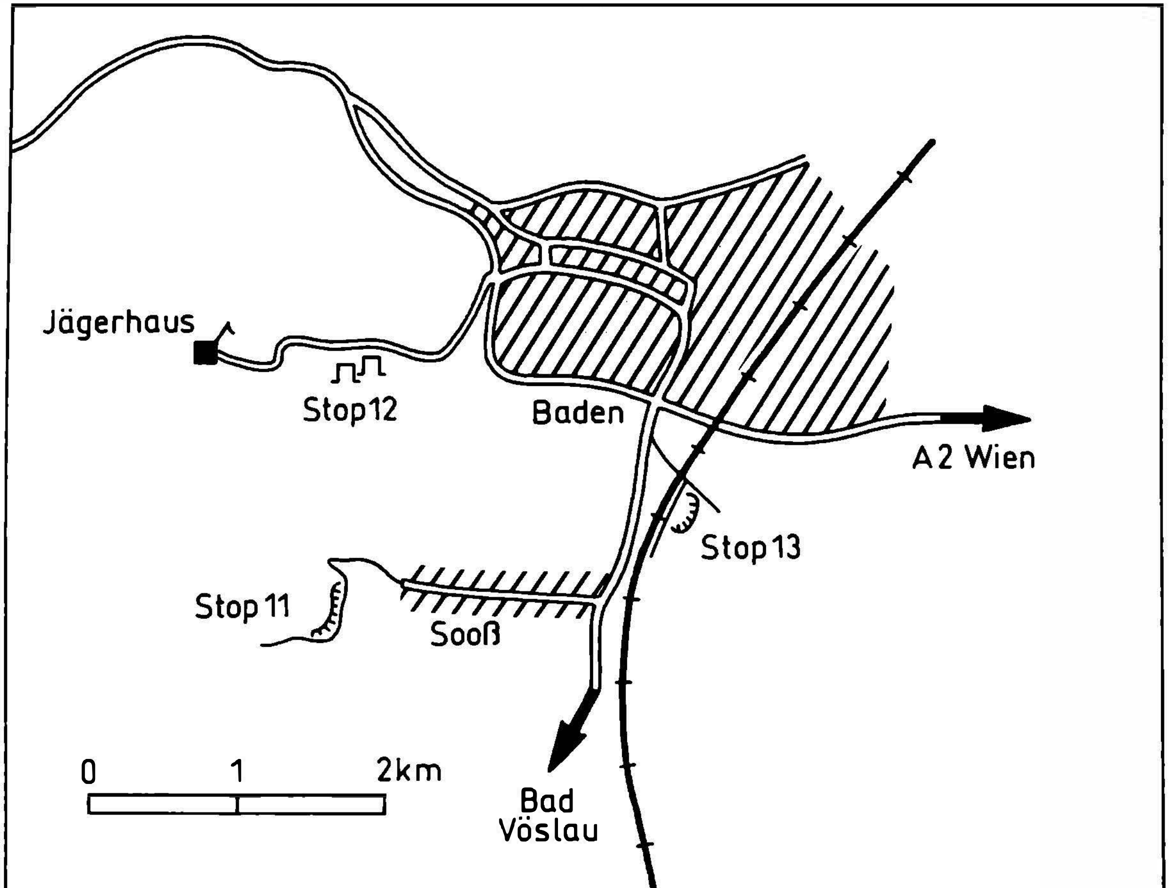
Upper Lagenid Zone (PILLER & VAVRA 1991).

**Description**

a) The upper quarry shows the following section (PILLER & VAVRA 1991):

* Basal sandstone (only partly outcropped)
* Fine conglomeratic to coarse calcareous sandstone (280cm) with clypeastrid echinoids in live position
* Fine sands to sandy marls (250cm) with lebensspuren, echinoids, sandstone concretions, and a poor microfauna with foraminifera (*Ammonia beccarii*, *Elphidium crispum*) and ostracods. Also the skull of a sirenia (*Thalatosiren petersi*) is reported from this bed.
* Polymictic, well rounded, badly sorted conglomerates (500cm) with internal subparallel oblique bedding (20° SE), sometimes fining upward. Besides thalassinoid lebensspuren oysters and

Fig. 4:Location map of Stops 11, 12, 13.



pectinids are common.

* Homogenous conglomerate with similar composition as below.

* Marly coralline algal limestone (badly outcropping only in the eastern part of the quarry).

b) The lower quarry shows the following sequence (PILLER & VAVRA 1991):

* Basal conglomerate (partly outcropping in the eastern part of the quarry).

* Alternation of "Bryozoan marls" (marly sands with bryozoan and larger foraminifera) with fine conglomerates.

* Sandy coralline algal limestones

**Fauna and flora**

a) Besides the fossils already mentioned (foraminifera, ostracods, clypeasterid echinoids, sirenia, lebensspuren), the upper quarry is well known for its rich mollusc fauna. SCHAFFER (1907) listed the following genera: *Panopaea, Gastrochaena, Tellina, Venus, Pinna, Lima, Cardium, Glycymeris, Pecten, Ostrea, Conus, Cypraea, Tritonium* and *Xenophora*.

In the basal beds coralline algae are rare and occur as branch fragments or thin crusts on conglomerate pebbles or sand grains. Mostly they are heavily damaged and/or show dissolution features. However, these conglomerates are the type locality of *Archaeolithothamnium leithakalki* described by CONTI (1946). Only in the uppermost, eastern part a well preserved and diverse algal flora is present.

CONTI (1946) mentioned: *Lithothamnium ramosissiumum, Mesophyllum ingestum, Lithophyllum ramosissimum, L. pseudo-ramosissimum, L. Piai, L. exiguum, Melobesia* sp. To this floral list several taxa can be added, e.g. *Lithothamnion operculatum* (CONTI), *Palaeothamnium archaeotypum* CONTI, *Spongites duplex* (MASLOV), *Spongites microsporum* (MASLOV).

**b)** The "Bryozoan marls" of the lower quarry are not only well known for their highly diverse bryozoan fauna (Cyclostomata and Cheilostomata; VAVRA 1974), but also for larger foraminifera (*Heterostegina costata*), small brachiopods, bivalves, decapod crustaceans, and an echinoderm fauna, consisting not only of regular and irregular echinoids but also of holothurian sclerites (PAPP & KÜPPER 1953).

**Environment**

The different conglomerates and sandstones of the upper quarry point to a fluvially influenced sedimentation, probably to foreset beds of a delta (compare also PLÖCHINGER & PREY 1974). These conglomerates can be related to the fluvial Baden conglomerate of the Helenental occurring closeby. The overlying coralline algal limestones reflect autochthonous carbonate production and decreasing terrigenous influx upsection.

The "Bryozoa marls" of the lower quarry represent the bathymetric deepest parts of this locality being interbedded with conglomeratic sandstones, which reflect the coarse siliciclastic sediments transported downslope. Although the origin of the coralline algae in these coarse-grained sediments is not clear (autochthonous vs. transported origin) the occurrence of *Heterostegina* clearly points to a sedimentation in the photic zone for the "Bryozoan marls"

**References**

CONTI 1946; PAPP & KÜPPER 1953; PILLER & VAVRA 1991; PLÖCHINGER & PREY 1974; SCHAFFER 1907; VAVRA 1974.

## Stop 13

**Locality**
Baden-Sooß Clay pit
**Topography**
Clay pit (abandoned) for brick production between Baden and Sooß (approx. 500f south of the town margin, Fig. 4); Map: ÖK 1:50.000, Sheet 76 Wiener Neustadt.
**Stratum**
Baden Tegel. Holostratotype of Badenian stage and type locality of the Baden Tegel (PAPP & STEININGER [in:] PAPP et al.1978: 138 ff.); the easternmost part consists of Sarmatian Tegel.
**Age**
Upper Lagenid Zone (the easternmost part Sarmatian).
**Description**
The large clay pit, an area of several thousand $m^2$ and over 20 m depth has been abandoned for a few years, and weathering has increasingly obscured the outcrops.
The main part of the pit is made up of Baden Tegel. It represents a grey-blue, plastic clay with intercalated sandy layers and lenses. The clays are mainly massive; only occasionally do fine laminations occur. These sediments, especially the sandy layers and lenses, are extremely rich in excellently preserved fossils, containing calcareous nannoplankton, foraminifers, ostracods, molluscs, fish teeth and otoliths, sometimes also small fragments of badly preserved coralline algae. On the lowermost level, now flooded by ground water, a layer with brachiopods (*Terebratula macrescens*) and crustaceans was present. The mollusc fauna (gastropods, bivalves and scaphopods) is chatacterized by infaunal elements. Axial segments of the gorgonian *Isis melitensis* GOLDFUSS and small solitary corals, e.g. *Stephanophyllia*, occur very rarely (PILLER & KLEEMANN 1991).
Near the eastern margin of the pit, clays with a completely different and restricted fauna are exposed. The faunal association mainly contains cerithiid gastropods and cardiid bivalves.
**Environment**
First of all a sharp differentiation between the Badenian and Sarmatian clay is necessary. Both are separated by a steep fault belonging to the fault system separating the marginal blocks from the more downthrown, central units.
The Baden Tegel represents a quiet water environment where fine-grained clays were deposited. This soft sediment was inhabited by a diverse infauna of foraminifers and molluscs. The sandy layers and lenses reflect a stronger terrigenous influx easily explainable by the marginal basin position of the outcrop. These sands were transported gravitatively or reflect a very distal position of a delta.
The latter interpretation is supported by the occurrence of thick fluviatile conglomerates along the coast west and southwest of the town Baden (Baden Conglomerate). The fauna in the sandy parts is especially rich in fossils and contains associations pointing to a different environment. The depositional depth of the clays may be reconstructed at 50 - 100m (STEININGER & PAPP in: PAPP et al. 1978: 140) or 100 - 200m (TOLLMANN 1985: 500).
The sands originate from shallower areas, as demonstrated for example by the occurrence of small fragments of coralline algae and by the larger foraminifers *Amphistegina*, *Heterostegina* and *Borelis melo*, as well as abundant *Elphidium*. The frequent occurrence of planktonic

foraminifers and calcareous nannoplankton in the clays reflects open water conditions.

**References**

PAPP et al. 1978; PILLER & KLEEMANN 1991; TOLLMANN 1985.

## Stop 14

**Locality**

"Fenk" Quarry/Burgenland

**Topography**

A group of abandoned limestone quarries in the Kalkofenwald approx. 1400m NNW of Großhöflein (SW of Eisenstadt, Burgenland; fig. 5); Map: ÖK 1:50.000, Sheet 77 Eisenstadt.

**Stratum**

Leitha Limestone; Faciostratotype (STEININGER & PAPP in: PAPP et al. 1987: 194ff.; PILLER & KLEEMANN 1991).

**Age**

*Bulimina-Bolivina* Zone.

**Description**

Composed of several quarries totally abandoned a few years ago. The main part of the large area is used as a refuse dump. Nowadays only the uppermost level of the quarry area is well preserved. The rest is buried except some of the lowermost part, which is still visible.

**A)** In the lowermost part of the quarry area an approx. 9m section is outcropping (section Ff in DULLO 1983 fig.8).

Its base is built by a thick bed of bioclastic limestones, rich in coralline algae, bryozoans, bivalves, gastropods, and echinoderms. Layers with rhodoliths occur (poorly exposed).

Upsection, a thinner bedded (few cm to 70 cm) sequence with alternating limestones and more (?)terrigenous and weakly cemented silty layers occurs (pl. 2, fig.1). The limestones represent bioclastic types - similar to the basal layer - belonging mainly to the foraminiferal rhodolite facies or foraminiferal algal debris facies of DULLO (1983).

In some beds, layers of large spheroidal, columnar or columnar/laminar coralline algal rhodoliths occur (pl. 2, fig. 2). The thin silty to marly intercalations are sometimes finely laminated and poor in macrofossils. Some of the thin beds show foldings and dislocations due to slumping. Related to this slumping structures are fissures filled with calcites. The foraminiferal fauna contains uvigerinids and planktonic forms.

In the upper part of the section the relatively thin-bedded sequence is obliquely truncated by a limestone bed showing strong lateral thickness variations (40 - 145cm); larger fragments of crystalline rocks occur here (up to 10cm diameter).

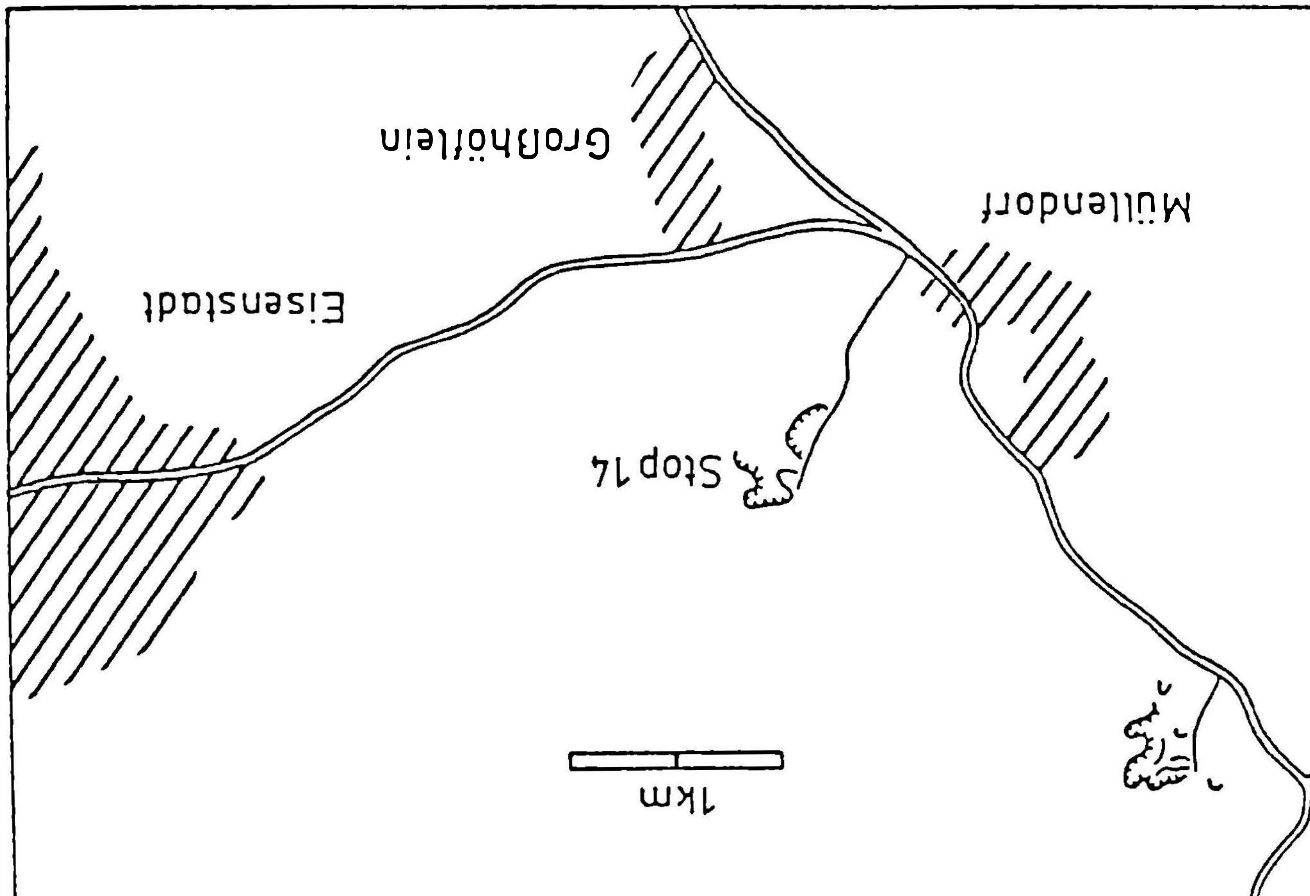
This bed can be subdivided into two parts: a basal layer of coralline algal floatstone with large moulds of aragonitic bivalves, pectinids (sometimes double-valved), bryozoan branches, and echinoderm fragments; an upper layer of bioclastic grainstone fining upwards and containing rhodoliths (up to 7cm) in addition to the bioclastic material. The bioclasts contain rare coral fragments.

The sequence continues with more thin-bedded layers composed of limestones, marly limestones, and terrigenous sand, in part strongly weathered.

B) The upper level of the quarry area contains the largest outcrop; it shows a section of nearly 20m height (PILLER & KLEEMANN 1991: fig. I/10 & I/11). Most obvious are thick limestone beds dipping with approx. 5 - 10° against WNW to SW.

* The lowermost bed - outcropped at the moment - can be subdivided into

Fig. 5: Location map of Stop 14.



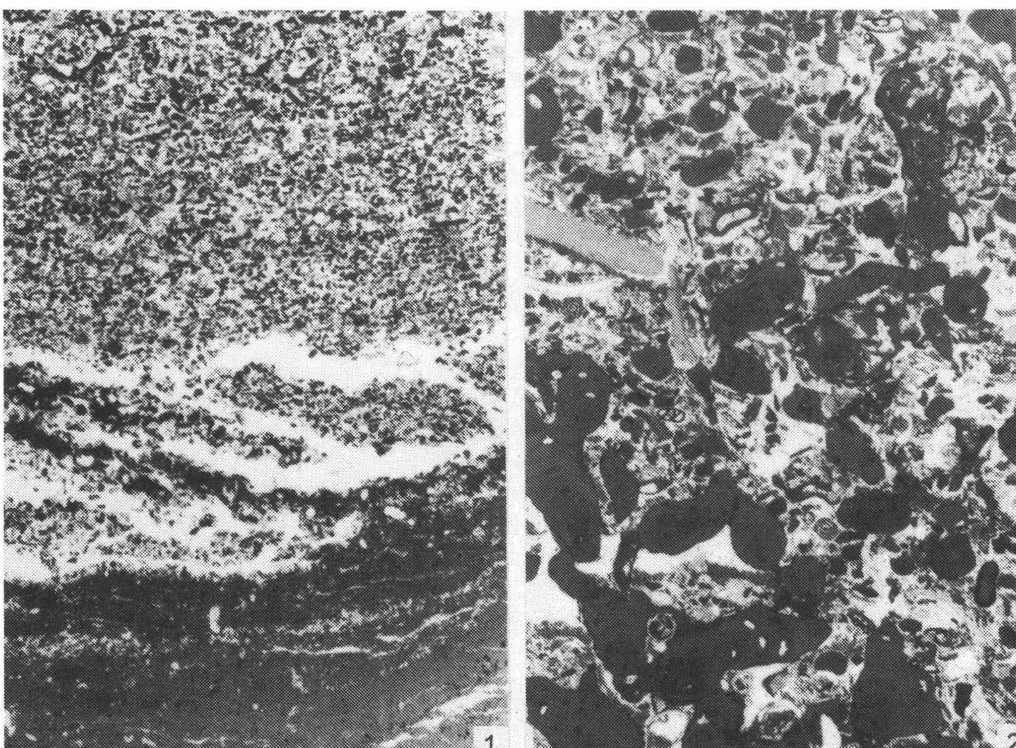


**Plate 2**

Fig. 1: Alternation of silty - muddy limestones (bottom) with bioclastic grainstones. The former represent the autochthonous sediment whereas the later are allodapic in origin, containing abundant coralline algal fragments. - Fenk quarry (Stop 14a9); magnification x14,4.

Fig. 2: Coarse-grained bioclastic coralline algal limestone with part of a columnar rhodolith (bottom left) built by *"Lithophyllum ramosissimum"* (REUSS). - Fenk quarry (Stop 14); magnification: x17,8.

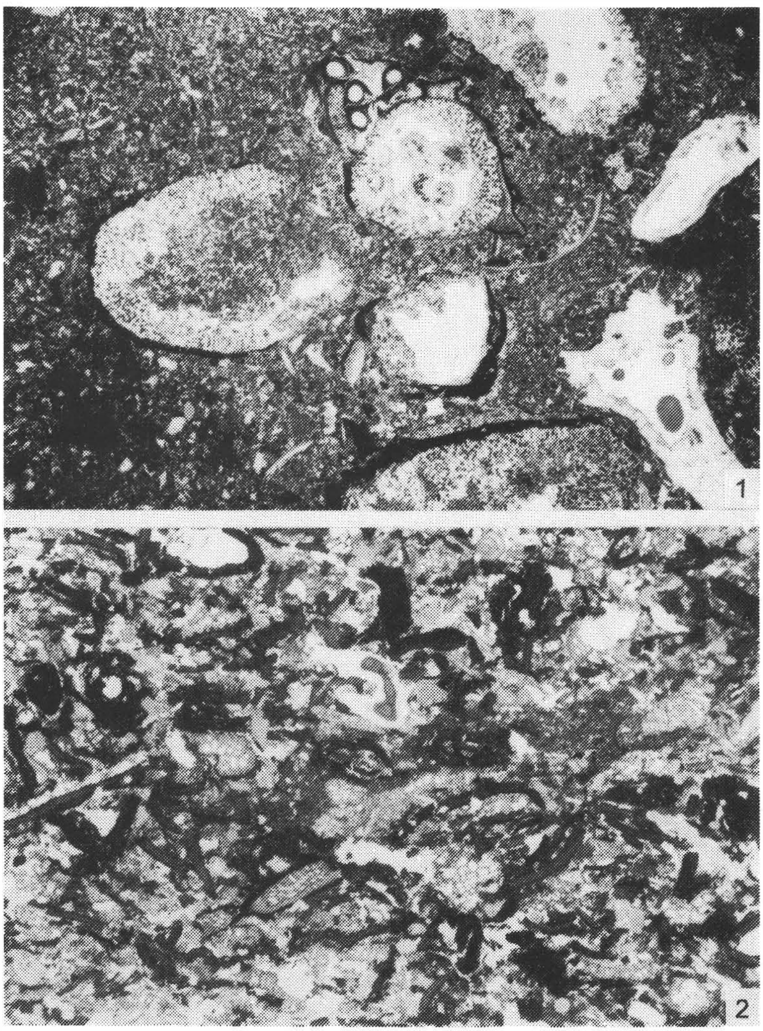



**Plate 3**

**Fig.** 1: Branched corals (*Porites*) encrusted by thin coralline algae and serpulids. -Fenk quarry (Stop 14b); magnification: x22,4.

**Fig.** 2: Coralline algal-bryozoan limestone with dominating lamellate coralline algal species. -Fenk quarry (Stop 14b); magnification: x12,8.

several vertical zones. At the base is a coral limestone (90cm), characterized in the uppermost 30cm by a dense gravel of *Porites* branches. It is overlain by the first "*Isognomum*-bed", where large, double-valved *Isognomum* are accompanying double-valved ostreids. Bioclasts of coralline algal branches occur.

A bed of echinoid-rich bioclastic limestone with large venerid bivalves (*Pitar*) is overlain by the 2nd "*Isognomum*-bed" (60 - 80cm). Double-valved *Isognomum* are very abundant at the base of the bed, where they occur mainly in a more horizontal position; above this layer, the bivalves are oriented more vertically. A coral-dominated zone tops this bivalve dominated zone. The corals are mainly branching *Porites* colonies of approx. 20cm height in an upright position. In this upper part, *Isognomum* again occurs more frequently.

* The next layer (approx. 350cm) is characterized by thick-branched (12 - 22mm) *Porites* bushes in growth position up to 90cm in height. They are rarely inhabited by single *Lithophaga* specimens. Next to these bushes and especially on their tops, thin, plate-like encrusting corals are present (*Porites incrustans* or a *Montipora* species). Other corals include *Caulastrea* - a dendroid faviid - and *Tarbellastraea*. The coral colonies show partly thick coralline algal crusts. Between the coral branches rhodoliths (up to 5cm in diameter) occur.

* This coral dominated horizon is overlain by a bioclastic coralline algal-bryozoan limestone with oysters and rare *Isognomum*. The coralline algae are either branches or small laminar rhodoliths. Bivalves give sometimes rise to thin-branched *Porites* preserved in upright position. The branches are encrusted by relatively thick coralline algal crusts. Interfingering with these coral limestones are limestones with columnar rhodoliths up to 5cm.

* Above follows a coralline algal-bryozoan arenite (70 - 85cm) occasionally containing chaetetids. This layer shows a fining and increasing of bryozoans upward. The rhodoliths are of laminar type.

* A thin marl bed (1-5cm) is developed on top of this arenite containing branched coralline algae. This interruption is followed by a fine-grained coralline algal-bryozoan bioclastic limestone (100cm). Besides branches, the coralline algae are represented by lamellate species (pl. 3, fig. 2,).

* This limestone grades into a brown marl (25cm) with coralline algae (branches as well as rhodoliths).

* A subsequent coralline algal-bryozoan limestone bed (130-160cm) contains fragments of thin-branched *Porites* cf. *leptoclada* REUSS (encrusted by bryozoans and coralline algae) as well as chaetetids. The basal 10-20cm are characterized by flat ellipsoidal rhodoliths (up to 10cm in longer axis). The following 130cm are dominated by bryozoans, being thickly incrusted by coralline algae, and by branched coralline algae. The uppermost part of this layer is characterized by rhodoliths frequently having a coral nucleus.

* A thin marl layer (1-5cm) separates this bed from a thick limestone sequence.

* The basal (90cm) part of the limestone sequence is characterized by frequent occurrence of rhodoliths of a crustose type. The coralline algae are intergrown with bryozoans and acervulinid foraminifers.

A zone (90cm) with abundant ostreids, corals, bryozoans, chaetetids, and serpulids follows. The corals are mainly represented by *Porites* branches preserved only as open moulds due to total dissolution. The oysters are frequently preserved double-valved (pl. 3, fig. 1). This zone grades into a bioclastic coralline algal limestone (70cm); branch fragments of coralline algae dominate here, but thin branches of *Porites* encrusted by corallines are also present. The next 150-160cm represent a coral limestone mainly with branched *Porites* or tiny, thin-branched *Stylocora exilis* REUSS.

The latter occurs mainly as autochthonous (?) rubble, sometimes several decimeters thick. Massive forms [*Tarbellastraea reussiana* (EDWARDS & HAIME)] may also be found in between. Large bivalves are present between the corals.

* The latter lead over to a thick part of the section (450cm) characterized by the frequent occurrence of large bivalves and a subordinate presence of corals. In addition to ostreids, large venerids [e.g. *Pitar*, *Venus* (*Periglypta*)] and carditids especially are abundant.

* The following sequence (400-450cm) is subdivided into only very indistinctly separated zones. At the base it is dominated by rhodoliths, overlain by a coral (*Tarbellastraea*) characterized limestone and by bryozoan limestones.

**Algal flora**

**A)** In the coarser bioclastic sediments branch fragments are dominating, sometimes showing repeated gowth but mainly strong abrasional surfaces. The dominating taxa are *" Lithothamnium ramosissimum* (GÜMBEL) CONTI", *Mesophyllum* div. sp., *" Lithophyllum ramosissimum* (REUSS)", *Spongites albanense* (LEMOINE), *Spongites anguineum* (CONTI), etc. In the finer grained bioclastic beds geniculate coralline algal fragments are relatively abundant. The columnar and columnar/laminar rhodoliths are dominated by *" Lithothamnium ramosissimum* (GÜMBEL) CONTI" and *" Lithophyllum ramosissimum"* (REUSS). Sporolithon sp. was found in the coarse bioclastic bed near the top.

**B)** The coralline algal flora of the upper quarry level is highly diverse and changes widely in composition between the horizons. Altogether, the entire spectrum of species listed in chapter A5 is present. Worth to mention is the presence of a species with heterocysts (=trichocytes).

**Environment**

The limestones of the upper levels of the quarry system are interpreted as representing a coral reef by several authors (e.g. TOLLMANN 1985; STEININGER & PAPP in: PAPP et al. 1978; DULLO 1983). Yet, the sequence represents clearly bedded limestones separated by marly beds and most of the limestones are characterized by a relatively fine bioclastic fabric and the corals are mainly present as rubble. However, some of the limestones contain abundant corals in growth position. One layer exhibits an especially clear sequence starting with an *Isognomum*-ostreid layer on which thick-branched, 90 cm high *Porites* colonies grew.

The latter are encrusted by platy corals (*Montipora*?), and several other coral taxa are present as well. The corals are also encrusted by coralline algal crusts, and a rich accompanying fauna is present between the corals [e.g. *Haliotis*, *Venus (Periglypta)*]. A similar sequence is following, being overlain by a coralline algal-bryozoan limestone. Whether this sequence represents a coral reef or a coral carpet cannot be determined

due to the limited outcrop situation. It can, however, be interpreted as coral buildup in the broadest sense. The flat dipping of the beds points basinwards.
The short section in the lowermost outcrop of the quarry system (A) with its relatively thin-bedded limestone-marl-sand sequence, represents time-equivalent basinal depositions. This sequence exhibits autochthonous fine-grained silty to marly limestones (characterized by organisms of an open marine environment) which are interrupted by allodapic limestones and a coarse-grained bioclastic limestone (representing a channel fill) and some more features pointing to a gravitational transport on a slope.

References

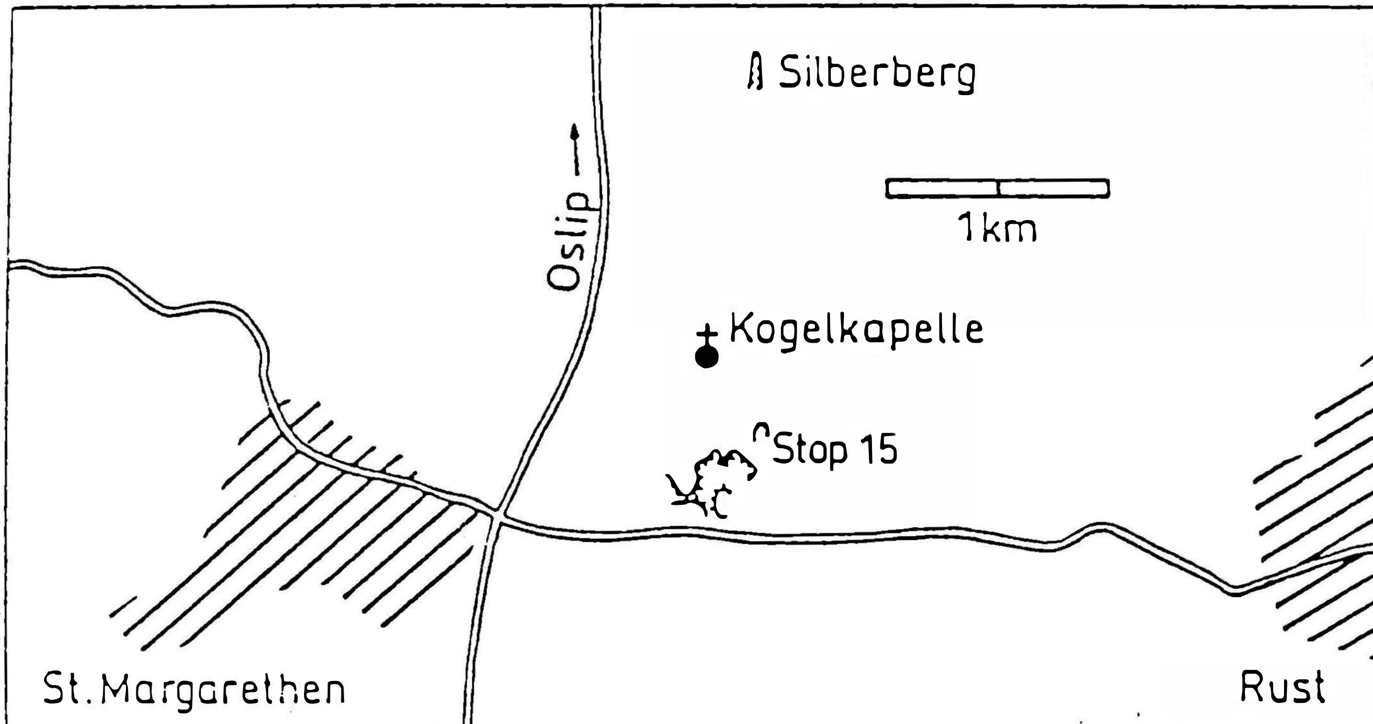
DULLO 1983; PAPP et al. 1978; TOLLMANN 1985.

### Stop 15

**Locality**
St. Margarethen (Roman quarry)
**Topography**
A group of limestone quarries located approx. 2km east of St. Margarethen along the main road to Rust, Burgenland (fig. 6). Some are still active (e.g., quarry "Hummel" north of the road, quarry "Kummer" southward), some date back to the Roman period; Map: ÖK 1:50.000, Sheet 78 Rust.
**Stratum**
Leitha Limestone.
**Age**
*Spiroplectammina* to *Bulimina-Bolivina* Zone; the passage into the quarry "Hummel" is of Sarmatian age (FUCHS 1965).
**Description**
The sections in the quarries are characterized by weakly cemented and highly porous limestones. According to DULLO (1983), the limestones represent serveral microfacial types ranging from foraminiferal facies, foraminiferal algal debris facies, foraminiferal rhodolite facies, to pavement facies. Generally, foraminifers, echinoids, bryozoans, and coralline algae are the dominant sediment constituents. The pavement facies is developed in layers with rhodoliths up to 10cm in diameter (pl. 4, figs. 1-2). Molluscs are represented mainly by oysters - in some layers enriched - and pectinids.
Remarkable is one facial development exposed in the quarry "Kummer" south of the main road; here, laminated marls and marly limestones containing a well-preserved fish fauna occur. The best impressions of the various limestone types are obtained by studying the large cut limestone slabs in "Hummel" quarry.

**Algal flora**
*Lithothamnion operculatum* (CONTI),
*Palaeothamnium archaeotypum* CONTI,
*Mesophyllum* sp.,
*"Lithophyllum ramosissimum"*(REUSS),
*pongites albanense* (LEMOINE),
*Spongites anguineum* (CONTI),
*Spongites duplex* (MASLOV),
*Spongites microsporum* (MASLOV),
*Lithoporella* sp.
The large rhodoliths of the pavement facies are multispecies aggregates, however, predominantly built by crustose coralline algae. Foraminifera, bryzoans and serpulids are of subordinate importance.
**Environment**
The sandy carbonates can be interpreted as shallow water sands, where, in shallow depressions, an accumulation of rhodoliths (pavement facies)

Fig. 6:Location map of Stops 15.



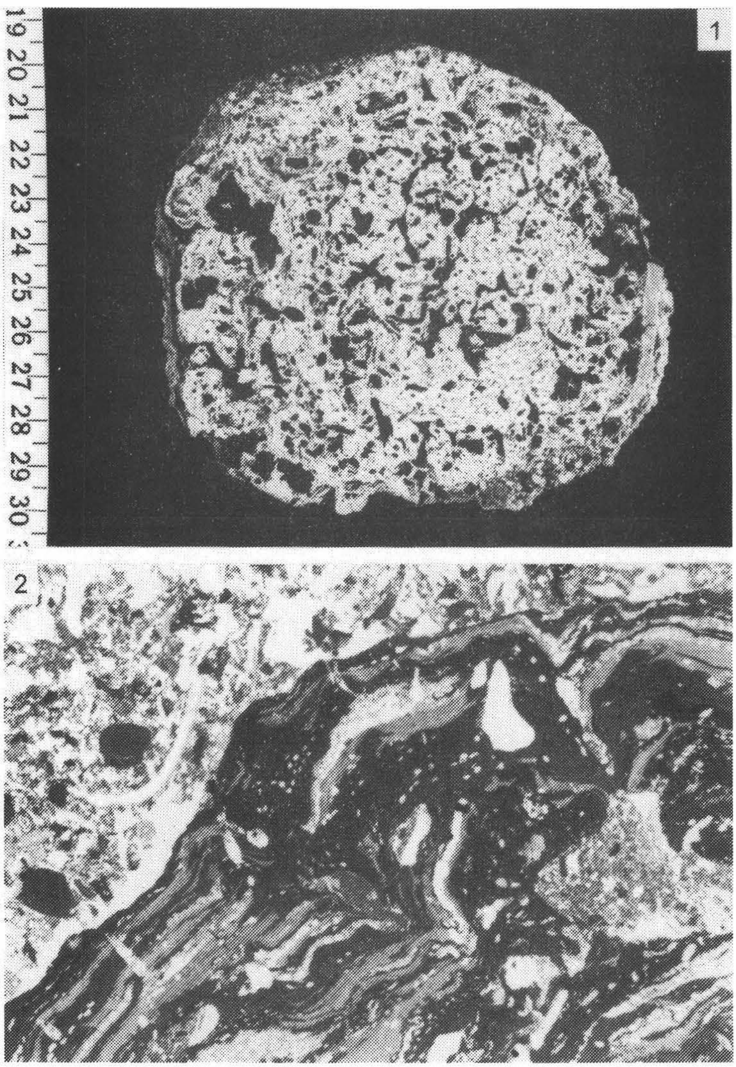



**Plate 4**

Fig. 1: Large, heavely bored, coralline algal-foraminiferan-bryozoan rhodolith. - St. Margarethen (Stop 15); impregnated with red-coloured resin and polished.

Fig. 2: Thin section of part of a rhodolith similar to fig. 1. Besides crusts of coralline algae of several species, abundant acervulinid foraminifera and bryozoans (bottom, left half) are visible. -St. Margarethen (Stop 15); magnification x17,6.

occurred. The laminated marls and marly limestones have been interpreted by DULLO (1983) as being deposited in depressions inside a lagoonal environment.

**References**

DULLO 1983; FUCHS 1965

**Acknowledgements**

The investigations were supported by project P 8090-GEO of the Austrian "Fonds zur Förderung der wissenschaftlichen Forschung". Thanks are due to a group of students working out more details in the "Fenk quarry" during a field course in spring 1993. The line drawings were performed by N. Frotzler (Institute for Palaeontology, University of Vienna).

BALDI, T.(1989): Tethys and Paratethys through Oligocene times. Remarks to a comment. - Geologica Carpathica, 40(1): 85-99, 3 figs.; Bratislava.

BRIX, F. & PLÖCHINGER, B.(1988): Erläuterungen zu Blatt 76 Wiener Neustadt. - 85 pp., 7 figs.; Vienna (Geol. Bundesanst.).

CONTI, S.(1946): Le Corallinacee del calcare miocenico (Leithakalk) del bacino di Vienna. - Publ. Ist. Geol. Univ. Genova, Quaderni 1 - 2, ser. A - Paleontologia: 31-68, 7 pl.; Genova.

DULLO, W.-CH.(1983): Fossildiagenese im miozänen Leitha-Kalk der Paratethys von Österreich: Ein Beispiel für Faunenverschiebungen durch Diageneseunterschiede. - Facies, 8: 1-112, 22 figs., 15 pls.; Erlangen.

FUCHS, W.(1965): Geologie des Ruster Berglandes (Burgenland). - Jahrb. Geol. Bundesanst., 108: 155-194, 3 figs., 2 pls.; Vienna.

HÖRNES, M.(1856): Die fossilen Mollusken des Tertiaer-Beckens von Wien. 1. Band: Univalven. - Abh. k. k. Geol. Reichsanst., 3: 1-736, 1 map, Atlas with 52 pls.; Vienna.

HÖRNES, M.(1870): Die fossilen Mollusken des Tertiaer-Beckens von Wien. 2. Band: Bivalven. - Abh. k. k. Geol. Reichsanst., 4: 1-479, Atlas with 85 pls.; Vienna.

HÖRNES, R. & AUINGER, M.(1879): Gasteropoden der Meeres-Ablagerungen der ersten und zweiten miocänen Mediterran-Stufe in der Österreichisch-Ungarischen Monarchie. - Abh. k.k. Geol. Reichsanst., 12 (1): 1-382, 50 pls.; Vienna.

KARRER, F.(1861): Über das Auftreten der Foraminiferen in den marinen Tegeln des Wiener Beckens. - Sitzber. kaiserl. Akad. Wiss., math.-naturwiss. Cl., Abt. I: 427-459, 2 pls.; Vienna.

KLEEMANN, K.H.(1980): Korallenbohrende Muschel seit dem mittleren Lias unverändert. - Beitr. Paläont. Österr., 7: 239-249, 1 pl.; Vienna.

D'ORBIGNY, A.(1846): Die fossilen Foraminiferen des tertiären Beckens von Wien... - XXXVII + 312 pp, 21 pls.; Paris (Gide et Comp.)

PAPP, A. & KÜPPER, K.(1953): Holothurienreste aus dem Torton des Wiener Beckens. - Sitzungsber. österr. Akad. Wiss., math.-naturwiss. Kl., Abt. 1, 162: 49-51, 1 pl.; Vienna.

PAPP, A.(1978): Die Entwicklung der Heterosteginen im Badenien. - in: PAPP, A., CICHA, I., SENES, J. & STEININGER, F. (eds.): M4 - Badenien (Moravien, Wielicien, Kosovien). - Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys, 6: 284-288, pls. 12-13; Bratislava (Slowak. Akad. Wiss.).

PAPP, A., CICHA, I., SENES, J. & STEININGER, F. (eds.)(1978): M4 - Badenien (Moravien, Wielicien, Kosovien). -Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys, 6: 1-594; Bratislava (Slowak. Akad. Wiss.).

PAPP, A., CICHA, I. & CTYROKA, J.(1978): Allgemeine Charakteristik der Foraminiferenfauna im Badenien. - in: PAPP, A., CICHA, I., SENES, J. & STEININGER, F. (eds.): M4 - Badenien (Moravien, Wielicien, Kosovien). - Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys, 6: 263-268, figs. 55-57; Bratislava (Slowak. Akad. Wiss.)

PAPP, A., RÖGL, F., CICHA, I., CTYROKA, J. & PISHVANOVA, S.(1978): Planktonische Foraminiferen im Badenien. - in: PAPP, A., CICHA, I., SENES, J. & STEININGER, F. (eds.): M4 - Badenien (Moravien, Wielicien, Kosovien). - Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys, 6: 268-278, pls. 1-8; Bratislava (Slowak. Akad. Wiss.).

PAPP, A. & SCHMID, M.E.(1978): Die Entwicklung der Uvigerinen im Badenien der Zentralen Paratethys. - in: PAPP, A., CICHA, I., SENES, J. & STEININGER, F. (eds.): M4 - Badenien (Moravien, Wielicien, Kosovien). - Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys, 6: 279-284, pls. 9-11; Bratislava (Slowak. Akad. Wiss.).

PILLER, W.E. & KLEEMANN, K.(1991): Middle Miocene reefs and related facies in Eastern Austria. I) Vienna Basin. - VI. International Symposium on Fossil Cnidaria including

Archaeocyatha and Porifera, Excursion-Guidebook, Excursion B4, 1-28, 12 figs.; Münster.

PILLER, W.E. & VAVRA, N.(1991): Das Tertiär im Wiener und Eisenstädter Becken. - in: ROETZL, R. & NAGEL, D. (ed.): Exkursionen im Tertiär Österreichs, Molassezone-Waschbergzone-Korneuburger Becken - Wiener Becken - Eisenstädter Becken: 161-216, figs. 41-49; Vienna (Österr. Paläont. Ges.).

PLÖCHINGER, B. & PREY, S.(1974): Der Wienerwald. - in: Sammlung Geologischer Führer, 59: 141 pp. 23 fifs., 3 tabs., 2 maps.; Berlin - Stuttgart (Borntraeger).

REUSS, A.E.(1849): Neue Foraminiferen aus den Schichten des österreichischen Tertiärbeckens. - Denkschr. K. Akad. Wiss., math.-naturwiss. Cl., 1: 365-390, 6 pls.; Vienna.

RÖGL, F. & STEININGER, F.F.(1983): Vom Zerfall der Tethys zu Mediterran und Paratethys. Die neogene Paläogeographie und Palinspastik des zirkum-mediterranen Raumes. - Ann. Naturhist. Mus. Wien, 85/A: 135-163, 2 figs. 14 pls.; Vienna.

ROYDEN, L.H.(1988): Late Cenozoic tectonics of the Pannonian Basin System. - in: ROYDEN, L.H. & HORVATH, F. (eds.): The Pannonian System. A study in basin evolution. - Amer. Assoc. Petrol. Geol. Mem. 45: 27-48, 13 figs.; Tulsa.

SCHAFFER, F.X.(1907): Geologischer Führer für Exkursionen im inneralpinen Becken der nächsten Umgebung von Wien. - in: Sammlung geologischer Führer, Bd. XII: 126 pp., 11 figs.; Berlin (Bornträger).

SENES, J. & STEININGER, F.F.(1985): I. Mediterranean Tethys and Paratethys Neogene Stages and their current correlation. - in: STEININGER, F.F., SENES, J., KLEEMANN, K. & RÖGL, F. (eds.): Neogene of the Mediterranean Tethys and Paratethys. Stratigraphic correlation tables and sediment distribution maps. - vol. 1: 1-10; Vienna (Inst. Paleontology).

STEININGER, F.F.(1977): Integrated assemblage-zone biostratigraphy at marine-nonmarine boundaries: examples from the Neogene of Central Europe. - in.: KAUFFMANN, E.G. & HAZEL, J.E. (eds.): Concepts and methods of biostratigraphy, 235-256, 11 figs.; Stroudsburg (Dowden, Hutchinson & Ross).

STEININGER, F.F., WESSELY, G., RÖGL, F. & WAGNER, L.(1986): Tertiary sedimentary history and tectonic evolution of the Eastern Alpine Foredeep. - Giornale di Geologia, ser. 3, 48(1-2): 285-297, 10 figs.; Bologna.

STEININGER, F.F., MÜLLER, C. & RÖGL, F.(1988): Correlation of Central Paratethys, Eastern Paratethys, and Mediterranean Neogene stages. - in: ROYDEN, L.H. & HORVATH, F. (eds.): The Pannonian System. A study in basin evolution. - Amer. Assoc. Petrol. Geol. Mem. 45: 79-87, 3 figs.; Tulsa.

STEININGER, F.F., BERNOR, R.L. & FAHLBUSCH, V.(1990): European Neogene marine/continental chronologic correlations. - in: LINDSAY, E.H., FAHLBUSCH, V. & MEIN, P. (eds.): European Neogene mammal chronology. 15-46: 1 fig.; New York (Plenum Press).

TOLLMANN, A.(1955): Das Neogen am Nordwestrand der Eisenstädter Bucht. - Wissenschaftliche Arbeiten Burgenland, 10: 1-75, 7 figs., sets A-G, 1 geol. map; Eisenstadt.

TOLLMANN, A.(1985): Geologie von Österreich. Band II. Außerzentralalpiner Anteil. - 710 pp., 287 figs.; Vienna (Deuticke).

VAVRA, N.(1974): Cyclostome Bryozoen aus dem Badenien (Mittelmiozän) von Baden bei Wien (Niederösterreich). - N. Jb. Geol. Paläont. Abh., 147: 343-375, 3 figs.; Stuttgart.

WESSELY, G.(1983): Zur Geologie und Hydrodynamik im südlichen Wiener Becken und seiner Randzone. - Mitt. österr. geol. Ges., 76: 27-68, 8 pls.; Vienna.

WESSELY, G.(1988): Structure and development of the Vienna Basin in Austria. - in: ROYDEN, L.H. & HORVATH, F. (eds.): The Pannonian System. A study in basin evolution. - Amer. Assoc. Petrol. Geol. Mem. 45: 333-346, 10 figs.; Tulsa.