

# Early Miocene (Ottangian) coastal upwelling conditions along the southeastern scarp of the Bohemian Massif (Parisdorf, Lower Austria, Central Paratethys)

by

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## Abstract

Lower Miocene clays of the Zellerndorf Formation and intercalated diatomites of the Limberg Member from the Alpine-Carpathian Foredeep in Lower Austria show distinct features for coastal upwelling conditions along the steep southeastern scarp of the Bohemian Massif during the Ottangian. The sediments were deposited in a deep marine sublittoral environment, in a pelagic, deep-neritic zone. The communities of diatoms, calcareous nannoplankton and planktonic foraminifera clearly point to the influence of cold and nutrient-rich deep-water currents, typical for upwelling zones. The very high content of smectitic clay minerals in both the sediments and volcanoclastics of time-equivalent strata in this area indicate prominent acidic volcanic input at this time. Thus, besides the nutrient-rich deep-water currents, the induced high silica content in the sea also boosted biogenic productivity, especially for diatoms.

The new species *Nonion gudrunae* RÖGL n. sp. is described from the Ottangian Zellerndorf Formation in the diatomite pit Parisdorf, and a lectotype of *Nonion commune* (d'ORBIGNY, 1846) is designated.

**Keywords:** Limberg Member, Zellerndorf Formation, diatomite, coastal upwelling, *Nonion gudrunae* RÖGL n. sp.

## Zusammenfassung

In den untermiozänen Tonen der Zellerndorf-Formation und den darin eingeschalteten Diatomiten der Limberg-Subformation der Alpin-Karpatischen Vortiefe in Niederösterreich sind deutliche Hinweise auf „coastal upwelling“ entlang des südöstlichen Steilrandes der Böhmisches Masse während des Ottangiums zu erkennen. Die marinen, sublitoralen Sedimente stammen aus der pelagischen, tiefneritischen Zone. Die Vergesellschaftungen von Diatomeen, Nannoplankton und planktonischen Foraminiferen lassen deutlich den für „upwelling“-Zonen typischen Einfluss von kalten und nährstoffreichen Tiefenströmen erkennen. Die sehr hohen Anteile von smektitischen Tonmineralen in beiden Sedimenttypen weisen in Verbindung mit vulkanoklastischen Einschaltungen in zeitgleichen Ablagerungen dieses Gebietes auf maßgeblichen Eintrag von sauren Vulkanoklastika zu dieser Zeit hin. Der dadurch hervorgerufene hohe Anteil gelöster Silikate im Meerwasser war neben den nährstoffreichen Tiefenströmen sicher ein zusätzlicher Faktor für die hohe biogene Produktivität, vor allem bei den Diatomeen.

Aus der Foraminiferenfauna von Mergeln der Zellerndorf-Formation (Ottangium) aus der Diatomitgrube Parisdorf wird die neue Art *Nonion gudrunae* RÖGL n. sp. beschrieben und für *Nonion commune* (d'ORBIGNY, 1846) ein Lectotyp bestimmt.

## 1. Introduction

Coastal upwelling is a very common phenomenon along coasts all over the world (SUMMERHAYES et al., 1992, 1995). Winds blowing nearly parallel to a continental coastline, combined with the effect of the earth's rotation, push the light coastal surface water toward the open ocean and away from the land. This offshore-moving water is replaced by cooler and saltier water, which upwells from the ocean's depths (SMITH, 1995). Typically, this water has a high concentration of nutrients such as nitrates, phosphates and silicates, which sustain biological production. Areas under coastal upwelling are highly productive, resulting in big populations of marine plankton and fish shoals, in

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turn attracting marine mammals and sea birds. Coastal upwelling systems have been studied in detail over the last decades because of their prime economic importance and impending anthropogenic impacts and interference.

The very high nutrient supply in coastal upwelling areas fuels high production rates of phytoplankton. Diatoms are the dominant phytoplankton under these conditions, forming the base of the food chain (HUTCHINGS et al., 1995). In geological time this phytoplankton helped create diatomites, which are indicative for such upwelling conditions in the past. In the geological record, however, diatomites are not very common and are concentrated mostly in Miocene and Pliocene deposits.

In the Alpine-Carpathian Foredeep in Austria, the most prominent deposit of diatomites is located about 60 km NW of Vienna, close to the SE margin of the Bohemian Massif, near the town of Maissau. In the older literature, these diatomites are known as “diatomites of Limberg” or “diatomites of Limberg-Parisdorf” More recently, the diatomites were defined as the Limberg Member (ROETZEL et al., 1999a).

Diatomites were once mined in the surroundings of Limberg and Oberdürenbach and were used as filler material, filtering agent, absorbent and clarifier (F.H.R., 1922; REIDL, 1939; LECHNER, 1956; OTRUBA, 1987). Currently, diatomites are mined only in the Parisdorf diatomite pit of the Wienerberger AG, 2.5 km ESE of Maissau and about 400 m SE of Parisdorf. This material is used as insulator in bricks (ROETZEL et al., 1999b; MANDIC et al., 2005).

The present paper discusses the indications for coastal upwelling conditions based on the records of diatoms, foraminifera and nannoplankton in the Limberg Member diatomites and the overlying pelites of the Zellerndorf Formation.

## 2. Geological setting

The geological situation of this area was described by SCHAFFER (1914), GRILL (1976) and ROETZEL (1994, 1996a, b, 2004), and is shown in detail on the Austrian geological map GÖK22 Hollabrunn (ROETZEL et al., 1998; Fig. 1).

The crystalline upland of the Bohemian Massif in Austria is bordered at its SE margin against the Miocene sedimentary area of the Alpine Carpathian Foredeep by a prominent fault zone. This Diendorf fault zone is formed by NE - SW running subparallel dislocations with sinistral strike-slip character (ROETZEL, 1996a). The morphological slope consists of several steep scarps, numerous spurs and frequent inselberg-like bedrock elevations scattered across the foreland (ROŠTÍNSKÝ & ROETZEL, 2005). Close to the main faults, both the crystalline rocks and the bordering sediments of the foredeep are heavily sheared and tectonically influenced.

In this area the crystalline rocks of the Bohemian Massif are mostly Precambrian granites of the Thaya Batholite. They are overlain by marine nearshore sediments of the Lower Miocene (lower Upper Eggenburgian; ROETZEL et al., 1999a), mainly represented by sands and gravel of the

Burgschleinitz Formation. The erosional contact is overlain by sandy shallow marine limestones of the Zogelsdorf Formation (uppermost Eggenburgian), which laterally and vertically pass into deepwater pelitic sediments of the Lower Miocene (Ottngian) Zellerndorf Formation. Drillings in this area show that the pelites above the Zogelsdorf Formation are about 25 - 100 m thick (RASCHKA, 1912; SCHAFFER & GRILL, 1951; ROETZEL, 1994, 1996a).

At the top part of the Zellerndorf Formation, diatomites of the Limberg Member are intercalated in the clays (ROETZEL, 1996a; ROETZEL et al., 1991, 1999b). Laterally towards the E, the diatomites thin out, interfingering with the Ottngian pelites. The occurrences of the diatomites are restricted to the surroundings of Limberg, Oberdürenbach and Parisdorf, very close to the Diendorf fault scarp (Fig.1).

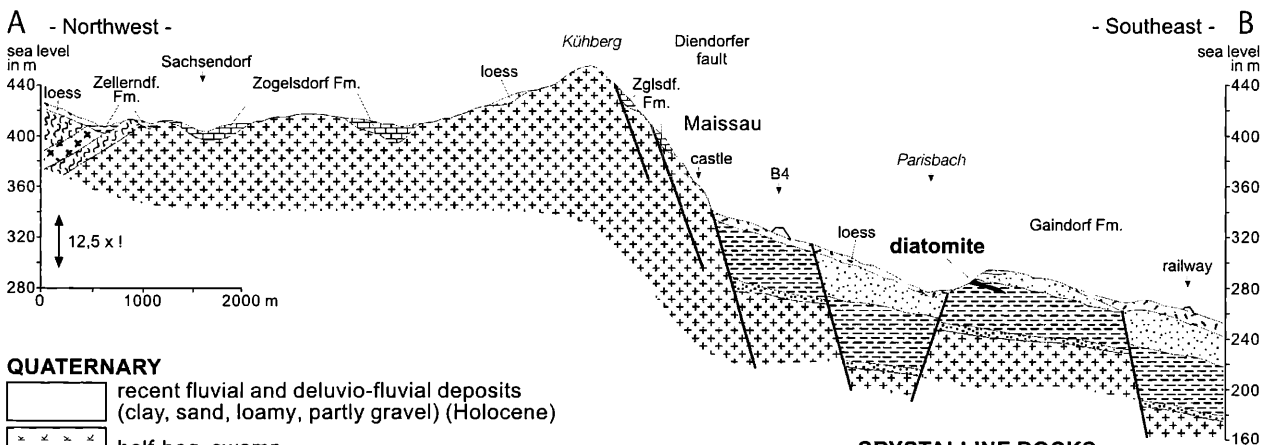
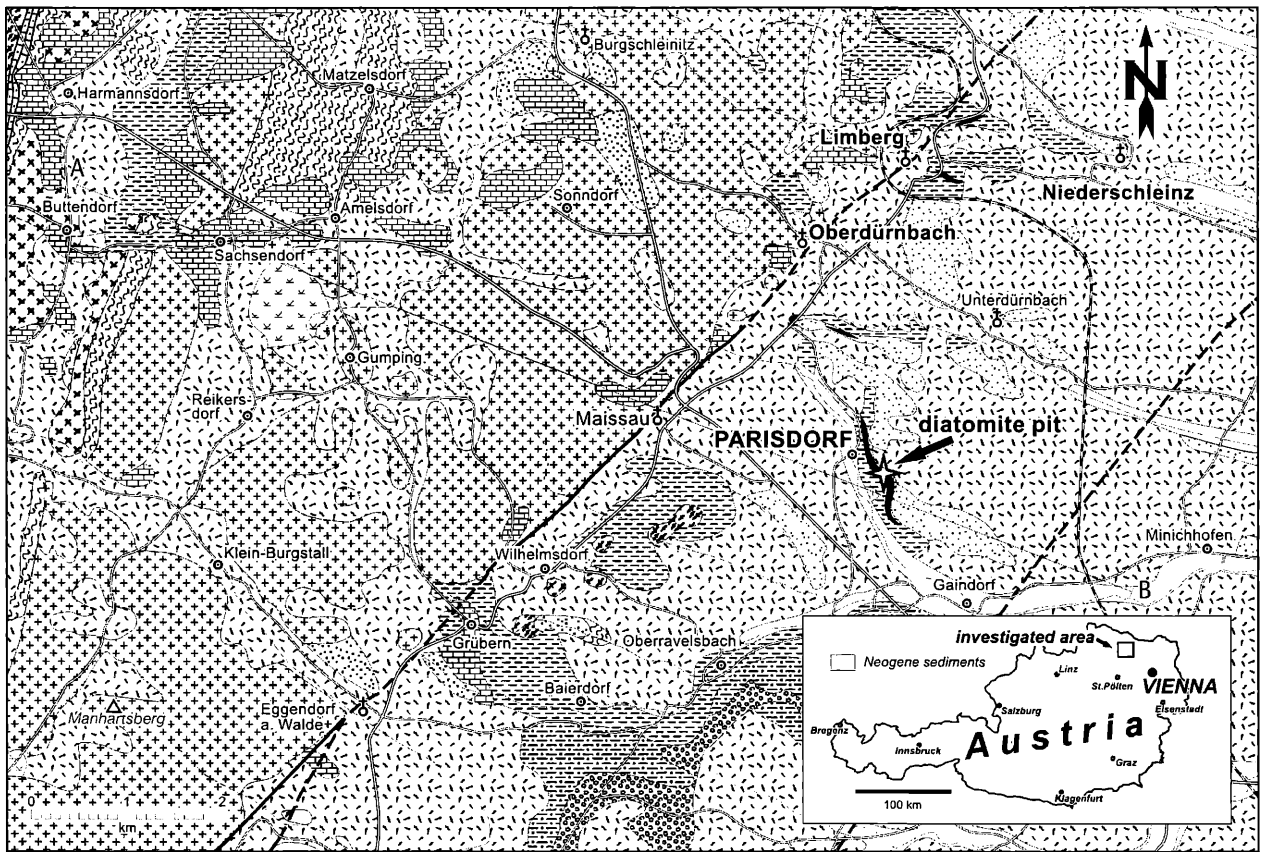
Marine silts and fine sands with gravelly intercalations above the Zellerndorf Formation belong to the Lower Miocene (Karpatian) Laa Formation (ROETZEL, 1996a). Additionally, in parts they are overlain by erosional relicts of the Middle Miocene (Lower Badenian). These clays, fine- to medium sands and gravel belong to the marine Gaidorf Formation (DAXNER-HÖCK, 2002; ROETZEL, 1996a). South to Southeast of this area, fluvial gravel and sands of the Hollabrunn - Mistelbach Formation lie above the Lower to Middle Miocene marine formations. These Upper Miocene (Pannonian) sediments were deposited by a pre-Danube river (NEHYBA & ROETZEL, 2004).

All these formations E of the Diendorf fault are affected by intensive horst-graben tectonics (cross section, Fig.1). On the surface, most of the area is covered by Pleistocene loesses.

The diatomites of the Limberg Member occur between the villages Parisdorf, Oberdürenbach, Limberg and Niederschleinz, E to NE of Maissau (Fig.1). Outcrops of the diatomites are very rare because of the widespread Quaternary cover and the intensive agricultural land use in this area. A few natural outcrops are located in small ditches 150 m N of the Limberg railway station and 670 m NW of the chapel of Niederschleinz (GRILL 1976; ROETZEL 1996a). In the outcrop at Niederschleinz, diatomites and diatomitic pelites are intercalated in silt-clays, showing a more distal facies of the Limberg Member (ŘEHÁKOVÁ, 1996; ROETZEL, 1996a). Recently the best profiles are open in the diatomite pit of Parisdorf (Pl.1) and the abandoned pit of Limberg (ROETZEL et al., 1991, 1999b). The old pit of Oberdürenbach, known from the literature, is closed and recultivated.

In the surroundings of the diatomite pit of Parisdorf, the diatomites overlie a light greenish-grey to greyish-brown, thin-bedded, but mostly massy and firm silty clay to clayey silt (ROETZEL, 1996a). In the outcrop Parisdorf, however, they are not exposed and are only proven by drillings (ROETZEL et al., 1999b). These pelites of the Ottngian Zellerndorf Formation are poor in fossils and only contain remains of siliceous organisms (sponges) and fishes.

The overlying diatomites of the Limberg Member are firm and finely laminated and more or less clearly striped due to rhythmic stratification of whitish and greyish layers (Pl.



**QUATERNARY**

- recent fluvial and deluvio-fluvial deposits (clay, sand, loamy, partly gravel) (Holocene)
- half-bog, swamp
- loess, decalcified loess, loam (Pleistocene)

**NEOGENE (MIOCENE)**

- Hollabrunn-Mistelbach Formation (gravel, sand) (Pannonian)
- Gaidorf Formation (clay, fine- to medium sand, gravel) (Badenian)
- Laa Formation (silt - fine sand, gravel) (Karpatian)
- Limberg Member (diatomite) (Ottangian)
- Zellerndorf Formation (clay - silt, mudstone) (Ottangian)
- Zogelsdorf Formation (sandy limestone, granite boulders) (Eggenburgian)
- Gauderndorf Formation (fine sand), Burgschleinitz Formation (fine- to coarse sand), Kühnring Member (sandy clay) (Eggenburgian)

**CRYSTALLINE ROCKS BOHEMIAN MASSIF**

- Moldanubian**
  - Gföhl gneiss
- Moravian**
  - Bittesch gneiss
  - marble
  - mica schist, paragneiss, quartzite
  - Therasburg gneiss
  - Thaya granite
  - fault

**Figure 1:** Geological map and cross section of the area around Maissau (modified after ROETZEL, 2004). Compilation of the map by R. ROETZEL; geological mapping by P. BATIK, I. CÍCHA, G. FRASL, P. HAVLÍČEK, O. HOLÁSEK, R. ROETZEL, J. RUDOLSKÝ, F.F. STEININGER, and W. VETTERS.

1E). In the area of Limberg - Parisdorf the diatomites are 5 to 7.5 m thick. In the Parisdorf pit they normally have a thickness of about 5 to 6 m (Pl. 1A,1B) and are divided in two parts by a 20 - 25 cm thick, greenish-grey clayey layer, about 2 m below the top of the diatomites (Pl. 1A). The diatomites of the lower part of the succession are characterized by a larger clay amount. In the upper part of the succession the diatomites are foliaceous and, after desiccation, disintegrate into sheets bounded originally by loose agglomerations of siliceous tests (ŘEHÁKOVÁ, 1994). The light interlayers are 1 - 2 mm thick, weakly silty and bear rich accumulations of well-preserved, mostly planktonic diatoms accompanied partly by silicoflagellates and archaeomonad cysts. The darker, grey to greyish-brown interlayers show a variable thickness of 1 - 10 mm. They have a higher inorganic siliciclastic content and mostly fragmented siliceous plankton tests which often have only a subordinate presence in the interlayers. The darker layers are partly represented by menilite, which is a greyish to reddish-brown form of opal, also known as "leberopal" (Pl. 1D). These chert layers were probably formed early in diagenesis (BEHL & GARRISON, 1994) and presumably represent secondarily lithified and siliciclastic-rich intercalations. Based on these cherty intercalations in the diatomites, the pelitic sediments with diatomites around Limberg and Parisdorf were summarised to "Menilitschiefer" in the first geological maps (CZIZEK, 1849; LIPOLD & PRINZINGER, 1851).

Grain size analysis shows that the diatomites in the ternary diagram (FÜCHTBAUER, 1959; MÜLLER, 1961) plot to silt-clays. The fractions of coarse and medium silt are around 10 % by weight. The major grain size is below 6  $\mu\text{m}$ , with an amount of about 30 % by weight of fine silt (6 - 2  $\mu\text{m}$ ) and 60 % by weight of the fraction < 2  $\mu\text{m}$ .

Mineralogically (Wimmer-Frey in ROETZEL et al., 1999b) the phyllosilicates dominate with 70 to 80 % by weight or somewhat more, nearly corresponding with the amount of the fraction < 2  $\mu\text{m}$ . On average the portion of quartz lies below 20 % by weight. Feldspar, mostly albite, comprises max. 6 % by weight. In the fraction < 2  $\mu\text{m}$  the smectite group prevails with more than 70 % by weight alongside small portions of kaolinite and illite.

Although the Limberg Member is known for spectacular findings of fishes (PILLER, 1991), palm leaves and bladder wrack (seaweed) (BERGER, 1955), birds (BACHMAYER, 1980), insects (BACHMAYER, 1975) and crabs (BACHMAYER, 1983), no such macrofossils are available yet from the Parisdorf pit. Until now, only fishes and indeterminate plant remains have been retrieved from the site.

Above the diatomites of the Limberg Member, a quick transition into pelitic sediments of the Zellerndorf Formation is again visible. In the Parisdorf pit the succession is at most about 5 to 6 m thick (Pl. 1A, 1B). The finely laminated diatomites are topped by 2 to 3 m of thin-bedded blue-grey and brownish non-calcareous silt-clays. The pelites are partly bioturbated and show some layers with *Bathysiphon* (agglutinated foraminifera) on the bedding planes (Fig. 2). This is followed by finely laminated and thin-bedded, light- and dark-brown silt-clays with alternat-



**Figure 2:** Sediment surface with agglutinated *Bathysiphon filiformis* M. Sars. Parisdorf, non-calcareous shales of the Zellerndorf Formation above the diatomite (Rö 62-93).

ing non-calcareous and calcareous layers. The typically white bedding planes, consisting of fine silt and calcareous nannoplankton, sometimes contain plant debris, fish scales and otoliths. The carbonate content increases up-section. About two meters below the Pleistocene cover, half a meter of a light-brown marl bed is exposed. The pelites are in part rich in micro- and nannofossils (see below).

The pelites of the Zellerndorf Formation in the Parisdorf pit have a grain size distribution very similar to that of the diatomites. The silt-clays, however, are somewhat finer with about 20 - 25 % by weight fine silt and 60 - 68 % by weight of the fraction < 2  $\mu\text{m}$ . Moreover, the middle silt fraction becomes more prominent upward the section.

The mineralogy of these pelites is also related with that of the diatomites. The phyllosilicates again dominate, but are not as prominent as in the diatomites below. The portions of quartz and feldspar are nearly identical. A major difference is the occurrence of carbonates. Dolomite lies below 3 % by weight, but calcite shows values of about 10 % by weight or higher. The clay mineralogy is both quantitatively and qualitatively nearly identical to that of the diatomites. In the spectra of heavy minerals, garnet, zircon and apatite dominate.

The Parisdorf pit is positioned along a large WNW - ESE striking regional fault, genetically in parts linked with the Diendorf fault system. The diatomite horizon of the southern block is almost undisturbed except for a vertical fissure system. Northwards, however, it becomes heavily pressed and folded (Pl.1D, 1F), with secondarily nearly doubled sediment thickness up to 10 m (Pl.1C). Therein, the succession is mostly tilted northwards by 40° to almost 75°, although the compression also renders southward tilting visible. The diatomites show a complex history of deformation with multiple NW- and SE- as well as NNE-directed overthrusts, and NNE- and SSW-directed normal faults (DECKER in ROETZEL et al., 1999b). Both overthrusts can only be dated as post-Ottangian. The NNE- and SSW-directed normal faults are connected with a graben-structure visible at the eastern end of the pit. Inside this graben, the clayey sediments of the Zellerndorf Formation

are accompanied by dark reddish brown soil sediments and loess (Pl. 1C). Normally, these dark, reddish brown soil sediments indicate Upper Pliocene to Lower Pleistocene (HAUŠLÍČEK et al., 1998) allowing this structure to be dated to this time.

### 3. Systematic paleontology

#### 3.1. Diatom and silicoflagellate record

The first mention of the diatom flora of the Limberg Member originates from TEMPERE & PERAGALLO (1907-1915), who named the locality Limberg “Limbourg (Autriche)”. In the papers “Diatomées du Monde Entier” they published a list with about 70 taxa. Thereafter, the diatom flora as a whole was never again revised. Recently, the diatoms of the Limberg Member were studied and published in overviews by ŘEHÁKOVÁ (1993, 1994, 1996, and 1997).

In the Limberg Member, the diatoms are the most abundant siliceous microfossils. Together with the less abundant silicoflagellates, as well as chrysoomonads with archeomonad cysts and ebridians, they are the principal rock-forming components of the diatomites (Tab. 1).

Nevertheless, the diatom assemblage shows a species diversity with about 90 taxa belonging to 46 genera (ŘEHÁKOVÁ, 1994). The most frequent genera are *Thalassionema*, *Chaetoceros*, *Coscinodiscus*, *Rhizosolenia*, *Stephanopyxis* and *Thalassiosira*. In the Parisdorf pit between 1.8 and 3.5 m of the profile, the whitish layer surfaces commonly comprise horizontally oriented, large disc-shaped *Coscinodiscus* tests (ŘEHÁKOVÁ, 1994). In the upper part of the Parisdorf profile, between 4.7 and 6.5 m, tests of the genera *Thalassionema*, *Chaetoceros*, *Rhizosolenia*, *Thalassiosira* and *Stephanopyxis* dominate.

The absence of shallow-sea benthic taxa is remarkable. Only certain layers in the profile in Parisdorf sporadically contain fragmented tests of *Diploneis smithii* (BRÉB.) CLEVE, *Navicula lyra* EHR., *Navicula hennedyi* W.SM., *Navicula praetexta* EHR. and *Isthmia szaboii* PANT. (ŘEHÁKOVÁ, 1994). Very rare elements are fragmented tests of *Triceratium*, *Cocconeis*, *Aulacodiscus* and *Asterolampra*.

Littoral meroplankton forms [*Actinocyclus ehrenbergii* RALFS, *Actinoptychus undulatus* (BAIL.) RALFS] are more frequent in the lower part of the profile (ŘEHÁKOVÁ, 1994). The same author reports a variable frequency of the genera *Goniothecium*, *Pseudopyxilla*, *Pterotheca*, *Xanthiopyxis*, *Dossetia*, *Liradiscus*, and *Stephanogonia* in the whole profile, probably representing resting spores.

Diatoms of the genus *Thalassionema* (*Thalassionema nitzschioides* (GRUN.) GRUNOW, *Thalassionema obtusum* (GRUN.) ANDREWS, *Thalassionema hirosakiensis* (KAN.) SCHRAD) are highly concentrated in the thin whitish layers of the laminated diatomites. Together with *Thalassiothrix* and certain other planktonic forms, they are typical for cool and nutrient-rich coastal upwelling conditions. In the communities with *Thalassionema*, spikes and spores of *Chaetoceros* are very common. The cysts of *Di cladia*

*capreolus* EHR. presumably also belong to this genus; these cysts are especially common in the Parisdorf pit from 4.3 - 4.5 m and 5.5 - 5.7 m. *Rhizosolenia*, a planktonic form of the marine pelagic area, is found together with *Chaetoceros*, *Thalassionema*, *Xanthiopyxis* or *Coscinodiscus* over nearly the entire profile between 1.0 and 6.5 m. The neritic planktonic forms *Stephanopyxis turris* (GREV.) RALFS and *Thalassiosira excentrica* (EHR.) CLEVE. are also homogeneously distributed, increasing in the upper part of the section (ŘEHÁKOVÁ, 1994).

The marine forms are also accompanied by a few, probably allochthonous euhaline diatoms such as *Hyalodiscus scoticus* (KÜTZ.) GRUN., *Podosira stelligera* (BAIL.) MANN, *Cyclotella striata* (KÜTZ.) GRUN., *Diploneis crabro* (EHR.) EHR., and *Diploneis smithii* (BRÉB.) CLEVE. (ŘEHÁKOVÁ, 1994). The freshwater form *Aulacoseira praegr anulata* (JOUSÉ) SIM. is rare, but can be found reworked in marine Miocene sediments.

Based on the composition of the diatom flora, the diatomites of the Limberg Member can be interpreted as deposits of the deeper marine sublittoral, with dominating neritic and pelagic marine plankton (ŘEHÁKOVÁ, 1994).

In the small ditch NW of Niederschleinz (ROETZEL, 1996a), where diatomites and diatomaceous clays interfinger with silt-clays of the Zellerndorf Formation, a more distal facies of the Limberg Member is recognizable (ŘEHÁKOVÁ, 1996). The species-rich diatom flora is comparable with Parisdorf, although benthic and epiphytic forms dominate in the lower part of the profile. In the higher and more laminated diatomites, planktonic forms prevail. Well-preserved pelagic diatoms document stable conditions in the deeper neritic zone (ŘEHÁKOVÁ, 1996). Up-section, the diatomites pass over into pelagic clays indicating the end of the diatom bloom.

The silicoflagellates and archaeomonads of the Limberg Member were investigated by STRADNER (1956, 1961, 1962, and 1971), BACHMANN & PAPP (1968), and MARTINI & MÜLLER (1975). In the Limberg pit, *Distephanopsis* dominates among the silicoflagellates (STRADNER, 1956, 1961; BACHMANN & PAPP, 1968; MARTINI & MÜLLER, 1975). The genera *Archaeomonas* and *Litheusphaerella* represent the archaeomonad cysts (STRADNER, 1971). The silicoflagellates, ebridians and archaeomonads from the Parisdorf section are listed in Tab.1, and partly documented on Pl. 2.

#### 3.2. Calcareous Nannoplankton

Calcareous nannofossils were studied from the localities Parisdorf and Niederschleinz (Tab. 2, Pl. 2). The diatomites of the Limberg Member from Parisdorf lack calcareous nannoplankton. Laminated calcareous layers of the Zellerndorf Formation from the same locality are very rich in well-preserved nannoplankton assemblages dominated by two taxa: *Coccolithus pelagicus* and *Coronosphaera mediterranea*. The accompanying assemblages consist of *Coccolithus miopelagicus*, *Cyclicargolithus floridanus*, *Helicosphaera ampliaperata*, *H. carteri*, *H. euphratis*, *H.*

DIATOMS	Roetzel P-1	Roetzel P-6	N 22/48-4/94	N 22/48-6/94	Temp. (°C)
<i>Achnanthes</i> sp.				x	
<i>Actinocyclus hungaricus</i> (PANT.) HAJÓS	x	x			
<i>Actinocyclus octanarius</i> EHRENBURG	x			x	
<i>Actinocyclus octanarius</i> EHRENBURG var. <i>minuta</i> (PANT.) HAJÓS				x	
<i>Actinocyclus octanarius</i> var. <i>tenellus</i> (BREB.) HENEDEY	x			x	
<i>Actinoptychus senarius</i> (EHR.) EHRENBURG	x	x	x	x	C
<i>Arachnoidiscus</i> sp.	x				
<i>Chaetoceros affinis</i> LAUDER	x			x	
<i>Chaetoceros</i> spp.	x			x	T - C
<i>Cladogramma ellipticum</i> LOHM.	x				
<i>Cocconeis concitata</i> PANT.				x	
<i>Cocconeis notabilis</i> A. SCHM.				x	
<i>Cocconeis scutellum</i> EHRENBURG				x	5 - 25
<i>Cocconeis vetusta</i> A. SCHM.				x	
<i>Coscinodiscus antiquus</i> (GRUN.) RATTR.	x			x	
<i>Coscinodiscus</i> cf. <i>apiculatus</i> EHR. var. <i>ambigua</i> GRUNOW				x	
<i>Coscinodiscus bulliens</i> A. SCHM.	x				
<i>Coscinodiscus curvatus</i> GRUNOW	x			x	C - T
<i>Coscinodiscus</i> cf. <i>excentricus</i> EHRENBURG	x			x	
<i>Coscinodiscus globosus</i> HAJÓS	x			x	
<i>Coscinodiscus grunowii</i> PANT. var. <i>minor</i> (PANT.) RATTR.				x	
<i>Coscinodiscus</i> cf. <i>moelleri</i> A. SCHM.				x	
<i>Coscinodiscus oculus iridis</i> EHRENBURG	x			x	C - T
<i>Coscinodiscus papillosum</i> HAJÓS				x	
<i>Coscinodiscus stellaris</i> ROPER				x	W - C
<i>Coscinodiscus vetustissimus</i> PANT.				x	
<i>Coscinodiscus</i> spp.	x	x		x	
<i>Delphineis penelliptica</i> ANDREWS				x	
<i>Delphineis</i> sp.				x	
<i>Dimeregramma angustatum</i> HAJÓS				x	
<i>Diploneis szontaghii</i> (PANT.) CLEVE				x	
<i>Diploneis taschenbergi</i> (A. SCHMIDT) HUSTEDT				x	
<i>Diploneis</i> sp.				x	
<i>Grammatophora</i> spp.				x	
<i>Hemiaulus hungaricus</i> PANTOCSEK	x				
<i>Hemiaulus polymorphus</i> GRUNOW				x	
<i>Hyalodiscus planus</i> KOZYR.				x	
<i>Liradiscus asperulus</i> ANDREWS				x	

**Table 1.** Distribution of siliceous microfossils in samples from Parisdorf (P) and Niederschleinz (N) with their paleotemperature indication (W – warm water species, T – species characteristic for more temperate areas, C – cold water species).

*mediterranea*, *Pontosphaera multipora*, *Reticulofenestra bisecta*, *R. daviesii*, *R. pseudoumbilica*, *Sphenolithus disbelemnus* and *Sphenolithus moriformis*. All investigated samples contain low percentages of reworked Cretaceous forms: *Arkhangelskiella cymbiformis*, *Arkhangelskiella maastrichtiana*, *Eiffellithus gorkae*, *Calculites obscurus*, *Microrhabdulus undosus*, etc.

The Niederschleinz sediments – both the diatomites of the Limberg Member and the underlying pelites of the Zellerndorf Formation – contain calcareous nannoplankton. All samples from the Limberg Member yield rich and well-preserved but poorly diversified nannoplankton assemblages, identical to the nannoflora from Parisdorf.

	Roetzel P-1	Roetzel P-6	N 22/48-4/94	N 22/48-6/94	Temp. (°C)
<i>Melosira clavigera</i> GRUNOW					x x
<i>Melosira omma</i> CLEVE					x
<i>Melosira</i> sp.					x
<i>Navicula</i> sp.					x
<i>Paralia sulcata</i> var. <i>genuina</i> fa. <i>radiata</i> GRUNOW					x x W - C
<i>Periptera tetracladia</i> EHRENBURG					x x x x
<i>Podosira robusta</i> PANT.					x
<i>Psammodiscus nitidus</i> (GREG.) ROUND & MANN					x
<i>Pseudodimerogramma elongata</i> SCHRAD.					x
<i>Pseudopodosira westii</i> (W. SM.) SHESH. & GLESER					x
<i>Rhaphoneis amphiceros</i> (EHR.) GRUN.					x T
<i>Rhaphoneis elegans</i> (PANT. & GRUN.) HANNA					x T
<i>Rhizosolenia</i> spp.					x x
<i>Stephanopyxis turris</i> (GREV.) RALFS					x x x x
<i>Thalassionema nitzschioides</i> (GRUN.) GRUNOW					x x x x W - T
<i>Thalassiosira</i> cf. <i>leptopus</i> (GRUN.) HASLE & FRYXELL					x W - T
<i>Xanthiopyxis acrolopha</i> FORTI					x
<i>Xanthiopyxis hystrix</i> FORTI					x
<b>SILICOFLAGELLATES</b>					
<i>Distephanopsis crux</i> (EHR.) DUMITRICA					x x x T
<i>Distephanopsis crux parvus</i> (BACHMANN) DESIK. & PREMA					x x T - C
<i>Distephanopsis hannai</i> (BUKRY) DESIK. & PREMA					x T
<i>Distephanopsis stradneri</i> (JERKOVIC) PREMA & DESIK.					x T - C
<i>Distephanus speculum</i> (EHR.) HAECKEL					x x C (0-15)
<i>Mesocena elliptica</i> (EHR.) EHRENBURG					x T
<i>Mesocena quadrangula</i> EHR. ex HAECKEL					x T
<b>EBRIIDALES</b>					
<i>Ammodochium rectangulare</i> (SCHULZ) DEFLANDRE					x
<i>Ebria triparita</i> (SCHUM.) LEMMERMANN					x
<i>Ebriopsis valida</i> DEFLANDRE					x x x
<i>Hermesinum adriaticum</i> ZUCHARIAS					x x W - T
<i>Parathranium clathratum</i> (EHR.) DEFL.					x x
<b>CHRYSOMONADALES</b>					
<i>Archaeomonas</i> spp.					x x x W
<b>GYMNODINIALES</b>					
<i>Actiniscus pentasterias</i> EHRENBURG					x x x W

Nannofossil assemblages from diatomites are dominated by *Coccolithus pelagicus* and *Coronosphaera mediterranea*. Underlying sediments from the Zellerndorf Formation are characterized by less abundant nannoplankton with very rare *Coronosphaera mediterranea*.

### 3.3. Foraminifera

The foraminiferal fauna of the Ottnangian stage was mainly characterized by assemblages from the western Alpine-Carpathian Foredeep (CICHA et al., 1973; WENGER, 1987; RÖGL et al., 1998). In this region the underlying

CALCAREOUS NANNOFOSSILS	Sample- No.	PARISDORF								NIEDERSCHLEINZ							Laa For- mation (Laa / Thaya)
		Roe	Roe	Roe	Roe	Roe	Roe	Roe	Rö	N	N	N	N	N	N	N	
		P-1	P-2	P-4	P-5	P-7	P-9	P-10	65/93	22/48- 1/94	22/48- 2/94	22/48- 3/94	22/48- 4/94	22/48- 5/94	22/48- 6/94	22/48- 7/94	
<b>abundance</b>		B	A	C	A	A	C	A	A	F	C	C	C	A	C	C	F
<b>preservation</b>			G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
<b>diatoms</b>		x							x	x	x	x	x	x	x		
<i>Calcidiscus leptoporus</i> (MURRAY & BLACKMAN) LOEBLICH & TAPPAN																	f
<i>Coccolithus miopelagicus</i> BUKRY				r	r								r		r		r
<i>Coccolithus pelagicus</i> (WALLICH) SCHILLER		f/c	c	a	c	a	a	c		c	c	c	c	c	c	a	c
<i>Coronocyclus nitescens</i> (KAMPTNER) BRAMLETTE & WILCOXON																	r
<i>Coronosphaera mediterranea</i> (LOHMAN) GAARDER		f/c	f/c		f		r	f		f/c	f/c	r	f/c	f/c			f
<i>Cyclicargolithus floridanus</i> (ROTH & HAY) BUKRY		r		r	r					r	r	r		r	r		r
<i>Geminolithella</i> sp.																	
<i>Helicosphaera ampliaperta</i> BRAMLETTE & WILCOXON		r						r		r	r				r		r
<i>H. carteri</i> (WALLICH) KAMPTNER				r				r		r	r			r	r		f
<i>H. euphratis</i> HAQ		r															r
<i>H. mediterranea</i> MÜLLER		r		r													
<i>Pontosphaera discopora</i> SCHILLER								r									
<i>P. multipora</i> (KAMPTNER) ROTH		r						r				r			r		r
<i>Reticulofenestra bisecta</i> (HAY) ROTH		r								r	r	r					
<i>R. haqii</i> BACKMAN																	f
<i>R. daviesii</i> (HAQ) HAQ		r	r	r				r		r							
<i>R. minuta</i> ROTH																	f
<i>R. pseudumbilica</i> (GARTNER) GARTNER		r	r	r	r	r	r	r		r	r	r		r			r
<i>Sphenolithus disbelemnus</i> FORNACIARI & RIO		r										r					
<i>S. heteromorphus</i> DEFLANDRE																	r
<i>S. moriformis</i> (BRÖNNIMANN & STRADNER) BRAMLETTE & WILCOXON		r		r	r	r		r		r							r
<i>Thoracosphaera saxea</i> STRADNER		r															r
<i>Triquetrorhabdulus milowii</i> BUKRY				r													r
<b>reworked Paleogene/Neogene</b>																	
<i>Chiasmolithus</i> sp.				r	r			r	r	r					r		
<i>Ericsonia formosa</i> (KAMPTNER) HAQ		r															
<i>Reticulofenestra hillae</i> BUKRY & PERCIVAL					r												
<i>R. stavensis</i> (LEVIN & JOERGER) VAROL		r	r														
<i>R. umbilica</i> (LEVIN) MARTINI & RITZKOWSKI		r															
<i>Toweius</i> spp.		r															
<i>Zygrhablithus bijugatus</i> (DEFLANDRE) DEFLANDRE								r									
<b>reworked Mesozoic</b>																	
<i>Arkhangelskiella cymbiformis</i> VEKSHINA				r	r								r	r	r	r	
<i>A. maastrichtiana</i> BURNETT		r															
<i>Broinsonia parca</i> (STRADNER) BUKRY		r	r														
<i>Calculites obscurus</i> (DEFLANDRE) PRINS & SISSINGH		r								r	r					r	
<i>Ceratolithoides sesquipedalis</i> BURNETT				r													
<i>Cyclagelosphaera reinhardtii</i> (PERCH-NIELSEN) ROMEIN																	
<i>Eiffelithus gorkae</i> REINHARDT		r	r	r				r				r		r	r		
<i>E. turriseiffelii</i> (DEFLANDRE) REINHARDT							r	r		r	r						
<i>Microrhabdulus undosus</i> PERCH-NIELSEN		r										r					
<i>Micula decussata</i> VEKSHINA		r	r	r	r		r	r		r	r	r	r	r	r	r	
<i>Prediscosphaera</i> sp.				r	r		r			r				r	r		
<i>Reinhardtites levis</i> PRINS & SISSINGH											r	r	r			r	
<i>Retecapsa crenulata</i> (BRAMLETTE & MARTINI) GRÜN							r										
<i>Uniplanarius sissinghii</i> PERCH-NIELSEN										r							
<i>Watznaueria barnesae</i> (BLACK) PERCH-NIELSEN		r	r	r	r	r	r	r		r	r	r	r	r	r	r	
<i>W. biporta</i> BUKRY		r						r									
<i>W. britannica</i> (STRADNER) REINHARDT		r															
<i>W. fossacineta</i> (BLACK) BOWN		r	r	r	r	r				r					r	r	
<i>Zeughrabdodus diplogrammus</i> (DEFLANDRE) BURNETT						r		r	r			r				r	

reworked  
up to  
50%

**Table 2:** Distributions of calcareous nannoplankton in the Parisdorf (P) and Niederschleinz (N) sections, in comparison with assemblages from the Karpatian Laa Formation. Abundance: A = abundant (nannoplankton bloom), C = common (> 10 specimens in one field of view), F = few (1-10 specimens in one field of view), B = sample is barren of calcareous nannoplankton; a (taxon participates with more than 90% in a nannofossil assemblage); c (50% - 90%); f (10-50%); Preservation: G - good; Roe - Roetzel, Rö - Rögl.

PLANKTONIC FORAMINIFERA	Rö 62-93	Rö 63-93	Roetzel P-3	Roetzel P-4	Roetzel P-5	Rö 65-93	Nieder- schleinz	N Paris- dorf	Gross- kadolz	Laa a.d.Th. (8/01)	
<i>Globigerina lentiana</i> RÖGL		cf.	x		x	x	cf.	cf.		x	
<i>Globigerina ottnangiensis</i> RÖGL		x	x	x	x	x	x	x		x	
<i>Tenuitella clemenciae</i> (BERMUDEZ)		x	x	x	x	x	x	x		x	
<i>Tenuitellinata selleyi</i> LI, RADFORD & BANNER		x	x	x	x	x	x	x	x	x	
<i>Tenuitellinata</i> sp. 1		x	x	x	x	x	x		x		
<i>Tenuitella minutissima</i> (BOLLI)		x		x		x	x		x	x	
<i>Globigerinita</i> cf. <i>glutinata</i> (EGGER)		x		x							
<i>Globigerina praebulloides</i> BLOW			x		x			x		x	
<i>Globigerina gnaucki</i> BLOW & BANNER			x	x	x	x		x	x	x	
<i>Globigerina</i> cf. <i>ouachitaensis</i> HOWE & WALLACE			x			x					
<i>Globoturborotalita connecta</i> (JENKINS)			x	x	x	x					
<i>Globoturborotalita woodi</i> (JENKINS)			x		x		x				
<i>Turborotalita quinqueloba</i> (NATLAND)				x	x	x	x	x	x	x	
<i>Turborotalita</i> sp. 1				x		x		x			
<i>Globigerinoides immaturus</i> BOLLI				x	x						
<i>Globigerina steiningeri</i> RÖGL					x						
<i>Globigerina dubia</i> EGGER						x					
<i>Tenuitellinata angustiumbilitata</i> (BOLLI)								x		x	
<i>Cassigerinella boudecensis</i> PORONY								x		x	
<i>Catapsydrax</i> cf. <i>unicavus</i> BOLLI et al.								x			
<i>Globigerinita uvula</i> (EHRENBERG)									x		
<i>Globigerinella obesa</i> (BOLLI)										x	
<i>Globigerina bulloides</i> d'ORB.										x	
<i>Globigerina</i> cf. <i>falconensis</i> BLOW										x	
<i>Globigerina pseudociperoensis</i> BLOW										x	
<i>Cassigerinella globulosa</i> (EGGER)										x	
cf. = confer determination	OTTNANGIAN							KARPATIAN			

**Table 3:** Distribution of planktonic foraminifera in the Parisdorf section (Samples Rö = Rögl and Roetzel = P), in comparison with Niederschleinz and nearby Karpatian localities.

Eggenburgian Hall Formation shows an impoverishment towards *Cyclammina-Bathysiphon* assemblages in the basin development. At the beginning of the Ottnangian a new development – with rich assemblages of *Lenticulina melvilli*, cibicidids, and small five-chambered globigerinas – appears in the Innviertel Group (“Robulus-Schlier”). New species in the assemblages are *Sigmoilopsis ottnangensis*, *Amphicoryna ottnangensis*, *Bolivina matejkai*, *B. scitula*, *Pappina primiformis*, and the first *Uvigerina acuminata*. Paleocological analyses of Ottnangian sediments in the Upper Austrian Foredeep (RUPP & HAUNOLD-JENKE, 2003) demonstrate a cool environment at sublittoral depths. In the eastern areas north of the Danube, the Zellerndorf Formation replaces the “Robulus-Schlier” development, generally with scarce foraminiferal assemblages (CICHA, 1999).

The regression at the end of the Ottnangian is associated with a widespread extension of brackish *Rzehakia* beds. Basinward these sediments contain scarce assemblages of mainly small foraminifera (comp. HOLCOVA, 1999, and pers. observations in the Upper Austrian Molasse Basin). This is followed discordantly by deposits of the Karpatian, with the first appearance of *Uvigerina graciliformis*.

The investigation of foraminifera from the higher part of the Zellerndorf Formation, overlying the Limberg Member, reveals assemblages entirely different from those described from the Alpine-Carpathian Foredeep. In this region the *Rzehakia* beds are missing and the sediments are transgressed discordantly by the Karpatian Laa Formation. Therefore, for comparison, assemblages of nearby Karpatian outcrops have also been studied

(Tabs. 3, 4). Foraminiferal faunas from the Zellerndorf Formation on top of the Limberg Member were briefly described by ROETZEL et al. (1991, 1999b) and MANDIC et al. (2005). For the present investigation, a set of samples from the Parisdorf pit north of the main fault (collected by R. Roetzel) and a few samples south of the fault in a normal untilted position have been studied. The dark thin-bedded clays and fine silts are non-calcareous in the lower 2 - 3m. The carbonate and fossil content increase up-section, still interbedded with non-calcareous layers. Near the top, a light brown marly layer is intercalated; it is very rich in foraminifera.

Within the lower part of the sequence, overlying the Limberg Member, a horizon of agglutinated *Bathysiphon filiformis* was observed (Fig. 2). In the non-calcareous clays, fish bones and teeth as well as siliceous sponge spicules (Pl. 3, Figs. 33 - 36) and diatoms occur. The foraminiferal fauna (Tab. 3) is dominated by very small planktonic species (Pl. 5), with floods of *Tenuitellinata selleyi*, *Tenuitellinata* sp. 1 (with an elongated sack-like final chamber) and *Turborotalita* sp. 1 (similar to *T. quinqueloba*, but with looser coiling and a larger test). From the same groups, *Tenuitella clemenciae*, *T. minutissima* and *Turborotalita quinqueloba* occur throughout. Other common small globigerinids are *Globigerina lentiana*, *G. ottnangiensis* and *G. praebulloides*. In contrast to the Zellerndorf Formation, the co-occurring species *Globoturborotalita connecta*, *G. woodi* and *Globigerinoides immaturus* are rather rare in the western foredeep. In the benthic assemblages (Pl. 3, 4), agglutinated and miliolid species are scarce. Abraded



BENTHIC FORAMINIFERA	Rö 62-93	Rö 63-93	Roetzel P-3	Roetzel P-4	Roetzel P-5	Rö 65-93	Nieder- schleinz	N Parisdorf	Grosskadolz	Laa a.d.Th. (8/01)	
<i>Bathysiphon filiformis</i> M. SARS	x										
<i>Milliammina</i> sp.		x									
<i>Textularia</i> sp.										x	
<i>Alabamina tangentialis</i> (CLODIUS)						x	x				
<i>Allomorphina trigona</i> REUSS								x			
<i>Ammonia pseudobeccarii</i> (PUTRJA)								x		x	
<i>Ammonia viennensis</i> (d'ORB.)							x	x		x	
<i>Amphicoryna badenensis</i> (d'ORB.)										x	
<i>Amphimorphina haueriana</i> NEUGEBOREN		x	x	x	x	x	x	x	x	x	
<i>Angulogerina angulosa</i> (WILLIAMSON)				x	x	x					
<i>Aubignyna perlucida</i> (HERON-ALLEN & EARLAND)										x	
<i>Baggina arenaria</i> (KARRER)								x	x	x	
<i>Bolivina</i> aff. <i>korynoides</i> HOFMANN								x	x		
<i>Bolivina</i> aff. <i>simplex</i> PHLEGER & PARKER					x	x			x		
<i>Bolivina dilatata</i> REUSS				x	x	x	x	x	x	x	
<i>Bolivina fastigia</i> CUSHMAN							x			x	
<i>Bolivina hebes</i> MACFAYDEN						x		x		x	
<i>Bolivina pokornyi pokornyi</i> CICHA & ZAPLETALOVA								x			
<i>Bolivina scitula</i> HOFMANN					x			x			
<i>Bolivina</i> sp.1				x		x		x			
<i>Buccella granulata</i> (DI NAPOLI)								x			
<i>Bulimina arndti</i> HAGN				x							
<i>Bulimina buchiana</i> d'ORB.								x			
<i>Bulimina striata mexicana</i> CUSHMAN										x	
<i>Bulimina striata striata</i> d'ORB.					x	x	x	x	x		
<i>Cancris</i> cf. <i>auriculus</i> (FICHEL & MOLL)						x	x		x		
<i>Cassidulina carinata</i> SILVESTRI										x	
<i>Cassidulina laevigata</i> d'ORB.								x	x		
<i>Caucasina cylindrica</i> ZAPLETALOVA			x					x			
<i>Caucasina elongata</i> (d'ORB.)								x	x	x	
<i>Caucasina schischkinskayae</i> SAMOYLOVA		x	x		x	x	x		x	x	
<i>Ceratocancris haueri</i> (d'ORB.)										x	
<i>Chilostomella ovoidea</i> REUSS								x		x	
<i>Cibicidoides ungerianus</i> (d'ORB.)								x	x	x	
<i>Cibicidoides vortex</i> (SEGUENZA)		x		x							
<i>Dentalina acuta</i> d'ORB.						x					
<i>Eilohedra pusilla</i> (PARR)						x					
<i>Elphidium angulatum</i> (EGGER)										x	
<i>Elphidium</i> cf. <i>matzenense</i> PAPP						x					
<i>Fursenkoina acuta</i> (d'ORB.)								x		x	
<i>Fursenkoina halyardi</i> (CUSHMAN)			x	x	x	x	x	x	x	x	
<i>Glandulina laevigata</i> d'ORB.						x					
<i>Globobulimina affinis</i> (d'ORB.)				x	x				x		
<i>Globobulimina pupoides</i> (d'ORB.)		x				x		cf.	x	x	
<i>Globobulimina pyrula</i> (d'ORB.)								cf.			
<i>Globocassidulina cruysi</i> (MARKS)				x							
<i>Globocassidulina oblonga</i> (REUSS)						x	x			x	
<i>Globocassidulina subglobosa</i> (BRADY)					x	x	x		x		
<i>Grigelis pyrula</i> (d'ORB.)						x					
<i>Gyroidinoides octocameratus</i> (CUSHMAN)				x		x	x		x	x	
<i>Gyroidinoides soldanii</i> (d'ORB.) - <i>umbonatus</i> (SILVESTRI)								x	x	x	
<i>Hanzawaia boueana</i> (d'ORB.)										x	
<i>Hanzawaia</i> sp.						x	x		x		
<i>Heterolepa praecincta</i> (KARRER)						x		x		x	
<i>Hoeglundina elegans</i> (d'ORB.)									x		
<i>Laevidentalina elegans</i> (d'ORB.)										x	
<i>Laevidentalina inornata</i> (d'ORB.)						x					
<i>Laevidentalina mucronata</i> (NEUGEBOREN)		x									
	OTTNANGIAN							KARPATIAN			

BENTHIC FORAMINIFERA	Rö 62-93	Rö 63-93	Roetzel P-3	Roetzel P-4	Roetzel P-5	Rö 65-93	Niederschleinz	N Parisdorf	Grosskadolz	Laa a.d.Th. (8/01)	
<i>Lapugyina schmidi</i> POPESCU				cf.		x	x				
<i>Lenticulina melvilli</i> (CUSHMAN & RENZ)			x		x	x	x	x		cf.	
<i>Lenticulina</i> spp.		x	x			x	x	x	x		
<i>Melonis pompilioides</i> (FICHTEL & MOLL)				x	x	x	x		x		
<i>Mylostomella advena</i> (CUSHMAN & LAIMING)		x	x	x	x	x	x		x	x	
<i>Mylostomella recta</i> (PALMER & BERMUDEZ)		x	x	x	x	x	x		x		
<i>Neugeborina irregularis</i> (d'ORB.)		x		x					x		
<i>Neugeborina longiscata</i> (d'ORB.)		x		x	x	x	x				
<i>Nonion commune</i> (d'ORB.)								x		x	
<i>Nonion gudrunae</i> RÖGL n.sp.						x	x	x	x		
<i>Nonionoides ventragranosus</i> (KRASHENINNIKOV)								x	x		
<i>Oridorsalis umbonatus</i> (d'ORB.)									x	x	
<i>Orthomorphina ambigua</i> (NEUGEBOREN)				x		x			x		
<i>Pandaglandulina elliptica</i> (KARRER)						x					
<i>Pappina breviformis</i> (PAPP & TURNOVSKY)								x	x	x	
<i>Pappina primiformis</i> (PAPP & TURNOVSKY)								x	x	x	
<i>Parvicarinina</i> cf. <i>tenuimargo</i> (HERON-ALLEN & EARLAND)						x					
<i>Planularia moravica</i> (KARRER)						x	x		x		
<i>Plectofrondicularia</i> cf. <i>medelingensis</i> (KARRER)						x			x		
<i>Plectofrondicularia digitalis</i> (NEUGEBOREN)		x						x	x	x	
<i>Pseudoparella exigua</i> (BRADY)		x			x			x		x	
<i>Pullenia quinqueloba</i> (REUSS) - <i>bulloides</i> (d'ORB.)				x	x	x	x				
<i>Pyramidulina elegantissima</i> (d'ORB.)						x					
<i>Pyramidulina continuicosta</i> (SCHUBERT)						x	x				
<i>Sigmolinita tenuis</i> (CZIZEK)						cf.			x	x	
<i>Sigmolopsis foeda</i> (REUSS)									x		
<i>Sigmolopsis ottnangensis</i> ZAPLETALOVA								x			
<i>Siphonodosaria adolphina</i> (d'ORB.)						x	x		x		
<i>Siphonodosaria consobrina</i> (d'ORB.)						x	x	x	x		
<i>Siphonodosaria nuttalli gracillima</i> (CUSHMAN & JARVIS)						x				x	
<i>Siphonodosaria scripta</i> (d'ORB.)		x							x		
<i>Spiroloculina badenensis</i> d'ORB.									x		
<i>Uvigerina acuminata</i> HOSIUS						x	x	x	x		
<i>Uvigerina</i> cf. <i>barbatula</i> MACFAYDEN									x		
<i>Uvigerina graciliformis</i> PAPP & TURNOVSKY								x		x	
<i>Uvigerina</i> cf. <i>saprophila</i> DANIELS & SPIEGLER						x	x				
<i>Uvigerina mantaensis</i> CUSHMAN & EDWARDS				x		x	x				
<i>Valvulineria complanata</i> (d'ORB.)				x	x	x	x	x	x	x	
<i>Virgulinita pertusa</i> (REUSS)								x			
	OTTNANGIAN							KARPATIAN			

**Table 4:** Distribution of benthic foraminifera in the Parisdorf section (Samples Rö and Roetzel P), in comparison with Niederschleinz and nearby Karpatian localities.

tests occur regularly. The calcareous benthic fauna consists of small species or specimens, often in small numbers but with high species diversity (Tab. 4). The richest assemblage was observed in the above-mentioned marly bed (sample Rö 65-93).

Most common are *Amphimorphina haueriana*, *Mylostomella advena*, *M. recta*, *Fursenkoina halkyardi*, *Bolivina dilatata*, *Pseudoparella exigua*, in some samples also *Melonis* and *Nonion*. In marly sediments (Rö 65-93 and Niederschleinz) the fauna changes to a *Lenticulina-Uvigerina* assemblage. For the first time in Ottnangian sediments, *Uvigerina acuminata* occurs frequently, together with *U. cf. saprophila* and *U. mantaensis*. To compare the development at Parisdorf, additional samples were studied from outcrops in a north-easterly direction. A similar

lithological development of the Zellerndorf Formation was observed at Niederschleinz. The planktonic assemblage in the ditch NW of Niederschleinz is dominated by *G. ottnangiensis* and *Tenuitellinata selleyi*, whereas the benthic fauna represents a *Lenticulina-Uvigerina-Nonion-Melonis* assemblage.

The Lower Karpatian sediments of the Laa Formation N of Parisdorf and NW of Seefeld-Grosskadolz comprise grey silty calcareous shales with a foraminiferal fauna showing strong similarities with those from the above-described Zellerndorf Formation. In the planktonic assemblages, *Tenuitellinata selleyi*, *Turborotalita quinqueloba* and *Turborotalita* sp.1 are common. The benthic assemblages are richer than in the Zellerndorf Formation. The stratigraphically important uvigerinids show the first appearance of

*Uvigerina graciliformis* and *U. cf. barbatula*, together with higher numbers of *Pappina breviformis* and *P. primitiviformis*. A comparative sample from the type locality of the Laa Formation (brickyard Wienerberger at Laa/Thaya) shows an increase in larger planktonic globigerinid species and common *U. graciliformis* and *Pappina* spp.

**Taxonomic Notes:** The marly layer of the Parisdorf section and the sample from Niederschleinz yielded a distinct new nonionid species. To clarify its position and to separate it from similar species, it is described here as new.

***Nonion gudrunae* RÖGL n. sp.**

Plate 4, figs. 1-3, figs. 32-34

non 1798 *Nautilus asterizans* FICHTEL & MOLL: p. 37, pl. 3, fig. e-h

non 1808 *Florilus stellatus* MONTFORT: p. 135, fig. p. 134

non 1846 *Nonionina boueana* d'ORBIGNY: p. 108, pl. 5, fig. 11-12

**Description of holotype** (Pl. 4, Fig. 1): Test small, planispirally coiled, involute, laterally compressed, periphery angled; bi-umbonate, umbilical region slightly depressed, filled with granular material which extends somewhat along the sutures; 10 ½ chambers visible, chambers broad, low, slowly increasing in height; sutures limbate, strongly thickened and elevated, slightly curved; apertural face slender lanceolate; aperture a low slit at the base of the apertural face, interiomarginal, indistinct, covered by granular shell material; wall smooth, finely perforate.

**Dimensions:** height 309  $\mu$ , breadth 259  $\mu$ , maximal breadth of apertural face 122  $\mu$ .

**Type locality:** Parisdorf (sample Rö 65-93), Lower Austria, Molasse Basin.

**Type level:** Early Miocene, Ottnangian, Zellerndorf Formation.

**Derivation of name:** This species is named after Gudrun Daxner-Höck (Museum of Natural History, Vienna) for her engagement in the marine - continental biostratigraphic correlation.

**Paratypes:** The main characteristics of the new species are the strongly thickened limbate sutures. Rarely, the sutures become less prominent in the younger part of the test, finally somewhat incised. The foramen of the intercameral septa forms a small hemi-circular equatorial arch with a thickened lip over the angled periphery. The new species differs from *N. commune* by the distinctly thickened and elevated sutures, and by a more compressed test with narrower peripheral margin.

Number of chambers: 9-12

Height of test: 274-355  $\mu$ m, mean 305  $\mu$ m

Breadth of test: 223-307  $\mu$ m, mean 246  $\mu$ m

Breadth of apertural face: 91 - 142  $\mu$ m, mean 123  $\mu$ m

**Paratypes:** Parisdorf, marly layer (Rö 65-93), measured: specimens Pl. 4, Figs. 2 - 3 and 20 additional specimens (Tab. 5); Niederschleinz: 10 specimens; Upper Austrian Molasse Basin, Innviertel Group, Braunau Schlier: Hub near Moosbach, 4 specimens; Mitterdorf near Treubach, 5 specimens.

**Stratigraphic range:** Typical specimens are recorded only

<i>Nonion gudrunae</i> n.sp. Parisdorf sample 65-93	height of test	breadth of test	breadth of apertural face	number of chambers
SEM no. 1/44	274.1	258.8	111.7	11.5
SEM no. 1/45	309.6	243.6	91.3	12
SEM no. 1/46 - holotype	309.6	258.8	121.8	10.5
<b>measured paratypes:</b>				
no. 1	309.6	253.8		10
no. 2	309.6	238.5		10
no. 3	324.8	258.8		12
no. 4	314.6	253.8		10.5
no. 5	324.8	253.8		11
no. 6	355.2	307.5		12
no. 7	309.6	258.8		10
no. 8	274.1	228.4		11
no. 9	289.3	223.3		10
no. 10	284.2	228.4		10.5
no. 11	304.5	226.3		10.5
no. 12	307.5	243.6	121.8	10.5
no. 13	319.7	243.6	121.8	11
no. 14	294.4	228.4		11
no. 15	284.2	223.3		11.5
no. 16	334.9	269.0	162.4	10
no. 17	324.8	253.8	116.7	11
no. 18	284.2	243.6	111.7	10
no. 19	289.3	223.3	131.9	11
no. 20	294.4	243.6	142.1	9

**Table 5:** Dimensions of *Nonion gudrunae* RÖGL n. sp. of holotype and paratypes from the type sample Parisdorf (Rö 65-93).

in the Ottnangian Zellerndorf Formation and in the Lower Karpatian outcrop at Grosskadolz. In the Ottnangian type area, in the Ottnang Schlier and in the "Robulus-Schlier" only *Nonion commune* is observed. In the Ottnangian Braunau Schlier this new species occurs together with *N. commune*, but with less prominently thickened sutures.

**Remarks:** Such nonionids have long been described as *Florilus* MONTFORT (1808) based on the elevated sutures and nearly planispiral test figured by FICHTEL & MOLL (1798) and MONTFORT (1808). The taxonomic position of *Florilus* has been clarified by RÖGL & HANSEN (1984). In the case of *Nonion*, these authors asked the Int. Commission on Zoological Nomenclature for suppression of the type species *Nautilus incrassatus* FICHTEL & MOLL and substitution by *Nautilus faba* FICHTEL & MOLL. This latter species has some similarities with *Nonion commune* (d'ORBIGNY) described from the Middle Miocene of the Vienna Basin, but differs in the development of the umbilical area by a set of branching furrows.

***Nonion commune* (d'ORBIGNY, 1846) – designation of a lectotype**

1826 *Nonionina communis* d'ORBIGNY: p. 128, no. 20 – nomen nudum

1846 *Nonionina communis* d'ORBIGNY: p. 106, no. 74, pl. 5, figs. 7-8

?1939 *Nonion commune* (d'ORBIGNY) – CUSHMAN: p. 10, pl. 3, fig. 2

1939 *Nonion boueanum* (d'ORBIGNY) – Cushman: p. 12, pl. 3, figs. 7-8

1985 *Nonion commune* d'ORBIGNY – PAPP & SCHMID: p. 45, pl. 34, figs. 2-3

non 1985 *Nonion commune* d'ORBIGNY – PAPP & SCHMID: p. 45, pl. 34, figs. 4-5

**Lectotype:** As lectotype of *Nonionina communis* d'ORBIGNY, the specimen figured by PAPP & SCHMID (1985) on pl. 34, fig. 3 is selected. This specimen compares best with the form described by d'Orbigny. It is bi-umbonate planispirally coiled, slightly compressed with a rounded-angled periphery. The final whorl consists of 12 chambers, separated by slightly incised sutures. The umbilical area shows some granular shell material. The aperture is a low slit at the base of the apertural face.

**Remarks:** During the revision of the Hauer - d'Orbigny collection by PAPP & SCHMID (1985), the authors failed to select a lectotype for *Nonionina communis*. As the figured specimens belong to two different species and genera, it is necessary to select a lectotype for taxonomic reasons. The revisers already mention that abundant material was preserved in bottle no. 74, and that this material contained specimens with a visible primary chamber and a somewhat asymmetrical test. The figured specimens have been re-investigated because figs. 4 - 5 already show some differences to the normal *N. commune*.

The specimens of figs. 2 - 3 show a typical symmetrical involute test, whereas the specimens of figs. 4 - 5 belong to the asymmetrical *Nonionoides ventragranosus* (KRASHENINNIKOV, 1958), described as *Nonionella*. This form is distinctly more strongly inflated, with a more rounded apertural face. The one side of the test shows a flat disc-like primary chamber, the other has a somewhat deeper umbilicus filled by granular shell material. The form figured by Cushman as *N. commune* probably also corresponds to this species, as it is more inflated than the typical species. The same problem apparently arises in the determinations of MARKS (1951), who determined the asymmetrical form as *Nonion scaphum* (FICHEL & MOLL) and the correct one as *Nonion boueanum*.

## 4. Interpretation and conclusion

The diatomites of the Limberg Member in the surroundings of Limberg, Oberdürnbach and Parisdorf are an intercalation inside the Ottnangian Zellerndorf Formation. They interfinger with these Lower Miocene pelites, laterally thinning out towards the East.

The diatomites show rhythmic bedding laminations which are probably cyclic. The finer and light layerings with rich accumulations of well-preserved, mostly planktonic diatoms represent rapid sedimentation rates. In contrast, the thicker and darker interlayers with higher inorganic siliceous content and mostly fragmented siliceous plankton tests are an indication for slower sedimentation (tending to obscure annual event) and thicker bedding units.

### 4.1. Paleoecology

Most of the biogenic content of the Ottnangian sediments in the Parisdorf pit points to a deposition in a deep marine

sublittoral environment. The diatom record in the section in the small ditch of Niederschleinz shows a deepening-upward in a more distal facies of the Limberg Member. In up-section direction in the sediments a shift from an open sublittoral environment to a pelagic, deeper neritic zone is recognizable (ŘEHÁKOVÁ, 1996).

Diatoms are characterized by the dominance of neritic and pelagic taxa. The frequent forms *Thalassionema* and *Thalassiosira*, especially from the whitish layers of the lower part of the diatomites in the Parisdorf pit, clearly point to paleoconditions of the coastal upwelling. These genera are typical representatives of environments influenced by cold, nutrient-rich, deep-water currents (ŘEHÁKOVÁ, 1994, 1996).

The cool coastal upwelling trend is further characterized by the occurrence of *Distephanopsis* and *Distephanus* species, *Actinoptychus senarius*, *Chaetoceros* spp., *Coscinodiscus curvatulus*, *Coscinodiscus oculus iridis* and *Thalassionema nitzschioides*. Temperature oscillations and a more temperate environment are documented by taxa such as *Distephanopsis crux*, *D. hannai*, *Mesocena elliptica*, *M. quadrangular*, *Rhaphoneis amphiceros* and *Rh. elegans*.

Abundant *Thalassionema nitzschioides* are characteristic for nutrient-rich and high-productivity nearshore areas (TREPPKE et al., 1996); they point to an upwelling zone comparable with coastal regions of the Paratethyan Sea (GALOVIĆ & BAJRAKTAREVIĆ, 2006).

In the nannoplankton record, *Coccolithus pelagicus* and *Coronosphaera mediterranea* sometimes comprise more than 90% of the calcareous nannofossil content. *Coccolithus pelagicus* is a very important paleoecological marker, used as a proxy for variations in nutrient availability and temperature of sea waters. This taxon belongs to the so-called r-strategists, which are common in nutrient-rich eutrophic environments. It is a cold water species, abundant at temperatures between -1.5 and +15°C, with optimum growth between 2°C and 12°C (OKADA & MCINTYRE, 1979; WINTER et al., 1994). A high percentage of this form in nannoplankton communities was documented in the Early Miocene Laa Formation (Karpatian) and "Robulus-Schlier" (Otnangian) from the Alpine-Carpathian Foredeep in Austria (ČORIĆ & RÖGL, 2004).

Strong upwelling paleoconditions in the proximal facies of Parisdorf hindered the development of calcareous nannoplankton. On the contrary, high nutrient input caused by the weaker upwelling regime in more distal diatomitic pelites of Niederschleinz increased the nannoplankton productivity.

A bloom of *Coccolithus pelagicus* points to a strong coastal upwelling which continued throughout the deposition of the clays of the Zellerndorf Formation, even after siliceous plankton blooms ended.

The foraminiferal record is also indicative of cooler water masses and upwelling conditions. An example are the small, five-chambered planktonic foraminifera of the Zellerndorf Formation, especially mass occurrences of *Tenuitellinata* and *Turborotalita*. Small microperforate tenuitellinid species are abundant in cooler water masses.

The evolution of the group corresponds to cooling of the ocean surface waters and the extending Antarctic ice sheet (LI et al., 1992). Today, along the southern Australian margin, the interaction of warm and cold water currents produces assemblages of abundant small species (LI & MCGOWRAN, 1998).

The common occurrence of small thick-walled *Globigerina ottnangiensis* is also of paleocological interest. Such forms strongly resemble *Neogloboquadrina pachyderma*, a typical species of subpolar to polar waters. In rather cool waters such species have a predominantly left-coiling test, whereas at surface water temperatures above 8°C, right-coiling, thin-walled specimens dominate (REYNOLDS & THUNELL, 1986). In the samples from the Zellerndorf Formation with higher numbers of *G. ottnangiensis* (Parisdorf Rö 65-93, Niederschleinz), a random coiling was observed, indicating rather temperate surface temperatures.

Both the diatomites of the Limberg Member and the pelites of the Zellerndorf Formation provide clear evidence for the influence of cold, nutrient-rich, deep-water currents typical for coastal upwelling systems. Accordingly, we conclude that such marine conditions were present on a steep paleocoast along this coastal section during the Ottnangian. This is supported by the morphology of the reconstructed paleocoast, which reveals a tectonically induced steep scarp along the eastern margin of the Bohemian Massif along the Diendorf fault zone.

The development of such algal blooms, including the mass production of diatoms, requires more than nutrient availability: a limiting factor in the reproductive rate of diatoms is the amount of available silica in solution. Most sources of silica are poorly soluble in water, but the silica in volcanic ash dissolves comparatively easily (BURNETT, 1993).

Mineralogy provides a clue for the diatomites of the Limberg Member. The pelitic sediments of the Zellerndorf Formation have an exceptionally high content of smectitic clay minerals in the clay fraction (41 - 96 %). Beyond the siliceous components, the Limberg Member diatomites contain a high portion of such phyllosilicates. The smectitic clay mineralogy of the Ottnangian sediments in this area are accompanied by tuffitic layers with volcanic quartz, glass and zircon of volcanic origin (ROETZEL et al., 1994; NEHYBA & ROETZEL, 1999; NEHYBA et al., 1999). This reflects the influence of volcanic activity during the Upper Eggenburgian and Ottnangian in this region. The volcanoclastics have an acidic character (rhyodacites) and probably stem from the Carpatho-Pannonian region, located in Northern Hungary and Eastern Slovakia. This points to a prominent acidic volcanic input at this time, providing a high content of silica in solution for the skeleton production of the diatoms during algal blooms.

#### 4.2. Paleogeography

The foraminiferal faunas of the Zellerndorf Formation raise new questions on marine connections and on the paleogeography of the Central Paratethys. The first appearance of *Uvigerina acuminata* in low numbers in the

Ottnangian Innviertel Group of Upper Austria is long-known. This species was described by HOSIUS (1893) from the Miocene of the North Sea Basin (Dingden, Westfalia). A mass occurrence of this species is registered here. Another new species appearing in our sections is *Uvigerina* cf. *saprophila* DANIELS & SPIEGLER (1977). This species was described from the Late Oligocene and Miocene of the North Sea Basin. Our species differs from the types in having a coarser ornamentation, which shows similarities with that of *Uvigerina dirupta* TODD (1948). Very common are also hispid *Uvigerina mantaensis* CUSHMAN & EDWARDS (1938), varying somewhat in test shape. Included in this species are *U. tenuipustulata* VOORTHUYSEN (1950) emend. DANIELS & SPIEGLER (1977) and *U. parviformis* PAPP (1953). *Uvigerina tenuipustulata* is the marker species for the Upper Hemmorian *tenuipustulata* Zone (DANIELS, 1986). These assemblages of uvigerinids show relations to the cooler waters of the Atlantic and the North Sea. The western Alpine Foredeep may have been the connecting seaway. Nonetheless, the differences in the uvigerinid and planktonic assemblages raise the question whether a direct northward connection through the Carpathian Foredeep existed.

#### 4.3. Biostratigraphy

The diatom flora of the Limberg Member stratigraphically belongs to the upper part of the Lower Miocene (Ottngian-Karpatian); a more precise attribution is currently not possible. The flora stands close to the Karpatian, although index-fossils are missing (ŘEHÁKOVÁ, 1993, 1996).

Among the silicoflagellates the species *Distephanopsis crux* (EHRENBERG) HAECKEL var. *parva* BACHMANN and *Distephanus speculum* (EHRENBERG) HAECKEL var. *cannopiloides* BACHMANN are typical for Ottnangian (BACHMANN, 1970, 1973).

The *Mesocena elliptica* silicoflagellate zone for the Karpatian Central Paratethys (HAJÓS, 1986) has been recorded in Niederschleinz samples. It can be correlated with the *Lancineis (Rhaphoneis) parilis* diatom zone (HAJÓS, 1986) based on the first/last appearance of *Hyalodiscus planus*, and the last appearance of *Delphineis penelliptica* and *Rhaphoneis elegans* in assemblage with *Cocconeis vetusta* and *Diploneis szontaghii*.

The *Distephanopsis crux parvus* silicoflagellate zone for the Ottnangian Central Paratethys (HAJÓS, 1986) has been established in Parisdorf. It can be correlated with the *Delphineis (Rhaphoneis) subtilissima* diatom zone (HAJÓS, 1986) based on the first appearance of *Actinocyclus hungaricus*.

More precise data are available from the nannoplankton content. *Helicosphaera ampliaperta* (stratigraphic range: from upper NN2 to the NN4/NN5 boundary) is rare but present in investigated sediments from both localities. Although *Sphenolithus belemnus* was not observed, the co-occurrence of *S. disbelemnus* with *H. ampliaperta* and *H. mediterranea*, as well as the absence of *Sphenolithus heteromorphus*, indicate the uppermost part of nanno-

plankton Zone NN2 and Zone NN3 (MARTINI, 1971). This also corresponds with the regional Ottnangian position of the succession. Occurrences of *Sphenolithus heteromorphus* were observed in the Karpatian sediments of the Laa Formation (SPEZZAFERRI & ČORIĆ, 2001).

The planktonic foraminiferal assemblages show high numbers of *Globigerina ottnangiensis* and few *Globigerinoides* specimens together with *Globoturborotalita woodi*, indicating an Early Miocene age. *Uvigerina accuminata* also first occurs in the Ottnangian. A more precise correlation is not possible based on the foraminiferal content. The Karpatian foraminiferal fauna is characterized by the first occurrence of *Uvigerina graciliformis* and *U. cf. barbatula*.

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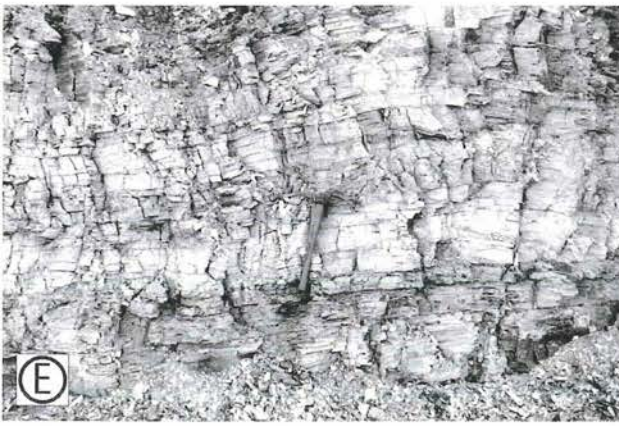
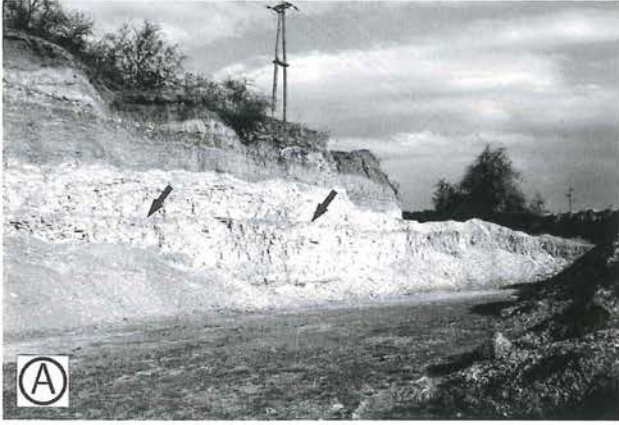
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## PLATE 1

### Parisdorf diatomite pit

- Fig. A, B Eastern part of the pit. Diatomites of the Limberg Member (base) overlain by pelites of the Zellerndorf Formation. Note the clayey layer (arrows) dividing the diatomites in two parts.
- Fig. C Graben-structure bounded by a SSW-directed normal fault at the eastern end of the pit in heavily pressed and folded diatomites (D). In the graben clays of the Zellerndorf Formation (Z), Pleistocene reddish brown soil sediments (S) and loess (L).
- Fig. D Heavily folded diatomites with dark menilitic layers at the western end of the pit with multiple duplex stacking indicating a southwest- (left) directed compression. Height of the section about 3 m. Cramp (arrow) for scale.
- Fig. E Thin laminated diatomites, weakly tectonically folded. Cramp for scale.
- Fig. F Deformation structures in diatomite. Southeast- (left) directed overthrust with ramp-flat thrusts and ramp folding. Pencil for scale.

PLATE 1

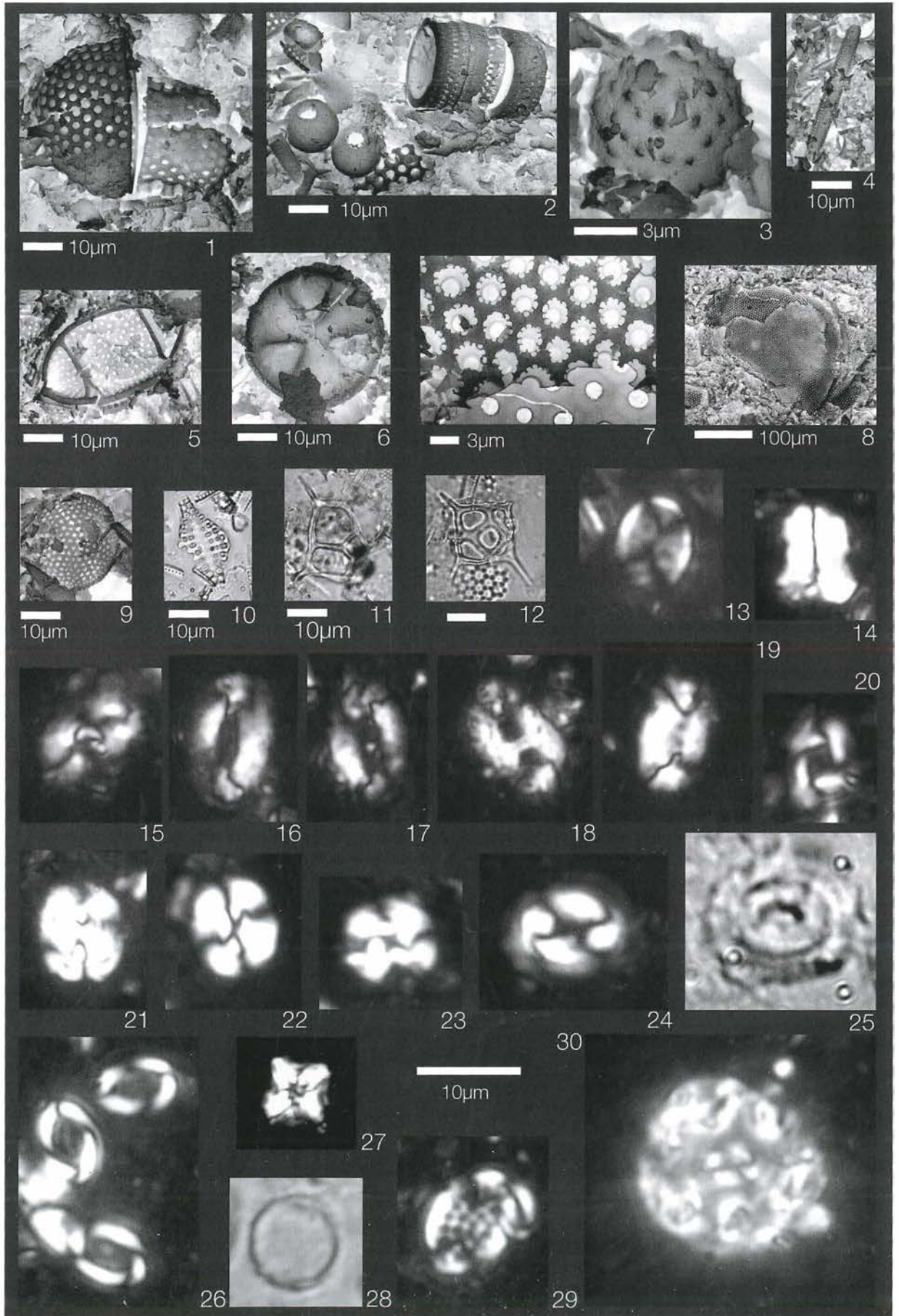


## PLATE 2

### Siliceous microfossils and calcareous nannofossils from the Limberg Member

- Fig. 1 *Stephanopyxis turris* (GREVILLE) RALFS; Sample N 22/48-4/94 (Niederschleinz)
- Fig. 2 *Melosira sulcata* (EHRENBERG) CLEVE; Sample N 22/48-4/94 (Niederschleinz)
- Fig. 3 *Archeomonas* cf. *mangini* DEFLANDRE; Sample Roetzel P-2 (Parisdorf)
- Fig. 4 *Thalassionema nitzschioides* (GRUNOW) GRUNOW; Sample Roetzel P-1 (Parisdorf)
- Fig. 5 *Hemiaulus hungaricus* PANTOCSEK; Sample Roetzel P-1 (Parisdorf)
- Fig. 6 *Actinoptychus senarius* (EHRENBERG) EHRENBERG; Sample N 22/48-4/94 (Niederschleinz)
- Fig. 7 *Coscinodiscus oculus iridis* EHRENBERG; Sample Roetzel P-1 (Parisdorf)
- Fig. 8 *Coscinodiscus radiatus* EHRENBERG; Sample Roetzel P-1 (Parisdorf)
- Fig. 9 *Pyxidicula minuta* GRUNOW; Sample Roetzel P-9 (Parisdorf)
- Fig. 10 *Rhaphoneis elegans* (PANTOCSEK & GRUNOW) HANNA; Sample N 22/48-6/94 (Niederschleinz)
- Fig. 11 *Distephanopsis hannai* (BUKRY) DESIKACHARY & PREMA; Sample N 22/48-6/94 (Niederschleinz)
- Fig. 12 *Distephanopsis crux parvus* (BACHMANN) DESIKACHARY & PREMA; Sample N 22/48-6/94 (Niederschleinz)
- Fig. 13 *Pontosphaera discopora* SCHILLER, 1925; Sample RÖ 65/93 (Parisdorf)
- Fig. 14 *Zygrhablithus bijugatus* (DEFLANDRE, 1954) DEFLANDRE 1959; Sample RÖ 65/93 (Parisdorf)
- Fig. 15 *Helicosphaera euphratis* HAQ, 1966; Sample Roetzel P-2 (Parisdorf)
- Fig. 16 *Helicosphaera ampliaperta* BRAMLETTE & WILCOXON, 1967; Sample RÖ 65/93 (Parisdorf)
- Fig. 17 *Helicosphaera ampliaperta* BRAMLETTE & WILCOXON, 1967; Sample Roetzel P-2 (Parisdorf)
- Fig. 18 *Helicosphaera mediterranea* MÜLLER, 1981; Sample Roetzel P-2 (Parisdorf)
- Fig. 19 *Helicosphaera carteri* (WALLICH, 1877) KAMPTNER, 1954; Sample N 22/48-2/94 (Niederschleinz)
- Fig. 20 *Reticulofenestra pseudoumbilica* (GARTNER, 1967) GARTNER, 1969; Sample RÖ 65/93 (Parisdorf)
- Fig. 21 *Reticulofenestra bisecta* (HAY, 1966) ROTH, 1970; Sample N 22/48-2/94 (Niederschleinz)
- Fig. 22 *Watznaueria barnesae* (BLACK, 1959) PERCH-NIELSEN, 1968; Sample N 22/48-2/94 (Niederschleinz)
- Fig. 23 *Cyclicargolithus floridanus* (ROTH & HAY, 1967) BUKRY, 1971; Sample N 22/48-1/94 (Niederschleinz)
- Fig. 24 *Coccolithus pelagicus* (WALLICH, 1871) SCHILLER, 1930; Sample RÖ 65/93 (Parisdorf)
- Fig. 25 *Coccolithus pelagicus* (WALLICH, 1871) SCHILLER, 1930; Sample RÖ 65/93 (Parisdorf)
- Fig. 26 *Coronosphaera mediterranea* (LOHMAN, 1902) GAARDER, 1977; Sample RÖ 65/93 (Parisdorf)
- Fig. 27 *Micula decussata* VEKSHINA, 1959; Sample N 22/48-1/94 (Niederschleinz)
- Fig. 28 *Coronocyclus nitescens* (KAMPTNER, 1963) BRAMLETTE & WILCOXON, 1967; Sample RÖ 65/93 (Parisdorf)
- Fig. 29 *Pontosphaera multipora* (KAMPTNER, 1948) ROTH, 1970; Sample RÖ 65/93 (Parisdorf)
- Fig. 30 Coccusphaere of *Coccolithus pelagicus* (WALLICH, 1871) SCHILLER, 1930; Sample RÖ 65/93 (Parisdorf)

PLATE 2



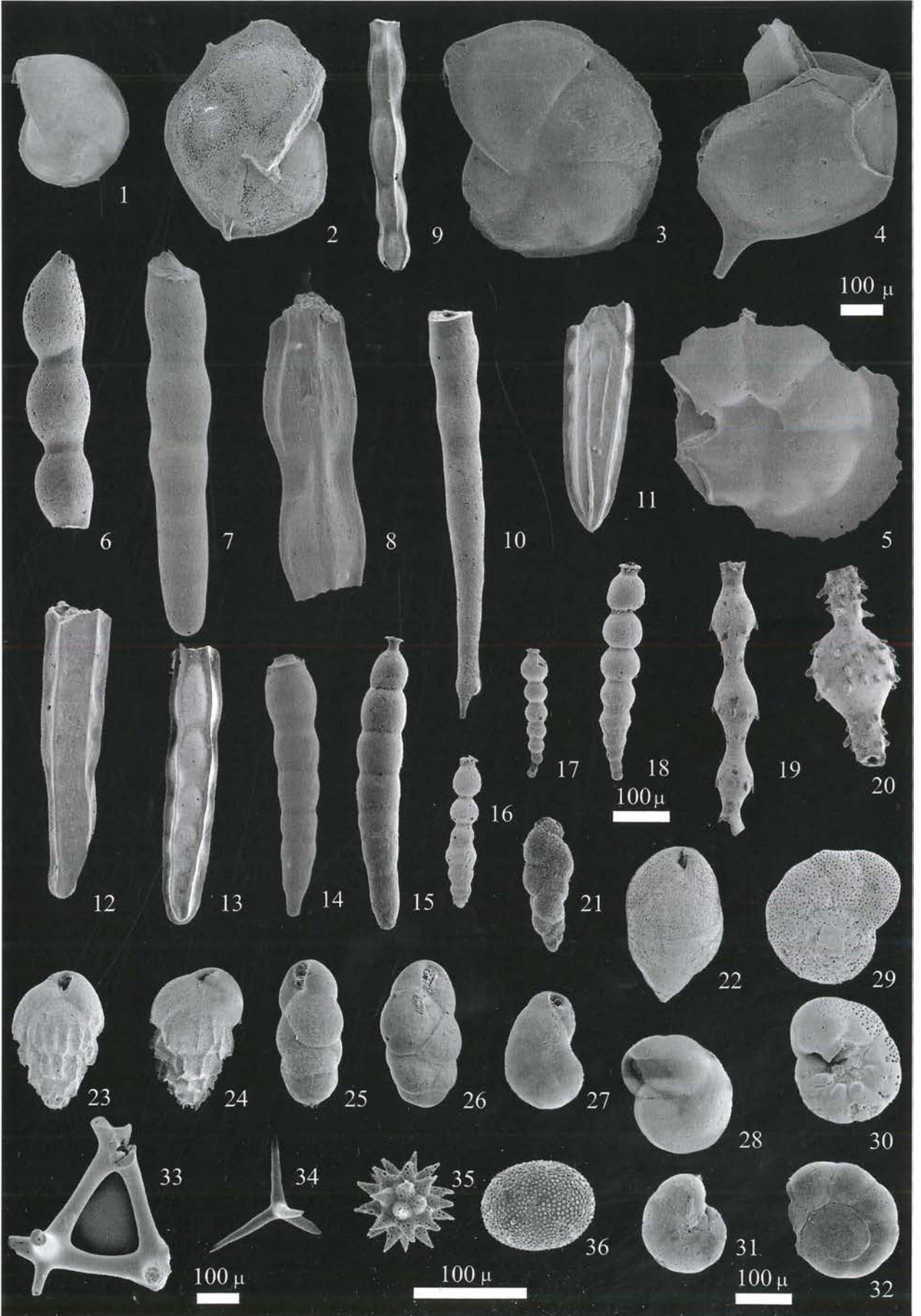
## PLATE 3

## Parisdorf, marly layer (Rö 65-93): Benthic Foraminifera

- Fig. 1 *Lenticulina inornata* (d'ORB.)  
 Fig. 2 *Lenticulina melvilli* (CUSHMAN & RENZ)  
 Fig. 3 *Lenticulina meynae* VESPERMANN  
 Fig. 4 *Lenticulina calcar* (LINNE)  
 Fig. 5 *Planularia moravica* (KARRER)  
 Fig. 6 *Laevidentalina guttifera* (d'ORB.)  
 Fig. 7 *Laevidentalina inornata* (d'ORB.)  
 Fig. 8 *Dentalina acuta* d'ORB.  
 Fig. 9 *Pyramidulina continuicosta* (SCHUBERT)  
 Fig. 10 *Siphonodosaria consobrina* (d'ORB.)  
 Fig. 11 *Plectofrondicularia digitalis* (NEUGEBOREN)  
 Fig. 12-13 *Amphimorphina haueriana* NEUGEBOREN  
 Fig. 14-15 *Myllostomella advena* (CUSHMAN & LAIMING)  
 Fig. 16-18 *Myllostomella recta* (PALMER & BERMUDEZ)  
 Fig. 19-20 *Siphonodosaria adolphina* (d'ORB.)  
 Fig. 21 *Fursenkoina halkyardi* (CUSHMAN)  
 Fig. 22 *Globobulimina affinis* (d'ORB.)  
 Fig. 23-24 *Bulimina striata striata* d'ORB.  
 Fig. 25-26 *Caucasina schischkinskayae* SAMOYLOVA  
 Fig. 27 *Globocassidulina oblonga* (REUSS)  
 Fig. 28 *Globocassidulina subglobosa* (BRADY)  
 Fig. 29-30 *Valvulineria complanata* (d'ORB.)  
 Fig. 31-32 *Gyroidinoides octocameratus* (CUSHMAN)  
 Fig. 33 Siliceous sponge spiculae: Hexactinellidae  
 Fig. 34 Siliceous sponge spiculae: tetraxon needle  
 Fig. 35 Siliceous sponge spiculae: *Oxyaster*  
 Fig. 36 Siliceous sponge spiculae: *Sterraster*

Magnifications: Figs. 1-13: 75 x; Figs. 14-32: 100 x; Figs. 33-34: 75 x; Figs. 35-36: 200 x

PLATE 3



## PLATE 4

### Parisdorf, marly layer (Rö 65-93): Benthic Foraminifera

Fig. 1-3 *Nonion gudrunae* RÖGL n. sp.: Fig. 1: holotype, Figs. 2-3: paratypes

Fig. 4-5 *Melonis pompilioides* (FICHTEL & MOLL)

Fig. 6 *Bulimina arndti* HAGN

Fig. 7 *Fursenkoina halkyardi* (CUSHMAN)

Fig. 8-9 *Lapugyina* cf. *schmidi* POPESCU

Fig. 10 *Bolivina hebes* MACFADYEN

Fig. 11-13 *Bolivina dilatata* REUSS

Fig. 14-18 *Bolivina* sp. 1 (cf. *Bolivina scitula* HOFMANN)

Fig. 19-21 *Charltonina tangentialis* (CLODIUS)

Fig. 22-23 *Eilohedra pusilla* (PARR)

Fig. 24-25 *Uvigerina acuminata* HOSIUS

Fig. 26-28 *Uvigerina* cf. *saprophila* DANIELS & SPIEGLER

Fig. 29-30 *Uvigerina mantaensis* CUSHMAN & EDWARDS

Fig. 31 Fish tooth, *Trichiurus* sp.

### Details of *Nonion gudrunae* n.sp.

Fig. 32 Apertural face of Fig. 3

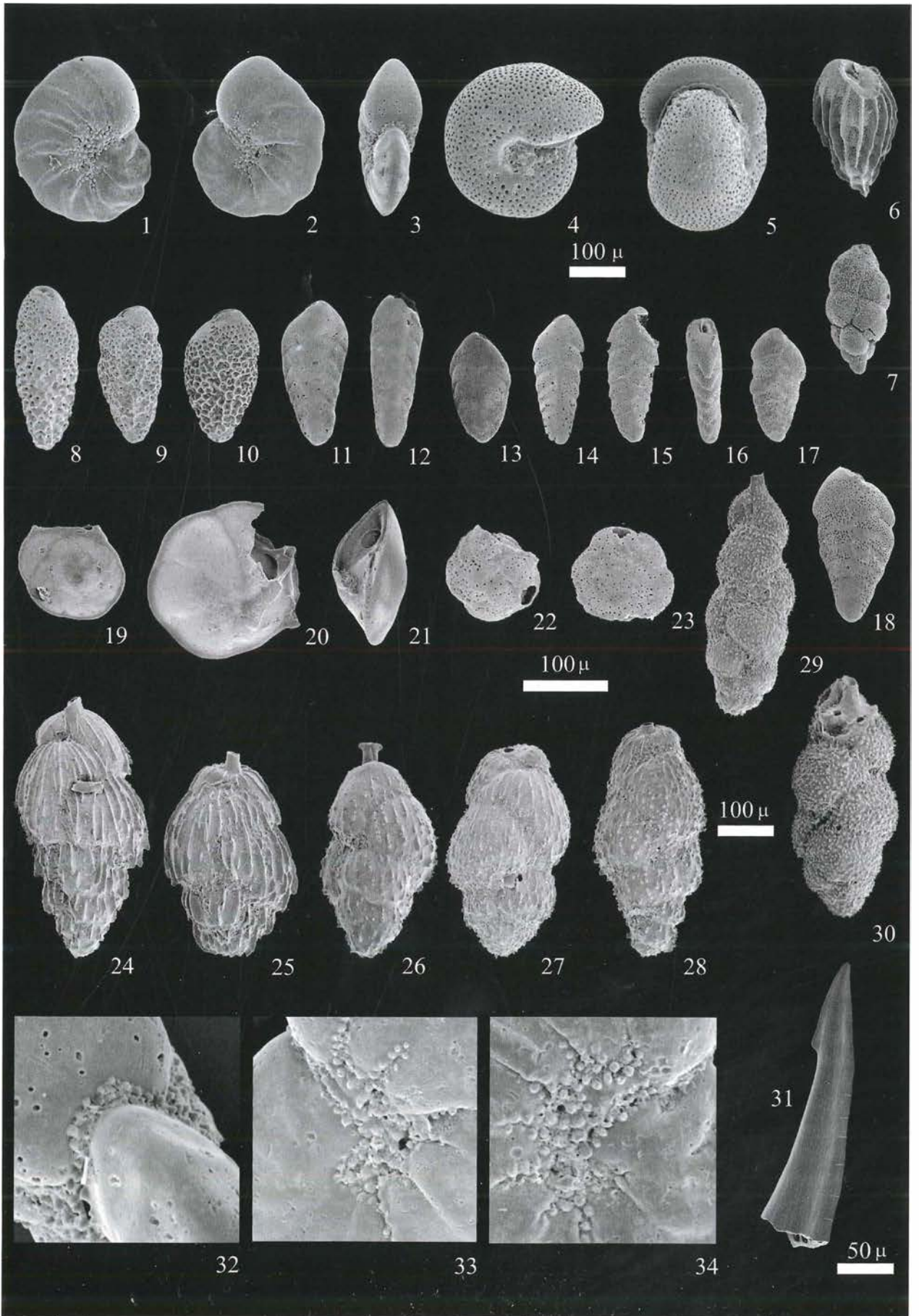
Fig. 33 Umbilical area of Fig. 2

Fig. 34 Umbilical area of Fig. 1

Magnifications: Figs. 1 - 21: 100 x; Figs. 22 - 23: 150 x; Figs. 24 - 30: 100 x; Fig. 31: 20 x



PLATE 4



**PLATE 5****Parisdorf, marly layer (Rö 65-93): Planktonic Foraminifera**

- Fig. 1-3 *Globigerina ottangiensis* RÖGL
- Fig. 4-5 *Globigerina dubia* EGGER
- Fig. 6 *Gobigerina lentiana* RÖGL
- Fig. 7-10 *Globigerina* cf. *ottangiensis* RÖGL: small, thick wall, compact coiling, left-coiling specimens
- Fig. 11 *Globigerina praebulloides* BLOW
- Fig. 12 *Globigerina gnaucki* BLOW & BANNER
- Fig. 13 *Globigerinoides diminutus* BOLLI
- Fig. 14 *Globigerinoides immaturus* BOLLI
- Fig. 15 *Globoturborotalita connecta* (JENKINS)
- Fig. 16-17 *Globoturborotalita woodi* (JENKINS)
- Fig. 18-20, 26-27 *Tenuitellinata selleyi* LI, RADFORD & BANNER
- Fig. 21-22 *Tenuitellinata* sp. 1 (with elongated final chamber)
- Fig. 23-25, 31 *Tenuitella clemenciae* (BERMUDEZ)
- Fig. 28-30 *Tenuitella minutissima* (BOLLI)
- Fig. 32-34 *Turborotalita quinqueloba* (NATLAND)
- Fig. 35-37 *Turborotalita* cf. *quinqueloba* (NATLAND)
- Fig. 38-39 *Turborotalita* sp. 1
- Fig. 40 Detail of final chamber of *Tenuitellinata selleyi* (Fig. 20)
- Fig. 41 Detail of final chamber of *Tenuitellinata* sp. 1 (Fig. 21)
- Fig. 42 Detail of final chamber of *Turborotalita quinqueloba* (Fig. 32)
- Fig. 43 Detail of final chamber of *Turborotalita* cf. *quinqueloba* (Fig. 36)

PLATE 5

