ABHANDLUNGEN DER GEOLOGISCHEN BUNDESANSTALT

Abh. Geol. B.-A.	ISSN 0378-0864	ISBN 3-85316-007-7	Band 56/2	S. 475-517	Wien, Dezember 1999

Geologie ohne Grenzen
Festschrift 150 Jahre Geologische Bundesanstalt

Redaktion:
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Biostratigraphy and Palaeoenvironment of the marly marine transgression of Weißenbachalm Lower Gosau-Subgroup (Upper Turonian-Lower Santonian Grabenbach-Formation, Northern Calcareous Alps, Styria)

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4 Text-Figures, 7 Tables and 11 Plates

Österreichische Karte 1:50.000
Blatt 97

Northern Calcareous Alps
Styria
Lower Gosau-Subgroup
Grabenbach-Formation
Late Turonian
Coniacian
Early Santonian
Mineral Analysis
Biostratigraphy
Foraminifera
Ostracoda
Nannofossils
Palynomorpha

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Biostratigraphie und Ablagerungsbedingungen der mergeligen Transgression der Ausseer Weißenbachalm-Gosau (Grabenbach-Formation, Oberturon-Untersanton, Nördliche Kalkalpen)

Zusammenfassung

Im Rahmen einer integrierenden Studie (Mineralanalyse, Nannoplankton, Foraminiferen, Ostracoden und Palynomorphen) haben die Autoren versucht, die Serie der grauen Mergel der Unteren Gosau-Gruppe der Ausseer Weißenbachalm biostratigraphisch zu untergliedern und deren Ablagerungsbedingungen zu interpretieren. Es zeigte sich, daß die mergelige Transgression der Grabenbach-Formation unmittelbar über dem Basiskonglomerat (Kreuzgraben-Formation) stark terrigen beeinflußt ist und außer wenig aussagekräftigen Palynomorphen keine biostratigraphisch verwertbaren marinen Biogene aufweist. Der stratigraphisch älteste Fossilbeleg spricht für das Einsetzen der marinen Transgression in der Nannoplankton-Zone UC9a sensu BURNETT (1998); das entspricht – aufgrund des Fehlens von Mittelturonium-Foraminiferen – dem tiefen Oberturonium. Die Untersuchung der Foraminiferen- und Nannoplankton-Assoziationen zeigte, daß die mergelige Sedimentation auch das gesamte Coniacium umfaßt und bis in das Untersantonium anhält (Nannozonen UC10 und UC11c sensu BURNETT (1998). Weiters belegen die Foraminiferen-Assoziationen aufgrund ihres Plankton/Benthos-Verhältnisses einen allmählichen Meeresspiegelanstieg bzw. ein Abtiefen des Ablagerungsraumes von einem seichten zu einem tieferen Schelfbereich. Auch die Ostracoden-Assoziationen spiegeln diesen Trend eines Meeresspiegelanstiegs vom Oberturonium in das Untersantonium wider. Auffällig ist auch, daß sowohl die Foraminiferen, als auch das Nannoplankton bzw. die Palynomorphen-Spektren eine erhebliche boreale Beeinflussung aufzeigen und somit die Grabenbach-Formation der Ausseer Weißenbachalm ein Mischbiotop zwischen der mediterranen und borealen Bioprovinz darstellen dürfte. Eine spezielle Entwicklung der basalen Grabenbach-Formation der Weißenbachalm stellen Korallenmergel dar, die stratigraphisch dem Oberturonium angehören. Im Hangendabschnitt der Grabenbach-Formation zeigen sich mehrere ± dm dicke Zwischenlagen von Pflanzenhäcksel-führenden Sandsteinen bzw. Muschel-Lumachellenkalken, die Tempestit-Ereignissen zugeordnet werden können. Weiters konnte ein etwa 70 cm mächtiges Kohlenflözchen lokalisiert werden, das nach der Vitrinitreflexion dem Glanzbraunkohlenstadium entspricht.

Abstract

An interdisciplinary study of the Weißenbachalm Lower Gosau-Subgroup comprising mineralogical analysis and the study of foraminifers, ostracodes, nannoplankton and palynomorphs provided the following results: Grey neritic marls of the Grabenbach-Formation were deposited within the Late Turonian-Early Santonian interval and are dated as being within the Dicarinella concavata Zone and UC9a, UC10 and UC11c nannoplankton zones sensu BURNETT (1998). Three types of foraminiferal assemblages documented by plankton/benthos ratio show a gradual sea-level rise within a shallow marine to neritic environment. The ostracode assemblages also reflect this trend of a gradual sea level rise from the Late Turonian to the Early Santonian. A peculiar facies development within the Grabenbach-Formation represented by coral marls occurs in the Late Turonian. The upper part of the Grabenbach grey marls, which are already of Early Santonian age, show dm-thick intercalations of pelecypod coquina limestones and plant debris bearing sandstones, which are interpreted here as tempestites. The occurrence of Boreal genera in the palynomorph spectrum which is otherwise Mediterranean in character gives evidence of a transitional area between the Mediterranean and Boreal bioprovinces. In addition, a partial revision of TOLLMANN'S (1960b) foraminiferal taxa is presented which, however, was only based on our new collections and not on the original material. A comparison of the foraminiferal and nannofossil associations with others from the Bohemian Cretaceous Basin is also given. Furthermore, a 70 cm thick coal seam was located, which according to vitrinite reflectance measurements is of the subbituminous B coal type.

1. Introduction

The small E–W striking Weißenbachalm Gosau basin is situated in the tectonically extremely complex central part of the Northern Calcareous Alps. Since the beginning of biostratigraphic and later tectonic (nappe tectonics) research in the Austrian Alps the "Ischl-Aussee-Hallstatt zone" in the heart of the Salzkammergut region plays a crucial role (see chapter 2). According to TOLLMANN (1985) the Weißenbachalm Gosau occurrence is part of the Warscheneck nappe, superposed discordantly over Late Triassic Dachstein Limestone.

Since the paper by TOLLMANN (1960b), the stratigraphy of the grey marls (Grabenbach-Formation) of Weißenbachalm seemed well established as Late Coniacian. However, some doubts have been cast already by KOLLMANN & SUMMESBERGER (1982) and already the first results of sample investigations by means of foraminifera and nannoplankton showed, that the stratigraphy comprises various stages ranging from the Late Turonian to the Coniacian/Santonian boundary. Since TOLLMANN'S (1960b) pioneer study almost 40 years elapsed and more advanced methods in respect to stratigraphical dating have evolved, like the application of nannoplankton and the successful application of benthonic foraminifera besides the planktonic taxa. Also the findings of Tethyan/Mediterranean and Boreal elements in the foraminifera, nannoplankton and palynomorpha assemblages was an interesting new aspect as well from the biostratigraphic, as also from the paleogeographic point of view.

The study of the Weißenbachalm Gosau occurrence was triggered by several primarily independet aspects. One aspect was a comparative study of Tethyan and Boreal faunas and floras on hand of well dated Late Cretaceous samples especially in respect to the assemblages of foraminifera, ostracodes, nannoplankton and palynomorpha. Another aspect for selecting this rather neglected Gosau occurrence for study was, that one of us (Lobitzer) intends to compile a geological guide booklet for the Ausseerland, one of the most scenic touristic areas in the Northern Calcareous Alps, located in the geographical center of Austria. Last but not least, the Ausseerland represents a classical region for the Alpine Mesozoic stratigraphy and the nappe tectonic concept.

The present paper is accompanied in this volume by two other papers dealing with the Weißenbachalm Gosau–Group. The paper by SZENTE et al. (1999) deals with microfacies and macrofauna (rudists, echinoids) of the "rudist-coral-brachiopod facies", whereas BARON-SZABO (1999) describes the coral assemblages of both the "rudist-coral-brachiopod facies" and of the Late Turonian coral marls of the lowermost Grabenbach-Formation (Plate 1, Fig. 2).

2. Previous research

The first record concerning geology of the small Gosau occurrence in Weißenbachalm area which is situated east of the Bad Aussee village dates back to the classic paper by SEDGWICK & MURCHISON (1831) "A sketch of the Structure of the Eastern Alps". According to them the sequence "of the Gosau beds near Old Aussee "(sic!)" comprises from bottom to top three units: red conglomerate – bluish marlstone with large univalves – blue marls with several species of Gosau shells (gastropodes, corals, a.o.). SEDGWICK & MURCHISON (1831) refer to the complex tectonic situation: "No drawing or description can convey more than a faint idea of the extraordinary contortions and dislocations of the rocks which surround the little upland valley of Zlam". BOUÉ (1832) also mentioned this small Gosau occurrence near Aussee in Styria.

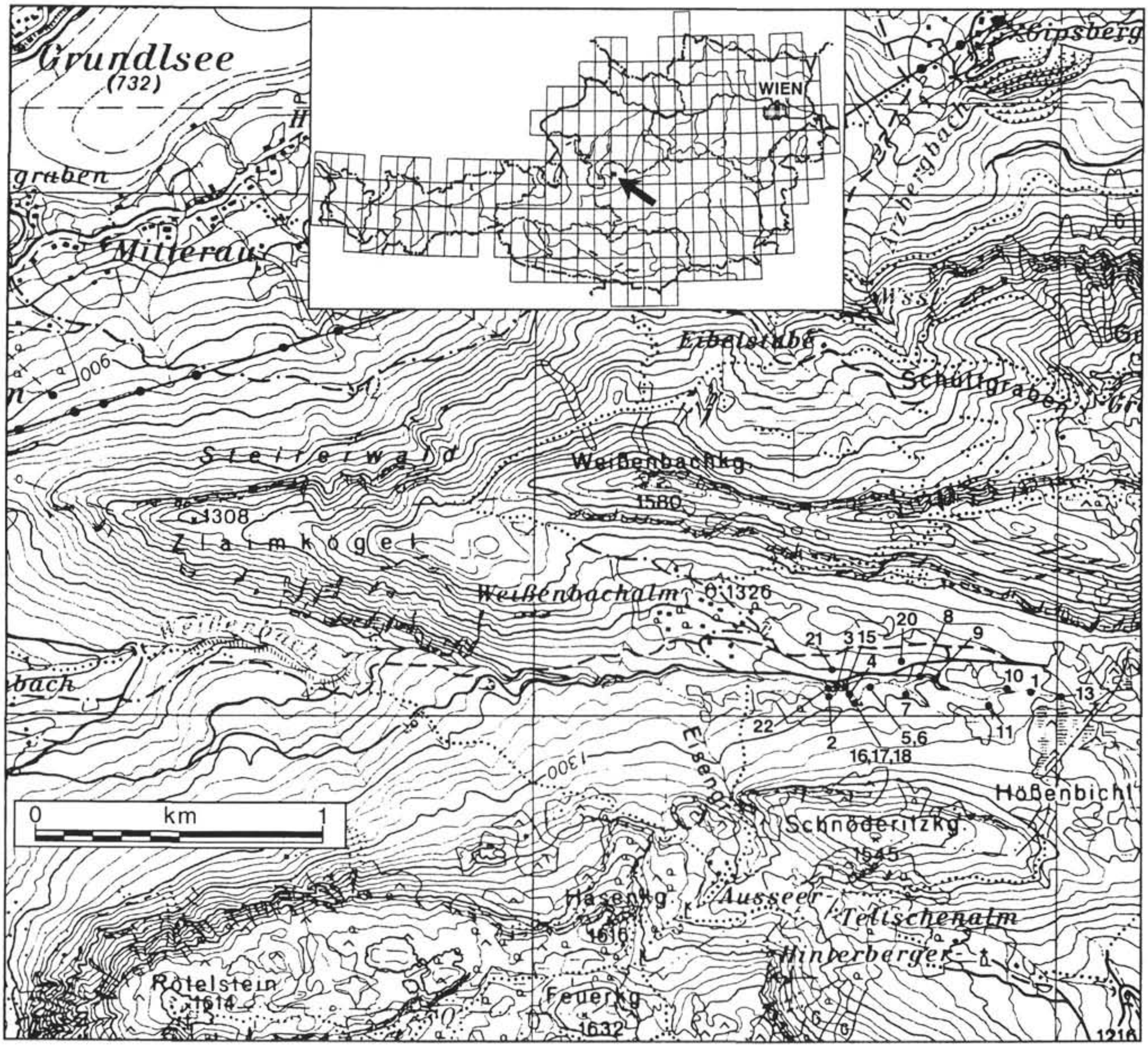
In 1852 PETERS gave the first detailed description of the stratigraphic sequence and of the macrofauna content. PETERS also published the first coloured sketch-map of this Gosau occurrence. According to him the sequence comprises four members, namely the Lower Conglomerate, followed by the fossiliferous (partly hippuritid) Marl-Limestone-Sandstone Complex, the upper unfossiliferous sandstone with coal particles and the Upper Conglomerate. According to the monographic paper by REUSS (1854) the sequence comprises red conglomerates at the base, followed by bluish-grey fossiliferous marls intercalated with hard grey marly limestones, brownish micaceous sandstones and limestones with mollusc fauna including *Hippurites cornu vaccinum* and *Actaeonella gigantea* (cf. PETERS, 1852). The sequence terminates with the conglomerates on Teltschenberg. REUSS (l.c.), however, doubted the existence of the Upper Conglomerate sensu PETERS (1852). REUSS (l.c.) also describes the foraminifer *Rotalina stelligera* and refers to material which he received from PETERS from the marls of Weißenbach, where the mentioned taxon according to him is relatively common. HAUER (1858) and REDTENBACHER (1873) reported on findings of ammonites in the marls of Weißenbachalm, however, they do not refer to an exact location. Also STUR (1871) reported new findings of fossils and listed former records. KITTL (1903) referred to the Gosau deposits in the Zlaim valley outcropping along the Weißenbach, which according to him were visited for the first time by LILL (von LILIENBACH) and later described by PETERS. This paper is illustrated by a coloured geological map 1:200 000. GEYER (1915) discussed the tectonic implications of the W–E striking Weißenbach Fault. Only one mapsheet 1:75 000 – Liezen (VACEK & GEYER, 1918) comprises this classic region for Alpine Mesozoic stratigraphy and nappe tectonics. Strange enough this region of eminent importance was never in the focus of attention of the mapping programme of the Geological Survey of Austria. Therefore, geologists dealing with the geology of this region had to produce their own maps (e.g. TOLLMANN, 1960a, b).

The last concise papers on the geology of the Weißenbachalm-Gosau are those by TOLLMANN. TOLLMANN (1960a) described in detail the different lithological units encountered and their tectonic situation. In an other paper (TOLLMANN, 1960b), he recorded an outstanding rich and well-preserved foraminiferal assemblage in the lowermost marls of Weißenbachalm, which he considered to be of Late Coniacian age. He also mentioned already the presence of ostracodes in the sieve residues. Research on ostracodes from the Cretaceous has been dône very rarely in Austria. The monograph of REUSS (1854) "Beiträge zur Charakteristik der Kreideschichten in den Ostalpen, besonders im Gosauthale und am Wolfgangsee" was the first in which Cretaceous ostracodes from Austria (in its todays boundaries) were described. Subsequently very few palaeontologists mentioned Cretaceous ostracodes and no further systematic research was done. The ostracodes from the Weißenbachalm area never have been worked on. The rudist-coral-brachiopod limestone member, however, was not mentioned in both papers by TOLLMANN, probably because fair exposures occurred only later in the course of a forest-road construction in 1972. More recent remarks on the Weißenbachalm-Gosau are documented in the excursion guidebook by KOLLMANN & SUMMESBERGER (1982). According to these authors the "rudist-coral-brachiopod facies" underlies the marl succession described herein. FAUPL, POBER & WAGREICH (1987) correlate the marl succession of Weißenbachalm with the Grabenbach-Formation of the Gosau Basin. The first palynological study of Weißenbachalm Lower Gosau-Subgroup, documented by floral list and photographs was carried out by SIEGL-FARKAS (1994). The sole sample investigated in that time was taken from the marly sandstone underlying the rudist-bearing bank exposed at Stop No. 31 of the excursion guide of KOLLMANN & SUMMESBERGER (1982). The palynological results do not contradict the biostratigraphic dating by TOLLMANN (1960a, b) according to which this rock was assigned to the Late Coniacian. The find identified as *Peroniceras* (SUMMESBERGER in SIEGL-FARKAS, 1994) determined the age of parts of the formation more precisely as the lower part of the Middle Coniacian (the ammonite was found in the scree!). Calcareous nannofossils in the Lower Gosau-Subgroup were recorded in several papers by WAGREICH who used them as a tool for biostratigraphic conclusions. For the Lower Gosau-Subgroup WAGREICH (1992a) reported nannofossil and planktonic foraminiferal marker species and correlated their distributions with the ammonite zones. WAGREICH (in SIEGL-FARKAS & WAGREICH, 1996) mentioned stratigraphically important nannoplankton species in the western Gams section, Lower Gosau-Subgroup, within the Late Turonian-Early Campanian interval and compared them with palyno-zones.

In an integrated study WAGREICH (1992a) correlates the Late Cretaceous calcareous nannofossils zones with the ammonite zones and with the planktonic foraminifera and confirms the onset of marine sedimentation in the Gosau-Group during the Late Turonian. SUMMESBERGER & KENNEDY (1996) were the first authors, who confirmed, based on ammonite studies, that the transgression in several of the Gosau "basins" (including the St. Wolfgang-Bad Ischl region) began in the Turonian, earlier than was previously believed. These authors also report on coal seams in the Late Turonian, e. g. in the Gosau Group of the Neualpe profile. A recent paper by WAGREICH (1998) deals with the Grabenbach-Formation of the Nussensee-Bad Ischl Lower Gosau-Subgroup. In contrast to the Gosau-Rußbach basin, where the Grabenbach-Formation shows an Early Santonian to early Late Santonian age, the Grabenbach-Formation in the area NW of Nussensee comprises the Early Coniacian to Early Santonian interval.

3. List of samples

In the course of our study samples of grey marls have been taken in the river bed of Weißenbach brooklet, respectively in outcrops along its slope. For the topographic situation of sample points refer to Text-Fig.1. Only one profile is



Text–Fig. 1.
Location map of the marl outcrops sampled in the Weißenbachalm Gosau.

exposed, which shows almost continuous outcrops for more than 30 m. In addition also isolated outcrops from different points along the Weißenbach stream have been sampled, which in part indicate lateral changes in facies respectively palaeoecology.

The main profile of the Weißenbachalm Grabenbach-Formation is represented by an approximately 25 m high outcrop of grey marls (TOLLMANN's sample localities 3-7; see Plate 1, Fig.1 – this paper). However, the marly sequence of this profile starts further downstream and comprises from the bottom to the top the following sequence:

Sample WB15: The marly transgression sequence starts discordantly on top of the basal conglomerate (Kreuzgraben-Formation). Due to a high content of detrital minerals, these greenish-grey soft marls show a gritty feeling.

Sample WB4: Following upstream the Weißenbach brooklet is cutting through a peat bog covered by swampy wool grass meadows. The sequence below the peat bog comprises soft grey marls, intercalated by beds of marlstone, which are more resistant to erosion and therefore build several decimeters high cascades (Text-Fig 2). Sample WB4 represents a relatively soft grey marl intercalation alternating with grey marlstones, which yield scarce findings of bivalves and some gastropods.

Sample WB6: Soft grey marls with findings of broken *Inoceramus* shells from the western base of the big marl wall (Plate 1, Fig.1).

Sample WB5: Soft grey marls from a side creek, which branches in the eastern part in southern direction of the big marl wall. The sample was taken about five meters above the bottom of Weißenbach stream.

Sample WB17: Soft grey marls from the middle part of the big marl wall.

Sample WB18: In the middle and upper part of the big marl wall soft grey marls are occasionally intercalated with beds in the dm-range both of plant debris bearing sandstones and of bivalve coquina limestones. Detailed study of the thin-sections of samples WB18 is still missing.

Sample WB16: Soft grey marls from the top of the big marl wall.

Text–Fig. 2.
Location of sample point WB4 in the Weißenbach brooklet situated about 30m downstream of the 25m high marl outcrop of Plate 1, Fig. 1.

In addition to the only continuous profile described before, several isolated outcrops were sampled in order to obtain additional information on possible stratigraphically younger horizons and lateral facies changes within the Grabenbach-Formation. There is no evidence so far of stratigraphically younger outcrops, however, lateral facies changes occur here as documented by the outcrop of coral marls (samples WB1 and WB1A). In the following paragraphs, the marl outcrops along the Weißenbach stream are described from west to east.

Sample WB2: The westernmost sampling point of this study is located on the left (southern) side of the Weißenbach stream on the first marly slope, approximately 8 m above the top of the river bed. Shallow digging is necessary to get fresh grey marl.

Sample WB21: Below the landslide slope of sample WB2 grey hard and soft sandy marls are cropping out in the river bed of Weißenbach stream. The Sample WB21 comes from a 20 cm thick layer of light grey soft marls.

Sample WB22: Slightly upstream from sample WB21 about 2 m thick hard grey Miliolid-bearing calcareous marls are cropping out on top of the base conglomerate (Kreuzgraben-Formation), followed by medium grey soft sandy marls of sample WB22.

Sample WB3: Soft grey marls close to the western end of the big marl wall. The sample WB3 comes from the slope and not from the Weißenbach river bed.

Sample WB7: Soft grey marls, about 50 m SE of Weißenbach bifurcation, in the sidestream.

Sample WB8: Soft grey marls about 100 m upstream of the Weißenbach bifurcation, in the mainstream bed.

Sample WB9: Soft grey marls about 180 m upstream of the Weißenbach bifurcation. About 2 m high marly slope.

Sample WB10: Soft grey marls further upstream. The outcrop is about 2 m high and 4 m long, situated in approximately 1320 m altitude.

Sample WB11: Gastropod-bearing soft grey sandy marls from a landside slightly downstream from sample point WB10.

Sample WB1, 1A: Hard and soft grey marls with corals and scarcely gastropods (Plate 1, Fig. 2), close to the source of Weißenbach stream. Accessible towards the south from the end of forestry road. This peculiar facies of coral marls was treated in a separate paper by BARON-SZABO (1999).

4. Lithologic succession of Weißenbachalm Lower Gosau-Subgroup

The succession of Weißenbachalm Lower Gosau-Subgroup comprises (from bottom to top) the following main lithologies (in brackets equivalent formations in the Gosau-Basin):

Basal conglomerate ("Kreuzgraben-Formation").

Grey marls with scarce sandstone/limestone intercalations ("Grabenbach-Formation"), including coral marls.

Rudist-coral-brachiopod-facies sensu KOLLMANN & SUMMESBERGER (1982) ("Hochmoos-Formation") – see papers by BARON-SZABO (1999) and SZENTE et al. (1999).

In addition, it has to be mentioned that stratigraphically younger conglomerate horizons cannot be ruled out according to the present state of knowledge. One of these conglomerates is covered by a thin coal seam. Loose pieces of *Actaeonella*-bearing limestones were found in the river load of the Weißenbach stream; this lithology, however, could not be localized in situ so far.

4.1. Kreuzgraben-Formation and Streiteck-Formation ("Basal conglomerate")

The "Lower Conglomerate" sensu PETERS (1852) shows the widest superficial area in the western and northwestern part of the Weißenbachalm Gosau. In according with the classical locality in the Gosau valley these conglomerates are integrated into the Kreuzgraben-Formation (e.g. WAGREICH, 1988, 1998). The typical lithology consists of poorly sorted and mostly clast-supported reddish conglomerates. The clasts range from centimetres to boulders of several decimetres in diameter (Text-Fig. 3).

Text–Fig. 3.
Outcrop of basal conglomerate ("Kreuzgraben-Formation") on forest-road SW of Weißenbachalm.

Another type of conglomerates is cropping out along a dirt road east of Weißenbachalm. It consists of well sorted and perfectly rounded clasts with pebble sizes in the cm-range (Plate 1, Fig. 4). Also these conglomerates are grain-supported, occasionally well-bedded, and lack the reddish coating of clasts. Whether the latter conglomerates are also a part of the basal conglomerate or represent the "Upper Conglomerate" horizon sensu PETERS (1852) is still a matter of discussion. This second type of conglomerates most probably resembles the "Streiteck-Formation", as recently recorded e.g. by WAGREICH (1998). Generally, the basal conglomerate sediments are interpreted as alluvial fan, braided river or local talus fan deposits (FAUPL & WAGREICH, 1996). The second type of conglomerates is interpreted by the same authors as a fan delta facies. The composition of the clast spectra is not the aim of this study, however, according to TOLLMANN (1960a) the material seems to be of a local provenance only.

4.2. Grey marls with scarce sandstone/limestone intercalations (Grabenbach-Formation)

The onset of marly sedimentation and the lithological changes from the Late Turonian to the Early Santonian can be excellently studied in a continuous section along the Weißenbach stream. From West to East the profile exposes the underlying rugged surface of the basal conglomerate, on top of which a more than 30 m thick fine clastic/marly sequence follows with a sharp boundary. The onset of the marly sedimentation is documented by sample WB15 (this paper). The section continues upstream being incised through a marshy peatbog at the beginning with low stream cascades. An approximately 25 m high outcrop of marls with a few intercalations in the dm-range by micaceous sandstone beds with coal particles and bivalve coquina limestones follows further upstream (Plate 1, Fig. 1), representing the most conspicuous marl outcrop in the Weißenbachalm Gosau (TOLLMANN's 1960b sample localities Nos. 3-7). The top of the exposed marly succession is represented by sample WB16 (this paper). It is important to note that the hangingwall of the Grabenbach-Formation of the Gosau-Group at Weißenbachalm is not exposed at any place at present.

4.3. Coal Seam

In a small creek east of Weißenbachalm, respectively north of the forestroad, a small coal seam about 70 cm thick is cropping out (samples WB20A and WB20B). As can be seen on Plate 1, Fig. 3, the coal seam is directly overlying a conglomerate horizon of the Streiteck-Formation type. The coal samples show vitrinite reflectance values of 0.41% Rr and 0.44% Rr respectively (Subbituminous B coal). These reflectance values are only slightly lower than the reflectance spectra of other neighbouring Gosau coals, e.g. St. Wolfgang 0.47% Rr, St. Gallen 0.55% Rr, Unterlaussa 0.52% Rr, etc. The coal seam consists in part of carbonaceous clay, which yielded no marine biota. Both the coal and the carbonaceous clay contain a poorly preserved palynoflora dominated by *Complexiopollis* without any redeposition of stratigraphically older taxa. Based on the Normapolles association the stratigraphic position of the coal seam points to (?) Late Turonian age (Complexiopollis zone).

5. Material and methods

The marl samples were collected within the framework of the bilateral cooperations between the Czech and Austrian Geological Surveys and between the Hungarian and Austrian Geological Surveys respectively (leg. L. HRADECKÁ, Á. SIEGL-FARKAS and H. LOBITZER).

5.1. Mineralogical Analyses

The mineralogical analyses were carried out at the Institute of Applied Geology, University of Agricultural Sciences, Vienna. The samples were studied by means of X-ray diffraction (XRD) using a Philips 1710 diffractometer with automatic divergent slit, 0.1° receiving slit, Cu LFF tube 45 kV, 40 mA, and a single-crystal graphite monochromator. The measuring time was 1s in step-scan mode and stepsize of 0.02°2θ. Bulk samples as well as the clay fractions (<2 μm) were analysed.

Sample preparation generally followed the methods described by WHITTIG (1965) and TRIBUTH (1989). Dispersion of clay particles and destruction of organic matter was achieved by treatment with dilute hydrogen peroxide. Separation of clay fraction was carried out by using centrifugation methods. The exchange complex of each sample (<2 μm) was saturated with Mg and K using chloride solutions by shaking. Similar to the methods of KINTER & DIAMOND (1956) the preferential orientation of the clay minerals was obtained by suction through a porous ceramic plate. To avoid disturbance of the orientation during drying, the samples were equilibrated during 7 days above saturated NH_4NO_3 solution. Afterwards expansion tests were made, using ethylenglycol, glycerol and DMSO as well contraction tests heating the samples up to 550 °C. After each step the samples were X-rayed from 2-40 °2θ.

The clay minerals were identified according to THOREZ (1975), BRINDLEY & BROWN (1980), MOORE & REYNOLDS (1997) and WILSON (1987). Semiquantitative estimations were carried out according to OTTNER et al. (1997) using the corrected intensities of characteristic X-ray peaks (RIEDMÜLLER, 1978).

Semiquantitative mineral composition of the bulk samples was estimated using the method described by SCHULTZ (1964).

The illite crystallinity was measured on glycolated 2 μm samples, using the method described by KISH (1991).

5.2. Palaeontology

5.2.1. Foraminifera and Ostracoda

Twenty-one samples were collected in the Weißenbachalm region for microbiostratigraphical research. The foraminiferal assemblages were studied from the nineteen samples which were collected at the outcrops situated along the Weißenbach stream. Ostracodes were examined from 13 samples. The microfossils were isolated in the laboratory of the Czech Geological Survey from samples approximately 0,75 – 0,9 kg in weight using current washing method with sieves. Coarse fraction (> 1 mm) was kept in some cases. More than 100 foraminifera species were identified, their stratigraphic ranges were evaluated and the plankton/benthos ratios were calculated. Ostracodes were very rare. The microfossils were studied using binocular microscope. Photographs of the species were made by scanning electron microscope in the Laboratory of the Czech Geological Survey in Barrandov for foraminifera and at the Geological Survey of Austria for ostracodes. Three samples (WB15, WB20A and WB20B) contained no foraminifers.

Planktonic foraminiferal zonation sensu CARON (1985) and ROBASZYNSKI & CARON (1995) was used in this paper. Taxonomy of Foraminifera adopted in this study follows the systematic parts of papers by TOLLMANN (1960b), HANZLÍKOVÁ (1972), HERCOGOVÁ (1976, 1982, 1984), ŠTEMPROKOVÁ-JÍROVÁ (1977), EDWARDS (1981) and HRADECKÁ (1996). Taxonomy of ostracode genera follows MOORE (1961), MORKHOVEN (1963), POKORNÝ (1964) and GRÜNDEL (1973).

5.2.2. Calcareous nannofossils

Samples were processed in the Laboratory of the Czech Geological Survey, Prague. Suspension slides were prepared using a standard method of decantation and inspected under light microscope Nikon at 1,000 x magnification. The calculation of relative abundances of nannofossil species was based on ca. 300–500 specimens.

Biostratigraphic data were correlated with the UC zones (Upper Cretaceous nannofossil zones) introduced by BURNETT (1998) and compared with the standard nannoplankton CC zones by SISSINGH (1977) and PERCH-NIELSEN (1985), with modified nannoplankton zonation proposed by WAGREICH (1992a) for the Gosau-Group and with the Integrated Cretaceous Microfossil Stratigraphy (IC zones) by BRALOWER et al. (1995).

5.2.3. Palynology

The maceration was processed in the Pollen Laboratory of the Geological Institute of Hungary. Samples were treated with HCl and HF acids. During processing tap water was added to avoid too violent reactions. ZnCl2 was used for gravity separation, s.g. 1.9-2.1. The residues were mounted in glycerin jelly. Slides were examined using an Amplival Zeiss microscope and microphotographs were taken with a HI-100/1.4 Apochromat objective. Crosstable numbers mentioned in the plate explanations indicate the position of concrete object in slide what is fixed in the microscope crosstable.

6. Results

6.1. Mineralogical analyses

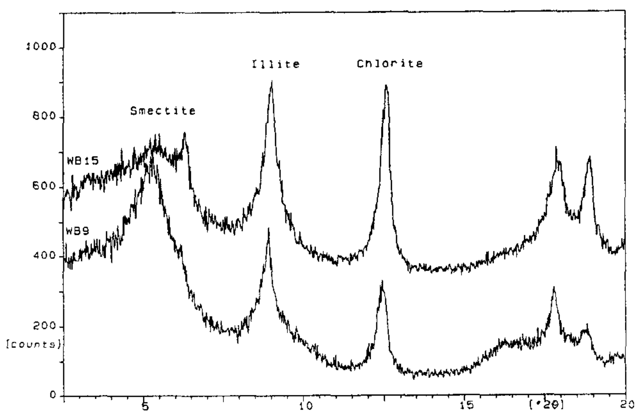
The results of bulk sample analysis are listed in Table 1; results of clay mineral analysis (fractions <2 µm) in Table 2.

Sample WB15 is characterized by a high influence of detrital minerals as quartz (26%), feldspars and muscovite. On the other hand lower contents of carbonate minerals calcite (19%) and dolomite (4%) were found (Table 1).

Some of the Turonian samples contain small amounts of gypsum (1-2%).

The quartz content of most samples is quite constant between 11 and 15%. In all the following samples from Turonian to Santonian the contents of calcite reach from 40 to 56%. In the Santonian samples feldspar is almost missing, which may indicate a decreasing terrestrial influence. All samples contain small amounts of pyrite.

The subbituminous coal and coal-clay samples WB20A and WB20B show a quite different mineralogical composition. Higher quartz and lower calcite contents maybe indicate terrestrial influence. The high pyrite values up to 8% are indicative for anoxic conditions during diagenesis.



Text–Fig. 4.
X-Ray-Diffractogram of sample WB15 from the transgression horizon versus sample WB9 with a high smectite content, fraction <2µ, glycolated.

Table 1.
Mineralogical composition of bulk samples (in mass %; tr: Traces)

Age	Sample	Quartz	Calcite	Dolomite	Feldspars	Phyllosilicates	Gypsum	Pyrite
Santonian	WB17	11	46	4	-	37	-	2
	WB16	13	43	4	-	39	-	1
	WB5	12	47	6	1	31	-	2
	WB2	11	40	2	-	45	-	1
	WB7	13	52	5	-	28	-	2
Coniacian	WB23	14	50	5	2	27	-	2
	WB22	15	47	5	3	28	-	2
	WB21	14	56	6	3	18	tr	2
	WB10	12	49	7	2	28	-	2
	WB9	11	40	3	1	43	-	2
Turonian	WB4A	11	49	6	1	32	-	1
	WB1	13	47	4	2	30	2	2
	WB1A	14	42	4	2	36	tr	2
	WB15	26	19	4	6	40	1	4
	WB20A	27	-	-	3	66	2	2
	WB20B	15	39	-	5	33	1	8

Table 2.
Clay minerals in the clay fraction <2 μm (in mass %)

Age	Sample	Smectite	Illite	Kaolinite	Chlorite	Mixed L.	IC
Santonian	WB17	64	16	13	7	-	0,50
	WB16	51	23	17	19	-	0,50
	WB5	52	22	17	9	-	0,45
	WB2	65	14	14	7	-	0,45
	WB7	61	19	13	7	-	0,45
Coniacian	WB23	44	35	10	11	-	0,60
	WB22	37	42	10	11	-	0,55
	WB21	36	42	10	12	-	0,50
	WB10	60	23	11	6	-	0,60
	WB9	69	15	10	6	-	0,55
Turonian	WB4A	61	20	12	7	-	0,45
	WB1	33	42	12	13	-	0,40
	WB1A	39	38	11	12	-	0,45
	WB15	33	45	4	18	-	0,60
	WB20A	19	70	11	-	*	0,55
	WB20B	35	45	9	11	*	0,55

In sample WB15 the detrital influence is not as clearly seen in the clay mineral composition than in the bulk sample. The amount of illite and chlorite is slightly higher and sectite lower than in the overlying samples (Table 2, Text-Fig. 4).

Especially the Santonian samples as well as some from Coniacian but only one from Turonian are dominated by smectite. Those samples contain only small amounts of illite. In general, the content of kaolinite is higher than that of chlorite.

In the coal sample WB20A chlorite is dissolved because of the acidic conditions in that environment.

Due to the high values of smectite in some samples (e. g. in sample WB9; see Table 2, Text-Fig. 4) detailed analyses of that clay mineral could be performed. In the analysed samples smectite is not a pure mineral phase but it is interlayered with small amounts of illite. For that it could be called a randomly interstratified illite-smectite mixed layer (MOORE & REYNOLDS, 1997). Furthermore it contains a high charged component that swells with ethylenglycol after Mg-saturation (like smectites) but does not swell after treatment with K (like vermiculites). This high K sensitivity is well known from clay minerals of soils in which strongly weathered vermiculite <2 μm occurs. Such high charged clay minerals (sometimes called 18 Å vermiculites) are typical for recent soils and paleosols too (SCHACHTSCHABEL et al., 1984). The occurrence of that less swelling 18 Å clay mineral together with smectite is indicated with an * in Table 2.

Illite crystallinity

IC is the sharpness of the 001 illite peak and is expressed in °2θ. During increasing diagenesis the illites recrystallize and become more muscovitic. The peak form becomes more sharp which results in lower °2θ values for higher IC. KÜBLER (1967) suggested 3 different zones of illite crystallinity: (1) diagenetic zone IC >0,42 °2θ, (2) anchizone 0,42-0,25 °2θ and (3) epizone < 0,25 °2θ .

In all analysed samples from Weißenbachalm the 10 Å peaks of the illites are very broad (Table 2). The measured values are between 0.45 and 0.60 °2θ, thus they all plot in the field of diagenesis. That indicates, that the deposited illites had been highly weathered before sedimentation and did not suffer any metamorphic alteration so far.

6.2. Palaeontology

6.2.1. Foraminifera

Rich foraminiferal assemblages showing varying stages of preservation were found in the studied samples from Weißenbachalm. In total more than 100 species were recognized in this material.

On the basis of the character of foraminiferal assemblages, three groups of samples could be recognized (Table 3). These groups are separated by thick lines in the Table 3. The plankton/benthos-ratio is shown on Table 4.

Relatively poorer foraminiferal assemblages were found in group 1 represented by the samples WB1, WB1A, WB4, WB4A, WB 9, WB10 and WB21. Benthic species prevailed but their calcareous, especially porcelaneous tests of suborder Miliolina, such as *Quinqueloculina angusta* (FRANKE), *Spiroloculina* sp., were decalcified. In many cases only infillings of ferruginous oxides and pyrite were visible. Also poorly preserved calcareous tests of other frequent species such as *Spirillina cretacea* (REUSS), *Osangularia biconvexa* (MARIE), *Epistomina scalaris* FRANKE were found to be poorly preserved. As concerns agglutinated foraminifers, *Bolivinopsis praelonga* (REUSS) was common together with *Tritaxia trilatera* (CUSHMAN), *T. tricarinata* REUSS, *Triplasia murchisoni* REUSS, *Dictyopsella* sp., *Glomospira irregularis* (GRZYBOWSKI). Coniacian age of these sediments is indicated, above all, by these benthic species: *Neoflabellina suturalis suturalis* (CUSHMAN), *Vaginulina trilobata* (D'ORBIGNY), *Praebulimina intermedia* (REUSS), *Globorotalites micheliniana* (D'ORBIGNY), etc., which were described as typical Coniacian taxa by HERCOGOVÁ (1982), ŠTEMPROKOVÁ-JÍROVÁ (1977) from the Bohemian Cretaceous Basin and by GAWOR-BIEDOWA (1984) from Poland. The diversity of benthic and planktonic species was low (Tables 3, 4). Rare occurrence of *Heterohelix moremani* (CUSHMAN), *Vaginulina trilobata* (D'ORBIGNY) and *Dicarinella imbricata* (MORNOD), together with the benthic species *Gavelinella praeinfrasantonica* MJATLJUK and *Gavelinella ukrainica* (VASILENKO) indicate Late Turonian-Early Coniacian age of the sediments of the first group of samples (HRADECKÁ, 1996), which points to the planktic zone Dicarinella concavata sensu ROBASZYNSKI & CARON, 1995.

Group 2 of samples (WB3, WB6 and WB8) contained a richer foraminiferal assemblage where calcareous tests of

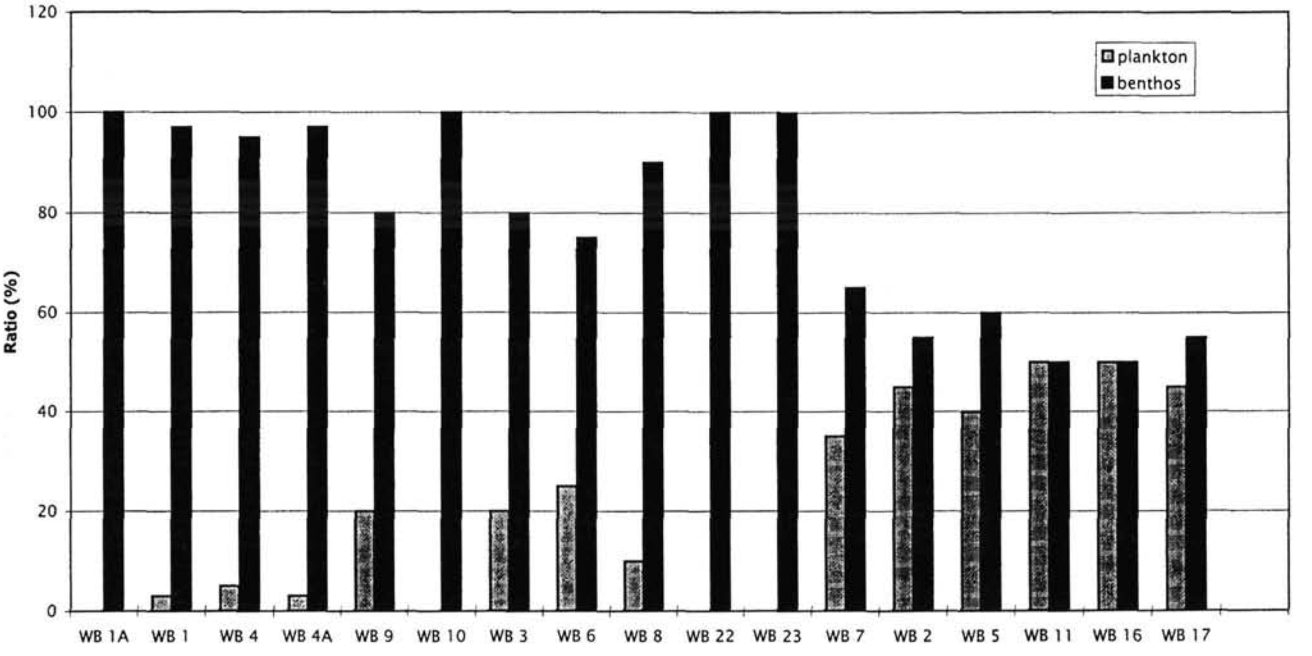
Table 3.
Distribution of Foraminifera in the studied samples from the Weißenbachalm. (• rare, O common, ● abundant)

stratigraphy	Late Turonian - Early Coniacian							Late Coniacian					Early Santonian					
planktic zonation	Dicarinella concavata Zone																	
species samples WB	**1A**	**1**	**4**	**4A**	**9**	**10**	**21**	**3**	**6**	**8**	**22**	**23**	**7**	**2**	**5**	**11**	**16**	**17**
agglutinated																		
Marssonella oxycona			•		•			O	O	O				•	●	O	O	O
Gaudryina trochus	•	O			O				O	O			•		O		O	O
Bolivinopsis praelonga		O	O		●			•					•	•				
Ammobaculites aequalis		•	•		•					•								
Tritaxia tricarinata		•	O	O				O	O	●			•	•	O	O		
Triplasia murchisoni			•	•	O	•		O	●				O	•				
Gyroidinoides nitida			•	•				●	●	●			●	●	O	O		
Haplophragmoides latidorsatum		•	•			•		O	•								O	•
Gaudryina laevigata		•	O	•	•	•												
Ammobaculites subcretaceus			•									•						
Spiroplectammina sp.			•	•										•				
Dorothia conula				•										•	•		•	•
Dorothia pupoides				•											O			
Tritaxia trilatera				•	O													
Gaudryina rugosa				•	•								•	•		O	•	
Gaudryina pyramidata					•								•			O	O	O
Trochammina sp.					O	•		O	•					•				
Glomospira irregularis					•													
Dorothia pupa								O	•	•			•					
Ammodiscus cretaceus																	•	
Dictyopsella sp.									O	•								
Gaudryina carinata									•				•				•	
Bolivinopsis anceps										•			•	•	•			
Verneuilina triquetra													•	O		•	•	
Gaudryina frankei															•			
Arenobulimina sp.														•				
Gaudryina variabilis																	•	O
Dorothia turris														O	•	•		
Spiroplectinata sp.																	●	O
calcareous benthos																		
Frondicularia inversa					•					•								•
Osangularia biconvexa			O	•														
Gavelinella lorneiana			•												●		●	●
Vaginulina gosae			O	O	O			O		O			O	O	•	O		
Gavelinella ukrainica			•		•													
Gavelinella schloenbachi			•					●										
Globorotalites michelinianus			•		•			•	O				●		●	●	●	●
Spirillina cretacea		•	●	O														
Quinqueloculina angusta	●	●	●	●			O			•	●	O	•					
Epistomina scalaris		O	●	●					•				•					•
Nodosaria zippei	•		•	•				•		•			O			•	•	
Frondicularia verneuiliniana			•	•				•		•							•	•
Gavelinella praeinfrasantonica			•															
Praebulimina hofkeri		•	O					●		O			O					
Valvulineria lenticula			•		•			●										
Neoflabellina sp.										•								
Praebulimina reussi			O		●			●	●	●			●	●	●	●	O	O
Lenticulina comptoni			•							O							•	O
Astacolus crepidula				•	•			•							•		•	O
Saracenaria triangularis				•	•									•				
Frondicularia bicornis				•	•			O		•			•	•			•	•
Neoflabellina suturalis suturalis					O			O	•	•			•	•			•	•
Frondicularia multilineata					•			O										
Vaginulina trilobata			•			•		•	•		•		•			O	O	

Table 3. - continuation

stratigraphy	Late Turonian - Early Coniacian							Late Coniacian					Early Santonian					
planktic zonation	Dicarinella concavata Zone																	
species / samples WB	1A	1	4	4A	9	10	21	3	6	8	22	23	7	2	5	11	16	17
Dentalina communis					o					o				•	•	o	•	•
Frondicularia inversa					•													•
Eouvigerina cretacea																	•	•
Quadrimorphina allomorphinoides					o			•		•			•	•	o	o	•	•
Frondicularia goldfussi								o					o	•				
Praebulimina intermedia								o										
Saracenaria navicula								•						•				
Dentalina sororia								•						•				
Lagena sulcatiformis								•	•					•			•	
Lagena aspera apiculata								•						•				
Neoflabellina laterecompresa								•						•		•		
Pyramidina kelleri									o									
Ceratobulimina woodi					•				•					•				
Ramulina laevis									•	•			•	•		•	•	
Gavelinella moniliformis										•			o	•		•		
Lenticulina marcki										o			•	•			o	o
Pseudouvigerina cristata													•	•				
Frondicularia turgida										•			•					
Lenticulina subalata										•			•					
Lenticulina orbicula										•			•					
Fissurina orbignyana										•								
Frondicularia angustissima														•				
Gavelinella tumida															o	o	o	
Neoflabellina sp.										•								
Dentalina gracilis														•	•			
Gavelinella stelligera														•		o	o	
Dentalina oligostegia																•	•	
Lenticulina truncata																•		
Saracenaria jarvisi																•	•	
Gavelinella pertusa																•	o	o
Neoflabellina suturalis praecursor																	•	
Pleurostomella viperinea																	•	
plankton																		
Marginotruncana angusticarinata			•		o			o	o				o	o	●	o		●
Marginotruncana pseudolinneiana			•					o	o					•		o	o	o
Globigerinelloides ultramicra		•	•		o								●	●		o	•	•
Marginotruncana marginata				•					•								●	o
Marginotruncana schneegansi				•	o				o				o			•	o	
Heterohelix globulosa					•					o			o	●	o	o	o	o
Dicarinella primitiva					o													
Archaeoglobigerina cretacea					•											•	•	
Heterohelix moremani					•													
Hedbergella flandrini																•	•	
Marginotruncana renzi								•					•		o			
Globotruncana globigerinoides									•									
Marginotruncana coronata													o		o			o
Dicarinella imbricata													•					
Rosita fornicata ?													•					
Heterohelix lata														•			•	
Globotruncana linneiana														•			●	
Marginotruncana tricarinata														•		o		
Globigerinelloides aspera														o				
Hedbergella holmdelensis														•	•	•	•	
Pseudotextularia sp.																	•	
Dicarinella concavata														•		•	•	

Table 4.
Plankton/benthos ratio of foraminiferal assemblages from the Weißenbachalm sediments.



Praebulimina, Gavelinella and *Gyroidinoides* prevailed together with large tests of agglutinated genera *Tritaxia* and *Triplasia*. The benthos was more diversified, but white-coloured, decalcified tests of species from group 1 were not so frequent. The relative abundance of planktonic species was higher. The occurrence of *Praebulimina intermedia* REUSS and *Pyramidina kelleri* (VASILENKO) indicates the Late Coniacian age of these sediments.

Sediments of group 3 (samples WB2, WB5, WB7, WB11, WB16 and WB17) contained rich, relatively well preserved foraminiferal assemblages. *Gavelinella lorneiana* (D'ORBIGNY), *G. tumida* BROTZEN, *Globorotalites micheliniana* (D'ORBIGNY), *Quadrimorphina allomorphinoides* (REUSS), *Praebulimina reussi* (MORROW) and species of the genera *Dentalina* and *Lenticulina* prevailed. The plankton was highly diversified and also its relative abundance in the foraminiferal assemblage was about 70 % (Table 4). The genera *Marginotruncana, Heterohelix* and *Globigerinelloides* dominated in these sediments.

The character of foraminiferal assemblages changed especially in samples WB5, WB11, WB16 and WB17. Species such as *Gavelinella tumida* BROTZEN, *Gavelinella stelligera* (MARIE), *Gavelinella pertusa* (MARSSON) appeared. The rare occurrence of other species such as *Neoflabellina suturalis praecursor* (WEDEKIND) and *Pleurostomella viperinea* HERCOGOVÁ (described from the Early Santonian of Tunisia by HERCOGOVÁ, 1976) and, on the other hand, the absence of *Bolivinopsis praelonga* (REUSS) indicate the Early Santonian age of sediments (GAWOR-BIEDOVA, 1984). Also *Globotruncana linneiana* (D'ORBIGNY), *Rosita fornicata* (PLUMMER) and the find of *Pseudotextularia* sp. in sample WB16 confirm the Santonian age (CARON, 1985; ROBASZYNSKI & CARON, 1995).

6.2.2. Ostracoda

In this paper a first attempt is made to identify the ostracode taxa of the Grabenbach-Formation from the Weißenbachalm area. For this reason some aspects of the characters of several species are given.

Sixteen samples were examined for ostracodes but only thirteen of them yielded ostracodes. In samples WB15, WB20A and WB20B ostracodes were lacking. The ostracode fauna has a low diversity not exceeding eight species per sample. Twelve different taxa can be distinguished. In general the state of preservation is bad, the specimens are often crushed, the surfaces corroded and/or the valves filled with sediment. The inner characters could not be studied in most of the specimens. On the other hand also complete carapaxes and juvenile specimens have been found. The samples with their species content are listed in Table 5.

The most common faunal element of the ostracode association is the genus *Cytherella* JONES, 1849 with several species, of which *Cytherella leopolitana* (REUSS, 1851) is most abundant. Representatives of *Cytherella* occur in all of the thirteen samples. Many of the *Cytherella* specimens are similar in outline to *Cytherella parallela* (REUSS, 1851), but the carapaxes of *Cytherella leopolitana* (REUSS, 1851) demonstrate, that these are the smaller valves of that species (Pl. 5, Fig. 4). *Cytherella parallela* (REUSS, 1851) obviously has two almost identical valves comparing the outline. Few specimens are similar in outline to these valves but have a pointed surface. They are provisionally named *Cytherella* sp. A (Pl. 5, Fig. 5). It cannot be excluded that more species are represented within the smooth specimens of *Cytherella* as it is not possible with the specimens at hand to decide whether the species *Cytherella leopolitana* (REUSS, 1851) shows a certain variability or if some specimens belong to other species.

Also quite abundant are *Brachycythere sphenoides* (REUSS, 1854), *Bairdia* sp., *Oertliella* sp. and *Schuleridea neglecta* (REUSS, 1854). More rarely *Dolocytheridea* ? sp., *Neocythere* ? sp. and *Parvacythereis* sp. are occurring. *Paracypris* sp. has only been found in two samples. Possibly it is identical with *Bairdia attenuata* REUSS, 1854. The specimens of *Schuleridea neglecta* (REUSS, 1854) show a variability in the length/width-ratio which is interpreted as sexual di-

Table 5:
Distribution of ostracodes in the studied samples from the Weißenbachalm.

Ostracoda	samples (WB)												
	1A	2	3	4	4A	5	7	9	10	16	21	22	23
Bairdia sp.	x	x	x		x	x	x	x		x		x	x
Cytherella leopolitana (REUSS, 1851)	x	x	x	x	x	x	x	x	x	aff.	x	x	x
Cytherella sp. A		x											
Paracypris sp.		x				x							
Dolocytheridea ? sp.	x	x	x			x	x	x		x			x
Schuleridea neglecta (REUSS, 1854)	x			x	x		x	x		x	x	x	x
Neocythere ? sp.	x			x	x				x		x		x
Oertliella sp.	x	x	x	x	x		x	x	x	x		x	x
Parvacythereis sp.		x	x	x	x		x						
Brachycythere sphenoides (REUSS, 1854)	x	x	x	x	x	x	x	x	x				x
Diogmopteron ? sp.								x					x
Ostracoda gen. et sp. inc.								x					

morphism. The specimen on Plate 6 (Fig. 2) represents a male, the figured specimen of REUSS (1854: Pl. 26, Fig. 11) is female. Most of the specimens of *Brachycythere sphenoides* (REUSS, 1854) agree with the figure in REUSS (1854: Pl. 27, Fig. 2) but in two samples (WB9 and WB23) few specimens are occurring which differ mainly in such a way that the ventrolateral rim forms a strong carina and is extended like in *Pterygocythereis.* They are herein assigned to *Diogmopteron* ? sp. One of these specimens is figured on Plate 6 (Figs. 7-8). The figured specimen of *Dolocytheridea* ? sp. (Pl. 6, Fig. 1) represents an individual with a low length/width-ratio. Most of the specimens are much more elongated and are similar to *Cytherina acuminata* ALTH, 1850 as it is figured in REUSS (1851: Pl. 6, Fig. 8).

The ostracodes of the present study are deposited in the collections of the Geological Survey of Austria in Vienna under the registration number 1999/4 (with subnumbers).

6.2.3. Calcareous nannofossils

Sediments provided mostly rare (< 5 specimens/1 field of view) and moderately well preserved calcareous nannofossils of remarkably small size where overgrowth and/or dissolution is evident. Nannofossil associations are characterized by the relative abundance (5–10%) of *Watznaueria barnesae, Zeugrhabdotus diplogrammus, Chiastozygus litterarius, Eiffellithus* spp. and *Prediscosphaera* spp. and, on the other hand, by markedly rare occurrence of (up to 0.5–1.0% in maximum) *Marthasterites furcatus, Lithastrinus septenarius, Eprolithus floralis, Broinsonia* spp. and accessory of *Micula decussata.* Significant component of the assemblages is formed by holococcoliths of the genus *Lucianorhabdus* which are distinct in their habitus and perfectly preserved.

Despite of overgrown material, "subtle tests" such as *Rotelapillus crenulatus, Corollithion signum, C. exiguum, Cribrosphaerella ehrenbergii* or *Sollasites horticus* are present in relatively higher numbers.

The following nannofossil associations were recognized (see Table 6):

1. Association with *Lithastrinus septenarius* and *Marthasterites furcatus* evidencing the UC9a Zone (the uppermost part of Middle Turonian – lower part of Late Turonian sensu BURNETT, 1998), which is here correlated with the lower part of the Late Turonian.
2. Association with *Zeugrhabdotus biperforatus* and *Lithastrinus septenarius,* evidencing the UC9b-c Zone (upper part of Late Turonian – lower part of Early Coniacian).
3. Association with *Micula staurophora* and *Lithastrinus septenarius,* evidencing the UC10 Zone (Middle Coniacian).
4. Association with *Lithastrinus grillii, Lucianorhabdus cayeuxii* species A (sensu WAGREICH, 1988 and 1992a), *Reinhardtites* sp., *Micrantholithus quasihoschulzii, Grantarhabdus coronadventis* and *Micula staurophora,* evidencing the UC11c Zone (upper part of Late Coniacian – Early Santonian). Furthermore, rare occurrences of *Watznaueria quadriradiata* and *Prediscosphaera* cf. *grandis* sensu BURNETT (1998) were recorded here which also support the Santonian age.

The Late Cretaceous nannofossil assemblages also contain reworked species, among others from the Late Oxfordian-Berriasian interval represented by *Conusphaera mexicana mexicana* and *C. mexicana minor* (see Plate 8, Figs. 17-19).

Finally, sample WB20B provided only rare coccoliths without any stratigraphic significance and sample WB15 was free of calcareous nannofossils.

6.2.4. Palynology

The organic microfacies of the samples is characterized uniformly by high organic matter content in the form of coal grains, fragments of epidermal tissues and splintery grains of resin. Generally the assemblages are characterized by rich sporomorph associations in good or medium state of preservation. Variations in their amount are shown in Table 7; the state of preservation can be seen in Plates 9-11. Very poorly preserved, intensively oxidized sporomorphs occurred in the coal, respectively coal clay samples (WB20 and WB20B) only.

The genera of Normapolles Stemma (Angiospermae) are dominant in the associations. Rich associations of pteridophytes could be determined in samples WB1A, WB22A and WB23 only. The composition of fern vegetation varies among the individual samples. In accordance with the general character of the Mediterranean region during the Late Cretaceous, the pollen grains of Gymnospermae are very rare. Marine phytoplankton was represented by some very poorly preserved individuals only. Other microfossils such as remains of organic-walled Foraminifera and of Scolecodonta (Annelida) were found, too. The associations are characterized by the

WEISSENBACHALM	TURONIAN / CONIACIAN												SANTONIAN					
Standard Nannofossil Zonation Sissingh,1977; Perch-Nielsen,1985	CC 13							CC 14					CC 16					
Upper Cretaceous Nannofossil Zonation (Burnett,1998)	UC 9 a				UC 9 b-c			UC 10					UC 11 c					
sample No.	1A	1	4	4A	9	10	21	3	6	8	22	23	7	2	5	11	16	17
relative sample abundance	•	•	○	■	•	•	•	■	○	○	•	•	○	●	●	●	●	●
nannofossil preservation	P	P	P	M	P	P	P	M	M	P	P	P	P	W	M	W	W	W
Amphizygus brooksii	•	•		•	•		•	○	•	○	•	•		○		○	•	•
Broinsonia enormis	•	•	•					•						•	•	•	•	•
Calculites ovalis	•	•	○	•	○			○	•	○	•	•		○	○	○	○	○
Chiastozygus litterarius	●	○	●	●	○	●	●	●	○	○	●	●	○	●	•	○	○	○
Corollithion exiguum	•	•	•	•														
Corollithion signum	•	○	○	○	○				○	•	•	○	•	○	•	○	○	•
Cretarhabdus conicus	○	○	○	○	○	○	•	○	○	○	●	●	○	○	○	○	○	○
Cribrosphaerella ehrenbergii	○	○	●	○	●	○	●	●	●	○	●	●	●	●	●	●	●	●
Cyclagelosphaera reinhardtii	•			•							•							
Cyclagelosphaera sp.	•									•			•			•	•	
Eiffellithus eximius	○	○	○	●	○	•	○	○	•	○	●	●	○	○	○	○	○	•
Eiffellithus gorkae		•											○	○	○			
Eiffellithus turriseiffelii	●	○	○	●	○	○	○	○	●	●	●	○	●	●	●	●	●	○
Eprolithus floralis	•									•		•						
Lithastrinus septenarius	•	•		•		•		○	○	○	○	○	•	•	○		•	•
Lucianorhabdus maleformis	○	○	○	○	○	•	•	●	○	●	●	○	○	○	○	●	○	○
Lucianorhabdus quadrifidus	•	•	○	○	○			○	•		●	○	○	○	○	○	○	○
Manivitella pemmatoidea	•		•		•			•	•	•			•	•	○	○	○	•
Marthasterites simplex	•													•				
Microrhabdulus belgicus	•		•	•	•			○	•	•			○	○	○	○	○	•
Prediscosphaera columnata	○	•		○	•			•				○		•	○			
Prediscosphaera cretacea	●		●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●
Prediscosphaera ponticula	○		○	○	•	•	•	•	•	•	•	○	○	○	○	○	•	•
Prediscosphaera spinosa	•		•					•	○	•			•	•	•	•	•	•
Retacapsa crenulata	●		●	●	○	○	●	•	○	○	●	●	○	○	○	●	○	•
Retacapsa ficula	•	•		•		•		•				•		•	•			
Retacapsa madingleyensis	○	•	•	•			○	•	•	•	○	•	•	•	•	•	•	
Retacapsa angustiforata	•			○	○		•	○	•		○	○		•	○	○	○	•
Rhagodiscus angustus	•	•	○	•	○	○	○	•	○	○	•		○	•	○	○	•	•
Rotelapillus crenulatus	•		○	○	○			○	○	○	○	•	•	○	○	○	○	•
Staurolithites sp.	•	•	•	•		•		•		•	•	•	•		•		•	•
Stoverius achylosus	•	•		•	•	•		•		•	○	•	•	•	•	•	•	cf.
Tegumentum stradneri	•		○											○	○			•
Thoracosphaera sp.	•				•				•	•					•	•		
Watznaueria barnesae	●	○	●	●	●	○	●	●	●	●	○	○	●	●	●	●	●	●
Watznaueria britannica	•	•	•	○	•	○		•	•		○		•		•	•		•
Watznaueria manivitae	○	•	•	•			○	○				○					•	
Zeugrhabdotus diplogrammus	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Neocrepidolithus sp. (rim)		•																
Corrolithion sp.		•	•		•				•	•	•		•	•	•	○		•
Haqius circumradiatus		•		•		•				•		•	○	•			•	
Lithraphidites carniolensis		○	○	•	○	○		○	○	○	•	•	•	○	○	○	●	○
Marthasterites furcatus		○	•	•	○	○	•	•	•	○		•	○	●	○	○	○	○
Octolithus multiplus		•	•		•				•	•				•	•	•	•	○
Helicolithus turonicus		•																
Biscutum ellipticum			•		•							•			•		•	•
Braarudosphaera bigelowii			•		•			•	•	•				○	•	•		•
Broinsonia signata			•	•				•	•	•				•		•		
Helicolithus trabeculatus			○	•		○		•	•	•		•	•	•	○	•	○	•
Micrantholithus			R											•				
Nannoconus sp.			•	•	•			•	•	•	•	•	•	•	•	•		•
Conusphaera mexicana mexicana			R	R	R		R	R	R	R	R	R	R		R	R		

WEISSENBACHALM	TURONIAN / CONIACIAN												SANTONIAN					
Standard Nannofossil Zonation Sissingh,1977; Perch-Nielsen,1985	CC 13							CC 14					CC 16					
Upper Cretaceous Nannofossil Zonation (Burnett,1998)	UC 9 a				UC 9 b-c			UC 10					UC 11 c					
sample No.	1A	1	4	4A	9	10	21	3	6	8	22	23	7	2	5	11	16	17
relative sample abundance	•	•	○	■	•	•	•	■	○	○	•	•	○	●	●	●	●	●
nannofossil preservation	P	P	P	M	P	P	P	M	M	P	P	P	P	W	M	W	W	W
Conusphaera mexicana minor			R		R							R			R			
Placozygus fibuliformis			•		•	•	•		○	•			•		•	•	•	•
Rhagodiscus eboracensis			○	•	•	•		•	○	○		•	•	•	•	○	•	•
Sollasites horticus			•	•	•			•	•	•			•	○	•	•	○	○
Cylindralithus biarcus			•				•		•	•	○			○	○	•	○	•
Zeugrhabdotus noeliae			•	•	•	•		•		•	•			•			•	
Isocrystallithus compactus			R															
Tranolithus minimus				•	•					•				•	○		•	•
Zeugrhabdotus bicrescenticus				•				○	•	•		•		○	•	•	•	○
Grantarhabdus coronadventis					•										•	•	•	•
Quadrum gartneri					•			•										
Watznaueria biporta					•			•								•	•	
Zeugrhabdotus biperforatus					•	•	•	○	•	○			•	○	○	○	○	○
Micula staurophora								•	•	•	○	•	•	○	•	•	○	○
Rhagodiscus asper								•	•		•		•	•		•	•	•
Gartnerago cf. *theta*								•		•				•	•		•	
Kamptnerius magnificus									•	•								
Ahmuellerella octoradiata										•	•						•	•
Microrhabdulus decoratus										•				•		•	•	
Lithastrinus grillii													•		○	○	•	•
Lapideacassis cornuta													•	•			•	
Tranolithus orionatus													•	•		•		
Gartnerago obliquum														•		•	•	•
Nannoconus elongatus														•		•	•	
Micrantholithus quasihoschulzii														•	•		•	•
Lucianorhabdus cf. *cayeuxii*														•			•	•
Lucianorhabdus inflatus														•				
Prediscosphaera cf. *grandis*														•				
Tranolithus gabalus														•				
Zeugrhabdotus embergeri														•				•
? *Reinhardtites* sp.															•	•		•
Uniplanarius gothicus															•			
Nannoconus cf. *farinacciae*																	•	
Nannoconus ex gr. *truittii*																R		R
Scapholithus sp.																	•	•
Zeugrhabdotus cooperi																	R	
Broinsonia parca expansa																	•	•
Watznaueria quadriradiata																		•

Table 6.
Distribution of calcareous nannofossils in sediments of Weißenbachalm. Relative sample abundance: ● abundant (>10 specimens/1 field of view), ■ less abundant (5-10 specimens/1 field of view), O common (1-5 specimens/1 field of view), • rare (<10 specimens/10 fields of view). Relative nannofossil species abundance: ● abundant (> 5%), O common (5-1%), • rare (<1%), R = reworked species, cf. = compare. Nannofossil preservation: W – well preserved, M – moderately well preserved, P – poorly preserved.

presence of abundant reworked Triassic sporomorphs.

Two biozones are recognized on the basis of palynological investigations:

1. Complexiopollis Dominance Zone

The following samples containing *Complexiopollis*-dominated associations can be assigned to this zone: WB1A (Late Turonian), WB7 (according to foraminifera and nannoplankton of Santonian age!), WB15, WB20A and WB20B (see Table 7). These samples regularly contain various *Complexiopollis* species of Early Senonian age having ornamented surfaces: *Complexiopollis microrugulatus*, *Complexiopollis christae* etc. In addition, thin-walled species of the same genus, *Complexiopollis labilis*, *Complexiopollis latis*, *Complexiopollis vulgaris* also having a primitive pore structure are still abundant. Unlike in younger associations, species of the genus *Oculopollis* are found here in small numbers only.

2. Oculopollis – Complexiopollis Assemblage Zone

The character of these palynomorpha associations is defined by the growing dominance of the genus *Oculopollis* and the concurrent recession of the hitherto frequent *Complexiopollis* species. Three consecutive associations were distinguished within this zone according to the quantitative variations in the proportion of the two genera and to the growing abundance of *Pseudoplicapollis peneserta*. Samples WB3, WB6, WB10 and WB23 are characterized by the approximately equal abundances of the *Complexiopollis* and *Oculopollis* species. Hence the large *Oculopollis zaklinskaiae* and *Oculopollis clausus*, both having strong pore regions with rich ornamentation can be found regularly, besides *Complexiopollis complicatus*, which occurs frequently in the upper part of the Santonian. Samples WB4, WB4A, WB9, WB21 and WB22 are characterized by a clear dominance of the genus *Oculopollis*. Also *Bakonyipollis galerus*, which is characteristic for the Transdanubian Central Range

Table 7.
Distribution of spores, pollen, phytoplankton and other organic walled microfossils in sediments of Weißenbachalm (I = very rare, II = rare, III = common, IIII = subdominant, IIIII = dominant).

SAMPLE NUMBERS	SPORES																								POLLEN: Gymnospermae			POLLEN: Angiospermae (Normapolles, etc.)						PALYNOZONES
	Bikolisporites toratus	*Cicatricosisporites* div.sp.	*Cyathidites* sp.	*Gleicheniidites senonicus*	*Leiotriletes* div. sp.	*Stereisporites europeum*	*Trilites* div. sp.	*Appendicisporites* div. sp.	*Klukisporites* div. sp.	*Gemmasporites* sp.	*Costatoperforosporites* sp.	*Uvaesporites* sp.	*Devecserisporites goczani*	*Dictyophillidites harrisii*	*Echinatisporites* sp.	*Osmundacidites wellmannii*	*Phlebopterisporites equiexinus*	*Phaeocerosporites purus*	*Vadaszisporites* div. sp.	*Zebrasporites* sp.	*Obtusisporites juriensis*	*Vinculisporites flexus*	*Toroisporites* sp.	*Foveolatisporites multifoveolatus*	*Araucariacidites hungaricus*	*Inaperturopollenites* div. sp.	*Monosulcites* sp.	*Complexiopollis* div. sp.	*Compexiopollis labilis*	*Complexiopollis vulgaris*	*Complexiopollis microrugulatus*	*Complexiopollis complicatus*	*Oculopollis* div. sp.	
2	II	II	I	I	I	I	I												I				I		I		I	III	I	I		I	IIIII	OCULOPOLLIS - COMPLEXIOPOLLIS ZONE
5	I			I	I			I	I										I		I							III		I		II	IIIII	
11		I		I		I													I	II	I							III		I		I	IIIII	
16	I			I	I															I								III		I		I	IIIII	
17	I				I	I			I										I					I				III	II	II		I	IIIII	
4	I	I	I																		I	I	I					III	I	I			IIIII	
4A	II	I	I		I	I			I				I								I				I			III	I	I			IIIII	
9	I	I		I			I							I	I				I							I		III	I	I			IIIII	
21			I		II		I			I										I						I		III	I	I		I	IIIII	
22A	III	I	I	I	IIIII	I	II	I		I	I	I	I	I	II				II						II			III	II	I		I	IIIII	
3	I			I	I		I												I			I						IIII	I	I			IIII	
6	II		I	I	I				I										I	I	I	I				I	I	IIII	I	I		I	IIII	
10	II	I	I	I	I	I			I										I		I	I						IIII	I	I			IIII	
23	IIIII	II	I	II	I		II		I										I	I					I	II		IIII	I	I		I	IIII	
1A	IIIII	II	I	II	I		III	I	I	II			I	I	I	I	I	I								II	I	IIIII	II	I	I		III	COMPLEX. ZONE
7	II	I			I	I	I			I																		IIIII	II	I	I		III	
15	I	I	I	I	I		I			I		I													I	I		IIIII	II	I	I		III	
20	I	I	I	I	I		I	I	I	I	I																	IIIII	II	I	I		III	
20B	I	I	I	I	I	I	I	I	I	I	I																	IIIII	II	I	II		III	

SAMPLE NUMBERS	POLLEN: Angiospermae (Normapolles, etc.)																				PHYTOPLANKTON												PALYNOZONES
	Oculopollis orbicularis	*Oculopollis zaklinskaiae*	*Pseudoplicapollis peneserta*	*Triatriopollenites* div. sp.	*Schulzipollis pannonicus*	*Retitricolporopollenites* sp.	*Tricolpopollenites suemegensis*	cf. *Pecakipollis* sp.	*Extratriporopollenites* sp.	*Trudopollis* sp.	cf. *Hungaropollis* sp.	*Triporopollenites robustus*	*Ephedripites* sp.	*Suemegipolls triangularis*	*Periporopollenites* sp.	*Quedlinburgipollis altenburgensis*	*Tetracolporopollenites globosus*	*Megatriopollis* sp.	*Bakonyipollis galerus*	*Praebasopollis* sp.	*Odontochitina* sp.	*Cladopyxidium* sp.	*Hystrichosphaeridium* sp.	*Pterospermella australiensis*	*Veryhachium cruciatum*	*Botryococcus* sp.	Fungi	Foraminifera	Scolecodonta	Gymnospermae (redep. Triassic)	Gymnospermae (redep. Late Permian)	*Oraveczia hungarica* (redep. Rhaetian)	
2	I	I	III	I	I				I																	I		II		IIII			OCULOPOLLIS - COMPLEXIOPOLLIS ZONE
5	I	I	III	II	I	I	I	I	I	I		I					I													III	I		
11	I	I	III	II	I		I												I						I					III	I		
16	I	I	III	II					I															I			I			II			
17	II	I	III	II	I				I											I							I	I		I	I		
4	I	I	I	I	I				I										I											IIII	I		
4A	I	I	I	I					II	I		I						I								I	I			III	I		
9	I	I	I	I													I									I			I	IIII		III	
21	I		I																											I			
22A			I																				I					I		III			
3	I	I	I	I								I										I				III	I	II		III	I		
6		I	I	II	I				I	I					I	I												I		III	I	II	
10	I	I	I	I	I		I			I				I												I				II			
23	I	I	I	I			I		I				I													I				III	I		
1A	I		I	I	I				I	I		I							I		I					II	I	I		IIIII			COMPLEX. ZONE
7			I	I	I				I	I	I																	I		II	I		
15			I																											I			
20	I		I	I		I	I																										
20B	I		I	I	I	I	I	I																									

associations in Hungary can be observed here. *Tetracolporopollenites (Becolpites) globosus,* a zone indicator of the Late Santonian age in Hungary, appears in the same samples, too. Besides the dominant genus *Oculopollis,* the genus *Complexiopollis* and both subspecies of *Pseudoplicapollis peneserta* (nov. ssp. *maior* and nov. ssp. *minor*) which are introduced here as nomina nuda, are approximately equally represented in the associations thought to be the youngest ones (represented by samples WB2, WB5, WB11, WB16 and WB17). The occurrence of *Complexiopollis complicatus* is consistent in this association and *Triatriopollenites,* a subzone indicator for the Late Santonian associations of Hungary, appears more frequently than the last mentioned species.

7. Discussion

7.1. Mineralogy

WB15 is stratigraphically the lowest sample and represents the transgression horizon of the marly Gosau sedimentation. Mineralogically it is well documented by the high amount of detrital minerals, e.g. quartz, feldspars and also illite (Text-Fig. 4). On the other hand calcite as well as dolomite are less present in that sample. WB4A is also of Turonian age but shows clearly less detrital influence and a high rate of carbonate production, the latter might be in part also of detrital origin. Among the clay minerals smectite becomes the most abundant mineral in the marls due to the small grain size (Table 2, Text-Fig. 4). The stratigraphically highest samples WB16 and WB17 (Santonian) show a similar mineralogical composition.

Most clay minerals of marine sediments are inherited from former exposed land masses. For that, clay mineral assemblages can express the intensity of weathering in the land masses adjacent to sedimentary basins (CHAMLEY, 1989).

The analysed high smectite content in these Gosau marls correlates quite well with former studies of Upper Cretaceous marine sediments (SAUER, 1980; POBER, 1984). This could be the result of erosion of thick pedogenic blankets developed under high temperature and seasonally contrasted humidity (CHAMLEY, 1989). The existence of pedogenetic minerals (soil vermiculite) supports this theory.

The very low values of IC also indicate resedimentation of a highly weathered material into the Gosau sea (Table 2).

7.2. Biostratigraphy and Palaeoecology of foraminifers, ostracodes and nannofossils

TOLLMANN (1960b) described rich foraminiferal assemblages from the Weißenbach section. From the 101 encountered taxa, TOLLMANN determined 93 on a species level. On the basis of rich, well preserved microfauna and a comparison with other localities TOLLMANN considered the age of the studied sediments as Late Coniacian.

During our present study of foraminifers more than 100 species were recognized. Because TOLLMANN published his study thirty-nine years ago, a partial revision of taxa had to be done. We had only TOLLMANN's figures of species published in his paper at our disposal and not the original material. In the new classification of LOEBLICH & TAPPAN (1988), many taxa were renamed (see Appendix No. 1). The revision is therefore not a profound one and it would be desirable to study the original foraminifera material of TOLLMANN (1960b) in the future.

Many species found in our material and also published by TOLLMANN (1960b), such as *Tritaxia tricarinata* REUSS, *Gaudryina pyramidata* CUSHMAN, *G. rugosa* D'ORBIGNY, *Globorotalites micheliniana* (D'ORBIGNY), *Gavelinella lorneiana* (D'ORBIGNY), *G. stelligera* (MARIE), *Praebulimina intermedia* (REUSS), *P. reussi* (MORROW), *P. hofkeri* (BROTZEN), *Neoflabellina suturalis suturalis* (CUSHMAN) were also mentioned by HERCOGOVÁ (1965, 1978) and HRADECKÁ (1997) from the Late Turonian and Coniacian of the northwestern part of the Bohemian Cretaceous Basin, e.g. from Březno and Úpohlavy localities. This similarity also mentioned by TOLLMANN (l.c.) may pose an evidence for the communication between basins during a specific period. New foraminiferal studies also allowed to recognize a higher number of species of the genera *Gaudryina, Gavelinella, Neoflabellina, Frondicularia* and *Praebulimina*. Their systematic descriptions were published by HANZLÍKOVÁ (1972), HERCOGOVÁ (1978, 1982), EDWARDS (1981), ŠTEMPROKOVÁ-JÍROVÁ (1977) and HRADECKÁ (1996).

Important systematic changes were recorded during the study of planktonic species. Many new genera were recognized, such as *Marginotruncana, Dicarinella, Hedbergella, Rosita* and *Archaeoglobigerina*. The presence of these planktonic species facilitated a more detailed subdivision of the Grabenbach-Formation of Weißenbachalm. According to the presence of *Dicarinella concavata* (BROTZEN), *D. imbricata* (MORNOD), *D. primitiva* (DALBIEZ), *Archaeoglobigerina cretacea* (D'ORBIGNY) and others, all these samples can be placed into the *Dicarinella concavata* Zone (Late Turonian to lower part of Early Santonian) sensu ROBASZYNSKI & CARON (1995).

Globotruncana ventricosa ventricosa WHITE was described by TOLLMANN (1960b, p. 196) from his samples Nos. 4, 5, 6. This species was not found in our material. In our opinion, TOLLMANNS *G. ventricosa* is probably *Dicarinella primitiva* (DALBIEZ). Both species are similar to each other. TOLLMANN (1960b) mentioned, that *G. ventricosa ventricosa* found in his samples was not a typical one and these specimens probably represent a transient form between *Globotruncana ventricosa ventricosa* and *G. ventricosa primitiva* DALBIEZ. *Dicarinella primitiva* (DALBIEZ) is a lectotype of the last mentioned species (ROBASZYNSKI & CARON, 1979). Later, OBERHAUSER (1963) also casts doubt on such a low stratigraphic position of *G. ventricosa* that is accompanied by the Coniacian species *Neoflabellina suturalis suturalis* (CUSHMAN), *N. laterecompressa* TOLLMANN, *Marginotruncana tricarinata* (QUEREAU), *M. schneegansi* (SIGAL), *M. marginata* (REUSS), *M. angusticarinata* (GANDOLFI) and others.

Many Coniacian species mentioned by TOLLMANN (1960b) were also found in our material (Table 3) but several species were not found at all, such as *Stensioeina exsculpta exsculpta* (REUSS) and *Globotruncana spinea* KIKOINE. Based on the occurrence of *Gavelinella tumida* BROTZEN, *Rosita fornicata* (PLUMMER) and *Globotruncana linneiana* (D'ORBIGNY), whose first appearance is reported from the base of the Santonian by EDWARDS (1981) and CARON (1985), the samples of group 3 (WB2, WB5, WB11, WB16 and WB17) were attributed to the Early Santonian.

Based on the studies by BUTT (1981) and WAGREICH & FAUPL (1994) in respect to foraminiferal palaeoecology, three palaeobathymetric environments, pertaining to different stratigraphic levels, have been recognized in our material:

1. Shallow-water conditions with water depth about 10–20 m pertaining to an inner neritic environment sensu WAGREICH & FAUPL (1994) were determined in samples WB1A, WB1 and WB4, WB4A, WB9 and WB10 by the abundance of benthic foraminifers such as *Quinqueloculina, Spirillina, Spiroloculina.* Plankton/benthos ratio is about 20–30 % in this group (Table 4). Genus *Hoeglundina,* mentioned in the cited paper, is characteristic for shallow-water facies of the Gosau Group. Its stratigraphic range (according to the new foraminiferal classification of LOEBLICH & TAPPAN, 1988) begins with the Paleocene. In this type of Cretaceous sediments, however, the genus *Epistomina,* which can be easily confused with *Hoeglundina* is very frequent.

2. The second group of samples (WB3, WB6, WB7 and WB8) comprises the Middle-Late Coniacian. It contains many calcareous species of genera *Praebulimina, Gavelinella* and *Gyroidinoides* but their tests are smaller in size. The plankton/benthos ratio ranges between 40–60 % (Table 4). Small, juvenile tests of *Globigerinelloides* and *Heterohelix* dominated in the planktonic assemblage. This foraminiferal assemblage probably represents a middle neritic environ-

ment with water depth of 30–100 m (WAGREICH & FAUPL, 1994).

3. The third group of samples from Weißenbachalm (samples WB2, WB5, WB11, WB16 and WB17) belongs to the stratigraphic interval of Late Coniacian-Early Santonian. The rich foraminiferal assemblage comprises species with well-preserved tests. Plankton is abundant (about 70 %; Table 4), dominated by large tests of *Marginotruncana*. Index benthic species belong to the genera *Gavelinella, Praebulimina, Dentalina* and *Lenticulina*. As concerns palaeobathymetry, sedimentation took place in the deepest parts of the shelf sea which represents the outer neritic environment with depths of about 200 m at maximum.

All three foraminiferal assemblages from the Grabenbach-Formation of Weißenbachalm show evidence of the shallow-marine facies of Lower Gosau-Subgroup as described by WAGREICH & FAUPL (1994) within the Late Turonian-Campanian interval. Nevertheless, changes in foraminiferal assemblages related to gradual sea-level rise were recorded during the Coniacian. Besides Foraminifera and Ostracoda, numerous fragments of Echinodermata, Mollusca (e.g. *Inoceramus* sp.), Bryozoa and small Gastropoda were found in washing residues of these sediments.

The ostracode associations indicate normal marine conditions. The occurrence of *Paracypris* in the samples WB2 and WB5 indicates deeper water conditions (infraneritic to bathyal according to MORKHOVEN, 1963). This corresponds very well with the results on Foraminifera, which indicate a depth around 200 m for the mentioned samples. The occurrence of Schuleridea indicates more shallow marine conditions, mainly less than 100 m and more often 10–20 m according to the foraminifera fauna. *Schuleridea* never occurs together with *Paracypris. Neocythere* ? sp. occurs in the samples which were identified as shallow marine by foraminifera and is associated in most samples with *Schuleridea*. Most of the other species occur in all depths.

After POKORNÝ (1964) the stratigraphical distribution of the genus *Oertliella* is restricted to the Late Cretaceous. *Brachycythere* ranges from Cenomanian to Oligocene (MORKHOVEN, 1963) and *Neocythere* is known from Barremian to Maastrichtian (MOORE, 1961). The characteristic distribution of the genus *Parvacythereis* is from Turonian to Early Tertiary, but is probably also occurring in the Cenomanian (GRÜNDEL, 1973). At present it is not possible to give a more detailed stratigraphical result by ostracodes than Late Cretaceous as the state of research on Cretaceous ostracodes in Austria is very poor and several taxonomic uncertainties remain.

According to the nannofossil study, samples WB1, WB1A and WB4, WB4A belong to the UC9a Zone with a stratigraphical range from the upper part of Middle Turonian to the lower part of Late Turonian (BURNETT, 1998). Nevertheless, the foraminiferal associatiation provided no typical Middle Turonian species. Therefore these sediments are correlated with the upper part of the UC9a Zone, i.e. with the lower part of the Late Turonian.

BURNETT (1998) pointed out the diachronous first appearance of *Marthasterites furcatus* and did not recommend it as a reliable marker species. *M. furcatus* gradually spread from Boreal to Mediterranean regions within the Early-Middle Turonian interval. In the "Tethyan-intermediate" province (sensu BURNETT, 1998) *M. furcatus* occurs for the first time in association with *Lithastrinus septenarius* which marks the base of the UC9a Zone in the upper part of the Middle Turonian. In the Bohemian Cretaceous Basin, ŠVÁBENICKÁ (1999) mentioned the coincident first occurrence of *L. septenarius* and *M. furcatus* in sediments where the peak and last occurrence of the brachiopod *Terebratulina lata* (SOWERBY) has been documented. This interval is compared with the lower part of the Late Turonian. WAGREICH (1992a) used both *L. septenarius* and *M. furcatus* as marker species for the basal marine sediments of the Austrian Gosau sections and dated their lower part as Late Turonian. In his review of low-latitude "Tethyan" nannoplankton assemblages WAGREICH (1992b) considered *M. furcatus* as a tropical to subtropical element. Nevertheless, this species was observed by the present author in high numbers in the Bohemian Cretaceous Basin (ČECH & ŠVÁBENICKÁ, 1992) and in the Münster Basin (ŠVÁBENICKÁ, 1986).

Rare occurrence of the solution-resistant species *Micula staurophora* and specimens of the family Polycyclolithaceae is interesting here. *M. staurophora* forms only a negligible component of the assemblage (<0.1%), whereas *Watznaueria barnesae* is relatively common here (5–10%). According to the observations by WIND (1979) and DOEVEN (1983) *M. decussata* (syn. *M. staurophora*) is abundant in higher palaeolatitudes and prefers cold to temperate waters, while *W. barnesae* dominates in tropical assemblages and decreases in frequency towards higher latitudes. This phenomenon may be caused here not only by palaeolatitudinal position of the depositional area but also by other specific palaeoenvironmental conditions of the sedimentary regime, among others by very shallow and relative warm waters.

Specimens of the genus *Lucianorhabdus* are considered as a hemipelagic nannoflora element (DOEVEN, 1983; PERCH-NIELSEN, 1985), so, a relatively higher number of *Lucianorhabdus* spp. may indicate nearshore and epicontinental marine conditions. Furthermore, *Lucianorhabdus cayeuxii* species A (sensu WAGREICH, 1988 and 1992a) was used here as an important marker for the base of UC11c Zone which is correlated within the interval from the uppermost part of Coniacian to Early Santonian.

Relatively higher coccolith abundances in samples WB2, WB5, WB11, WB16 and WB17 relative to other samples probably reflect a sea-level rise during the Early Santonian which was mentioned by WAGREICH & FAUPL (1994) and which is also supported here by the study of foraminifera assemblages.

The relative abundance of taxa and small size of coccoliths corresponds well with the description of the Early Santonian nannofossil assemblage from Russbach Gosau by WAGREICH (1988). The character of nannofossil associations is rather different and nannofossil tests are of a smaller size in comparison with coeval ones from both the Bohemian Cretaceous Basin (ČECH & ŠVÁBENICKÁ, 1992) and the Outer Western Carpathians (ŠVÁBENICKÁ in STRÁNÍK et al., 1996). This is supported especially by the markedly rare occurrence of species *Marthasterites furcatus* and *Micula staurophora*.

Accordig to foraminifers and calcareous nannofossils, the Weißenbachalm sediments coincide with the IC55-IC59 zones interval of the Integrated Cretaceous Microfossil Biostratigraphy (BRALOWER et al., 1995).

7.3. Palynology

Up to now the palynostratigraphy for the Turonian-Santonian time interval is not established sufficiently. The palynostratigraphy of the almost 800 m thick transgressive Senonian succession of the Hungarian Transdanubian Central Range has been dated as Santonian-Late Campanian (SIEGL-FARKAS & WAGREICH, 1996; SIEGL-FARKAS, 1997). As the Weißenbachalm associations can be considered slightly older than this time horizon, the data of Hungarian origin may serve here for a comparison (GÓCZÁN, 1964; GÓCZÁN & SIEGL-FARKAS,1990; SIEGL-FARKAS, 1993). At the same time the fossil assemblages are similar to those of Quedlinburg (PFLUG, 1953; GÓCZÁN et al., 1967) and Bohemia too (PACLTOVÁ, 1981). The associations of the Weißenbachalm can be correlated certainly in part with the sporomorph associations of the middle part of the Grabenbach-Formation of the Gams Basin, where the stratigraphy is well established by nannoplankton and planktonic foraminifera. At present the Late Turonian-Middle Santonian units of the Gams Basin (Noth-Member and Grabenbach-Formation) provide the most reliable basis for establishing a correlation with the isochronous deposits of the other Gosau basins. Here, the time of the shift in dominance from *Complexiopollis* to *Oculopollis* genera can be established in the Middle Coniacian (UC10 Zone of the nannoplankton zonation).

The genus *Devecserisporites* described from the associations of marine Campanian sediments in Hungary appears fairly earlier here. The very abundant occurrence of redeposited Triassic sporomorphs evidences a strong subaerial erosion causing an intense denudation of the surrounding Triassic terrain. It should be mentioned here that such a voluminous redeposition of Triassic sporomorphs has not been recorded yet in the Senonian associations of Hungary. Similarily, the species *Oraveczia hungarica* described from the Lower Rhaetian bituminous calcareous marl exposed in the Nagy-Köfejtö (i. e. Great Quarry) at Csövár (Börzsöny Mts., N Hungary) was found hitherto only here in samples WB6 and WB9. The in-situ presence of these poppy-seed-sized fossils was indicated by MORBEY (1975) in the Rhaetian sediments of the classical Kendelbachgraben profile in the Osterhorn mountain range, Salzburg. The form then assigned to the *Tytthodiscus* group was described under the name *Oraveczia faveola* (MORBEY, 1975); GÓCZÁN, 1997.

Based on the evidence provided by the defined pollen of Angiospermae the Grabenbach-Formation of Weißenbachalm region could have been a part of a Mediterranean-Boreal transitional zone within the Normapolles Province. Although the associations are dominated by Mediterranean elements the occurrence of several Boreal genera (*Quedlinburgipollis, Pecakipollis, Extratriporopollenites, Praebasopollis* etc.) can be observed as well.

The abundance of organic substance and the well-preserved sporomorphs accompanied by sparse microplankton all indicate a relative calm, nearshore marine sedimentation. The composition of fern vegetation with its dominant forms (*Bikolisporites, Gleicheniidites, Leiotriletes, Vadaszisporites*) supports the possibility of an open succession. The genera *Appendicisporites* and *Cicatricosisporites* are indicative for a humid climate.

7.4. Summarizing Discussion of the Weißenbachalm key profile

The marls of sample WB15 directly overlie the basal conglomerate. Besides the aforementioned mineralogical arguments, the terrestrial input into these marls is also supported by the presence of palynomorphs of the Complexiopollis Zone with conspicuous content of redeposited Triassic species. Marine biota, however, have not been identified so far in the basal Gosau marls of Weißenbachalm.

Following the outcrop upstream, the soft grey marls (sample WB4) show some intercalations of marlstone beds (sample WB4A) with bivalves and very scarce findings of poorly preserved gastropods (determination impossible, pers. comm. by H. KOLLMANN). The harder marls build low cascades (Text-Fig. 2) situated about halfway between the onset of the marls and the "big marl wall". According to the nannoplankton these marls can be correlated with the UC9a Zone (lowermost part of the Late Turonian). The pollen spectrum, however, already shows the dominance of genus *Oculopollis* and a significant redeposition of the Late Permian and Triassic gymnospermae.

The base of the 25 m high marl outcrop (TOLLMANN's sample localities 3-7) is represented by our sample WB6 (slightly higher located in the section). Nannoflora indicates the Middle Coniacian documented by UC10 Zone. Palynoflora shows an equilibrium between genera *Complexiopollis* and *Oculopollis*. Redeposition of Late Permian and Triassic gymnospermae is also conspicuous here, as well as the influence of Boreal pollen elements.

The middle part of the 25 m high marl wall shows a few intercalations of decimetre-thick beds of micaceous sandstone with coal particles, plant debris and also marly limestone beds, which represent bivalve coquinas. These intercalations most probably correspond to tempestites respectively allodapic layers (WAGREICH, 1989). Sample WB17 and also the hangingwall of the outcrop (top: sample WB16) correspond to the UC11c Nannofossil Zone which extends from the uppermost part of the Coniacian to the Early Santonian. Compared to other marl samples, the marls of the top of the exposed section show a different illite/chlorite ratio with relatively low contents of illite (23%) and high chlorite (19%) content. The palynomorph assemblage is dominated by the genus *Oculopollis*, followed by the genus *Complexiopollis* and also a conspicuous proportion of *Pseudoplicapollis penéserta*. Also the palynological data confirm a Santonian age, because the association points to a higher stratigraphic interval within the Oculopollis-Complexiopollis zone.

The slope morphology of the outcrop suggests that the marls certainly continue uphill for an indefinite distance and stratigraphically younger horizons (?Middle Santonian) can be possibly expected.

8. Conclusions

Since the classical study by TOLLMANN (1960b) the grey marls of Aussee Weißenbachalm have been considered as comprising only the Late Coniacian, however, especially due to the recently improved nanno- and foraminifera zonation a more precise biostratigraphical dating is now possible. However, our interdisciplinary study of the marly sediments of the Weißenbachalm Lower Gosau-Subgroup – comprising mineralogical and palaeontological aspects – shows, that the transgression sequence of grey neritic marls (Grabenbach-Formation) already started in the Late Turonian and that the sedimentation persisted at least till the Early Santonian. The outcropping sequence includes the Dicarinella concavata Zone, respectively the UC9a, UC10, and UC11c nannoplankton zones sensu BURNETT (1998). Palynological investigations confirmed the presence of two biozones, namely the Compexiopollis Dominance Zone and the Oculopollis-Complexiopollis Assemblage Zone.

The marly transgression sequence starts discordantly on top of the basal conglomerate (Kreuzgraben-Formation). The basal marls of the Grabenbach-Formation show a strong terrigenous influence, with a high content of detrital minerals such as quartz, feldspars and muscovite and a low content of carbonate minerals, which might be in part also of detrital origin.

The coral marls of the Weißenbachalm locality represent a peculiar facies development of the Late Turonian part of the

Grabenbach-Formation. A 70 cm thick seam of (?Turonian) subbituminous B coal was also detected, which rests directly on (the basal?) conglomerate.

– The Late Turonian age of the onset of the marine transgression is supported by the UC9a Nannoplankton Subzone and by benthic foraminifers.

Higher up in the profile the terrigenous influence is strongly reduced, while the calcite content increases. Among the clay minerals the marls of the basal transgression show a slightly higher content of illite and chlorite and a lower content of smectite as compared to the Coniacian and Santonian samples. In the latter samples smectite dominates.

Three foraminiferal assemblages can be distinguished on the basis of their plankton/benthos ratio. They confirm a gradual sea-level rise within a shallow marine to neritic environment for the period from Late Turonian to Early Santonian. In the higher part of the Grabenbach-Formation scarce dm-thick coquina layers can be observed, which are considered here as tempestites.

It is also evident, that temperate to boreal taxa of palynomorphs, but also of foraminifera and nannoplankton, constitute a conspicuous element in the otherwise Mediterranean assemblages, which is considered as evidence for a transitional area between the Mediterranean and Boreal bioprovinces.

The palynomorpha assemblages are very similar to those of the Grabenbach-Formation at Gams Basin, Lower Gosau-Subgroup. The Late Turonian and Coniacian foraminiferal assemblages are comparable with those of the same age from the NW part of the Bohemian Cretaceous Basin. In contrast, species diversity and preservation of calcareous nannofossils are of different character which is probably caused by a more shallow marine palaeoenvironment.

Acknowledgements

This study was carried out in the framework of the bilateral co-operation programme between the Geological Survey of Austria and the Geological Survey of Czech Republic, respectively the Geological Institute of Hungary (MÁFI). The authors are greatly indebted to Dr. MICHAEL WAGREICH (Institute of Geology, University of Vienna) for critical reviewing of the text. Dr. ALEXANDER LIEBAU kindly contributed valuable remarks to the systematics of the ostracodes. Thanks are due to Mr. MANFRED SCHILLER (Geological Survey of Austria) for processing the washed samples, to Mrs. ALENA TICHÁ for preparing the nannofossil samples, to Mgr. ANANDA GABAŠOVÁ for the scanning microphotographs of the foraminifera and to Mrs. NADĚŽDA HRDLIČKOVÁ for taking the photographs (all from Czech Geological Survey) and to Mrs. ILDIKÓ BÁTORI for maceration and to Mrs. ILDIKÓ LAKY for taking the photographs of palynomorpha (both from the Geological Institute of Hungary). The Grant Agency of the Czech Republic has supported this study: The nannofossil study is a contribution to project-No. 205/97/0687; the study of the foraminifera is a contribution to project-No. 205/99/1551.

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Appendix No. 1

Taxonomic list of Foraminifera (in alphabetic order) recorded in the Weißenbachalm "Grabenbach-Formation":

This paper	TOLLMANN (1960b)
Ammobaculites aequalis (ROEMER)	*Ammobaculites aequalis* (ROEMER)
Ammobaculites subcretaceus CUSHMAN & ALEXANDER	*Ammobaculites subcretaceus* CUSH. & al.
Ammodiscus cretaceus (REUSS)	----------
Arenobulimina sp.	*Arenobulimina d'orbigny* (REUSS)
Astacolus crepidula (FICHTEL & MOLL)	*Astacolus crepidula* (FICHTEL & MOLL)
Archaeoglobigerina cretacea (D'ORBIGNY)	? *Globigerina infracretacea* GLAESSNER
Bolivinopsis praelonga (REUSS)	*Spiroplectammina praelonga* (REUSS)
Bolivinopsis anceps (REUSS)	----------
Ceratobulimina woodi KHAN	*Ceratobulimina woodi* KHAN
Dentalina communis D'ORBIGNY	*Dentalina communis* D'ORBIGNY
Dentalina gracilis D'ORBIGNY	----------
Dentalina oligostegia REUSS	*Dentalina oligostegia* REUSS
Dentalina sorroria REUSS	-----------
Dicarinella primitiva (DALBIEZ)	? *Globotruncana ventricosa ventricosa* WHITE
Dicarinella imbricata (MORNOD)	----------
Dicarinella concavata (BROTZEN)	----------
Dictyopsella sp.	----------
Dorothia conula (REUSS)	*Dorothia conulus* (REUSS)
Dorothia pupoides (D'ORBIGNY)	*Dorothia pupoides* (D'ORBIGNY)
Dorothia pupa (REUSS)	----------
Dorothia turris (D'ORBIGNY)	----------
Eouvigerina cretacea (HERON-ALLEN & EARLAND)	----------
Epistomina scalaris FRANKE	? *Hoeglundina*
Fissurina orbignyana SEQUENZA	*Entasolenia orbignyana* (SEQUENZA)
Frondicularia angustissima REUSS	*Frondicularia angustissima* REUSS
Frondicularia bicornis REUSS	*Frondicularia bicornis marie* TOLLMANN
Frondicularia inversa REUSS	*Frondicularia inversa* REUSS
Frondicularia goldfussi REUSS	*Frondicularia goldfussi* REUSS
Frondicularia multilineata REUSS	*Frondicularia multilineata* REUSS
Frondicularia turgida REUSS	*Frondicularia turgida* REUSS
Frondicularia verneuiliniana D'ORBIGNY	*Frondicularia angusta* (NILSSON)
Gaudryina carinata FRANKE	----------

Gaudryina frankei Brotzen	----------
Gaudryina laevigata Franke	----------
Gaudryina pyramidata Cushman	*Gaudryina pyramidata* Cushman
Gaudryina rugosa D'Orbigny	*Gaudryina rugosa* D'Orbigny
Gaudryina trochus (D'Orbigny)	----------
Gaudryina variabilis Mjatljuk	----------
Gavelinella lorneiana (D'Orbigny)	*Gavelinella lorneiana* (D'Orbigny)
Gavelinella moniliformis (Reuss)	----------
Gavelinella pertusa (Marsson)	----------
Gavelinella praeinfrasantonica Mjatljuk	----------
Gavelinella schloenbachi (Reuss)	----------
Gavelinella stelligera (Marie)	*Gavelinella stelligera* (Marie)
Gavelinella tumida Brotzen	----------
Gavelinella ukrainica (Vasilenko)	----------
Globigerinelloides aspera (Ehrenberg)	----------
Globigerinelloides ultramicra (Subbotina)	? *Globigerinella aequilateralis* (Brady)
Globorotalites micheliniana (D'Orbigny)	*Globorotalites michelinianus* (D'Orbigny)
Globotruncana globigerinoides Brotzen	*Globotruncana globigerinoides* Brotzen
Globotruncana linneiana (D'Orbigny)	*Globotruncana lapparenti lapparenti* Brotzen
Glomospira irregularis (Grzybowski)	----------
Gyroidinoides nitida Reuss	*Gyroidinoides nitida* Reuss
Haplophragmoides latidorsatum (Bornemann)	*Haplophragmoides latidorsatum* (Bornemann)
Hedbergella flandrini Porthault	----------
Hedbergella holmdelensis Olssen	----------
Heterohelix globulosa (Ehrenberg)	----------
Heterohelix lata (Egger)	----------
Heterohelix moremani (Cushman)	----------
Heterohelix striata (Ehrenberg)	----------
Lagena aspera apiculata White	*Lagena aspera apiculata* White
Lagena sulcatiformis Pozaryska-Urbanek	*Lagena sulcata* Walker & Jacob
Lenticulina comptoni (Sowerby)	----------
Lenticulina marcki (Reuss)	*Lenticulina marcki* (Reuss)
Lenticulina orbicula (Reuss)	*Robulus orbiculus* (Reuss)
Lenticulina subalata (Reuss)	*Robulus subalatus* (Reuss)
Lenticulina truncata (Reuss)	*Robulus truncatus* (Reuss)
Lituola irregularis (Roemer)	*Lituola irregularis* (Roemer)
Marginotruncana angusticarinata (Gandolfi)	*Globotruncana lapparenti angusticarinata* GAND.
Marginotruncana coronata (Bolli)	----------
Marginotruncana marginata Reuss	----------
Marginotruncana pseudolinneiana Pessagno	----------
Marginotruncana renzi (Gandolfi)	----------
Marginotruncana schneegansi (Sigal)	*Globotruncana schneegansi* Sigal
Marginotruncana tricarinata (Quereau)	*Globotruncana lapparenti tricarinata*
(Quereau)	
Marssonella oxycona (Reuss)	*Marssonella oxycona* (Reuss)
Neoflabellina laterecompressa Tollmann	*Neoflabellina laterecompressa* Tollmann
Neoflabellina suturalis praecursor (Wedekind)	----------
Neoflabellina suturalis suturalis (Cushman)	*Neoflabellina suturalis* (Cushman)
Neoflabellina sp.	----------
Nodosaria monile (Hagenow)	----------
Nodosaria zippei Reuss	*Nodosaria zippei* Reuss
Osangularia biconvexa (Marie)	----------
Pleurostomella viperinea Hercogová	----------
Praebulimina intermedia (Reuss)	----------
Praebulimina hofkeri (Brotzen)	----------
Praebulimina reussi (Morrow)	----------
Pseudotextularia sp.	----------
Pseudouvigerina cristata (Marsson)	----------
Pyramidina kelleri (Vasilenko)	----------
Quadrimorphina allomorphinoides (Reuss)	*Quadrimorphina allomorphinoides* (Reuss)
Quinqueloculina angusta (Franke)	*Quinqueloculina* sp.
Ramulina laevis R. Jones	*Ramulina laevis* R. Jones
Rosita fornicata (Plummer)	----------
Saracenaria jarvisi Brotzen	*Saracenaria jarvisi* Brotzen
Saracenaria navicula (D'Orbigny)	*Saracenaria navicula* (D'Orbigny)
Saracenaria triangularis (D'Orbigny)	*Saracenaria triangularis* (D'Orbigny)
Spirillina cretacea (Reuss)	*Spirillina cretacea* (Reuss)
Spiroloculina sp.	----------
Spiroplectammina sp.	----------
Spiroplectinata sp.	----------
Triplasia murchisoni Reuss	*Triplasia murchisoni* Reuss
Tritaxia tricarinata Reuss	*Tritaxia tricarinata* Reuss
Tritaxia trilatera (Cushman)	----------
Trochammina sp.	*Trochammina* sp.
Vaginulina gosae (Reuss)	*Vaginulina gosae* (Reuss)
Vaginulina trilobata (D'Orbigny)	*Vaginulina ensis* Reuss
Valvulineria lenticula (Reuss)	*Valvulineria lenticula* (Reuss)
Verneuilina triquetra (Münster)	*Verneuilina münsteri* Reuss

Appendix No. 2

List of ostracodes mentioned in this paper in alphabetical order:

Bairdia sp.
Brachycythere sphenoides (REUSS, 1854)
Cytherella leopolitana (REUSS, 1854)
Cytherella sp. A
Diogmopteron ? sp.
Dolocytheridea ? sp.
Neocythere ? sp.
Oertliella sp.
Paracypris sp.
Parvacythereis sp.
Schuleridea neglecta (REUSS, 1854)

Appendix No. 3

List of calcareous nannofossils mentioned in this paper, in the alphabetical order of generic epithets:

Ahmuellerella octoradiata (GÓRKA, 1957) REINHARDT, 1966
Amphizygus brooksii BUKRY, 1969
Biscutum ellipticum (GÓRKA, 1957) GRÜN in GRÜN & ALLEMANN, 1975
Braarudosphaera bigelowii (GRAN & BRAARUD, 1935) DEFLANDRE, 1947
Broinsonia enormis (SHUMENKO, 1968) MANIVIT, 1971
Broinsoniaparca expansa WISE & WATKINS in WISE, 1983
Broinsonia signata (NOËL, 1969) NOËL, 1970
Calculites ovalis (STRADNER, 1963) PRINS & SISSINGH in SISSINGH, 1977
Chiastozygus litterarius (GÓRKA, 1957) MANIVIT, 1971
Chiastozygus stylesii BURNETT, 1998
Conusphaera mexicana mexicana TREJO, 1969
Conusphaera mexicana minor BOWN & COOPER, 1989
Corollithion exiguum STRADNER, 1961
Corollithion signum STRADNER, 1963
Cretarhabdus conicus BRAMLETTE & MARTINI, 1964
Cribrosphaerella ehrenbergii (ARKHANGELSKY, 1912) DEFLANDRE in PIVETEAU, 1952
Cyclagelosphaera reinhardtii (PERCH-NIELSEN, 1968) ROMEIN, 1977
Cylindralithus biarcus BUKRY, 1969
Eiffellithus eximius (STOVER, 1966) PERCH-NIELSEN, 1968
Eiffellithus gorkae REINHARDT, 1965
Eiffellithus turriseiffelii (DEFLANDRE in DEFLANDRE & FERT, 1954) REINHARDT, 1965
Eprolithus floralis (STRADNER, 1962) STOVER, 1966
Gartnerago obliquum (STRADNER, 1963) NOËL, 1970
Gartnerago theta (BLACK in BLACK & BARNES, 1959) JAKUBOWSKI, 1986
Grantarhabdus coronadventis (REINHARDT, 1966) GRÜN in GRÜN & ALLEMANN, 1975
Haqius circumradiatus (STOVER, 1966) ROTH, 1978
Helicolithus trabeculatus (GÓRKA, 1957) VERBEEK, 1977
Helicolithus turonicus VAROL & GIRGIS, 1994
Isocrystallithus compactus VERBEEK, 1976
Kamptnerius magnificus DEFLANDRE, 1959
Lapideacassis cornuta (FORCHHEIMER & STRADNER, 1973) WIND & WISE in WISE and WIND, 1977
Lithastrinus grillii STRADNER, 1962
Lithastrinus septenarius FORCHHEIMER, 1972
Lithraphidites carniolensis DEFLANDRE, 1963
Lucianorhabdus cayeuxii DEFLANDRE, 1959
Lucianorhabdus inflatus PERCH-NIELSEN & FEINBERG in PERCH-NIELSEN, 1986
Lucianorhabdus maleformis REINHARDT, 1966
Lucianorhabdus quadrifidus FORCHHEIMER, 1972
Manivitella pemmatoidea (DEFLANDRE in MANIVIT, 1965) THIERSTEIN, 1971
Marthasterites furcatus (DEFLANDRE in DEFLANDRE & FERT, 1954) DEFLANDRE, 1959
Marthasterites simplex (BUKRY, 1969) BURNETT, 1998
Micrantholithus quasihoschulzii BURNETT, 1998
Microrhabdulus belgicus HAY & TOWE, 1963
Microrhabdulus decoratus DEFLANDRE, 1959
Micula staurophora (GARDET, 1959) DEFLANDRE, 1963
Nannoconus elongatus BRÖNNIMANN, 1955
Nannoconus farinacciae BUKRY, 1969
Nannoconus truitti ? rectangularis DÉRES & ACHÉRITEGUY, 1980
Octolithus multiplus (PERCH-NIELSEN, 1973) ROMEIN, 1979
Placozygus fibuliformis (REINHARDT, 1964) HOFFMANN, 1970
Prediscosphaera columnata (STOVER, 1966) PERCH-NIELSEN, 1984
Prediscosphaera cretacea (ARKHANGELSKY, 1912) GARTNER, 1968
Prediscosphaera cf. *P. grandis* PERCH-NIELSEN, 1979 sensu BURNETT, 1998
Prediscosphaera ponticula (BUKRY, 1969) PERCH-NIELSEN, 1984
Prediscosphaera spinosa (BRAMLETTE & MARTINI, 1964) GARTNER, 1968
Quadrum gartneri PRINS & PERCH-NIELSEN in MANIVIT et al., 1977
Retacapsa angustiforata BLACK, 1981
Retacapsa crenulata (BRAMLETTE & MARTINI, 1964) GRÜN in GRÜN & ALLEMANN, 1975
Retacapsa ficula (STOVER, 1966) BURNETT, 1998
Retacapsa madingleyensis (BLACK, 1973) BLACK, 1975
Rhagodiscus angustus (STRADNER, 1963) REINHARDT, 1971
Rhagodiscus asper (STRADNER, 1963) REINHARDT, 1967
Rhagodiscus eboracensis BLACK, 1971
Rotelapillus crenulatus (STOVER, 1966) PERCH-NIELSEN, 1984
Sollasites horticus (STRADNER et al. in STRADNER & ADAMIKER, 1966) ČEPEK & HAY, 1969
Stoverius achylosus (STOVER, 1966) PERCH-NIELSEN, 1986
Tegumentum stradneri THIERSTEIN in ROTH & THIERSTEIN, 1972
Tranolithus gabalus STOVER, 1966
Tranolithus minimus (BUKRY, 1969) PERCH-NIELSEN, 1984
Tranolithus orionatus (REINHARDT, 1966) REINHARDT, 1966
Uniplanarius gothicus (DEFLANDRE, 1959) HATTNER & WISE, 1980
Watznaueria barnesae (BLACK, 1959) PERCH-NIELSEN, 1968
Watznaueria biporta BUKRY, 1969
Watznaueria britannica (STRADNER, 1963) REINHARDT, 1964
Watznaueria manivitae BUKRY, 1973
Watznaueria quadriradiata BUKRY, 1969
Zeugrhabdotus bicrescenticus (STOVER, 1966) BURNETT in GALE et al., 1996
Zeugrhabdotus biperforatus (GARTNER, 1968) BURNETT, 1998
Zeugrhabdotus cooperi BOWN, 1992
Zeugrhabdotus diplogrammus (DEFLANDRE in DEFLANDRE & FERT, 1954) BURNETT in GALE et al., 1996
Zeugrhabdotus embergerii (NOËL, 1958) PERCH-NIELSEN, 1984
Zeugrhabdotus noeliae ROOD et al., 1971

Appendix No. 4

Determined sporomorpha in this paper (summarizing floralist in alphabetic order of generic epithets):

Spores:

Appendicisporites tricornitatus WEYLAND & KRIEGER, 1953
Appendicisporites tricuspidatus WEYLAND & GREIFELD, 1953
Appendicisporites sp.
Bikolisporites bakonicus (JUHÁSZ, 1972) JUHÁSZ, 1977
Bikolisporites toratus (WEYLAND & GREIFELD, 1953) SRIVASTAVA, 1975
Bikolisporites sp.
Camarozonosporites concinnus SRIVASTAVA, 1972
Cicatricosisporites augustus AGASIE, 1968
Cicatricosisporites globosus DÖRING, 1965
Cicatricosisporites hughesi DETTMAN, 1963
Cicatricosisporites sp.
Costatoperforosporites fistulosus DEÁK, 1962
Cyathidites australis COUPER, 1953
Cyathidites minor COUPER, 1953
Cyathidites sp.
Devecserisporites goczani SIEGL-FARKAS, 1986
Dictyophyllidites harrisii COUPER, 1953
Echinatisporites sp.
Foveolatisporites multifoveolatus DÖRING, 1965
Gemmasporites sp.
Gleicheniidites senonicus (ROSS, 1949) BOLCH, 1968
Klukisporites foveolatus POCOCK, 1965
Klukisporites lacunus FILATOFF, 1975

Klukisporites scaberis (COOKSON & DETTMANN, 1954) DETTMANN, 1963
Leiotriletes sphagnoides SIMONCSICS & KEDVES, 1964
Leiotriletes div. sp.
Obtusisporites juriensis BALME, 1957
Osmundacidites wellmannii COUPER, 1953
Phaeocerosporites purus DEÁK, 1964
Phlebopterisporites equiexinus COUPER, 1958
Stereisporites europeum (BOLCH, 1953) ČORNA, 1972
Toroisporites sp.
Trilites asolidus KRUTZSCH, 1959
Trilites triangulus KEDVES, 1964
Uvaesporites sp.
Vadaszisporites pseudofoveolatus (DEÁK & COMBAZ, 1964) DEÁK & COMBAZ, 1967
Vadaszisporites sacali DEÁK & COMBAZ, 1967
Vadaszisporites sp.
Vinculisporites flexus DEÁK, 1964
Zebrasporites sp.

Gymnospermae:

Araucariacidites australis COOKSON, 1947
Araucariacidites hungaricus DEÁK, 1964
Cycadopites fragilis SINGH, 1964
Ephedripites sp.
Inaperturopollenites limbatus BALME, 1957
Inaperturopollenites undulatus WEYLAND & GREIFELD, 1953
Inaperturopollenites sp.
Monosulcites sp.

Angiospermae (Normapolles and others):

Bakonyipollis galerus GÓCZÁN, 1967
Complexiopollis cf. *christae* VAN AMEROM, 1965
Complexiopollis complicatus GÓCZÁN, 1964
Complexiopollis funiculus TSCHUDY, 1973
Complexiopollis helmigii (VAN AMEROM, 1965) SOLE DE PORTA, 1977
Complexiopollis labilis (GÓCZÁN, 1964) GÓCZÁN & KRUTZSCH, 1967
Complexiopollis latis (GÓCZÁN, 1964) GÓCZÁN & KRUTZSCH, 1967
Complexiopollis microrugulatus KEDVES, 1980
Complexiopollis vulgaris (GROOT & GROOT, 1962) GROOT & KRUTZSCH, 1967
Complexiopollis sp.
Extratriporopollenites div. sp.
cf. *Hungaropollis* sp.
Krutzschipollis sp.
Megatriopollis sp.
Oculopollis aestethicus WEYLAND & KRIEGER, 1953
Oculopollis clausus GÓCZÁN (nom. nud.)
Oculopollis orbicularis GÓCZÁN, 1964
Oculopollis parvoculus GÓCZÁN, 1964
Oculopollis predicatus WEYLAND & KRIEGER, 1953
Oculopollis principalis WEYLAND & KRIEGER, 1953
Oculopollis zaklinskaiae GÓCZÁN, 1964
Oculopollis div. sp.
cf. *Pecakipollis* sp.
Periporopollenites sp.
Praebasopollis praebasalis GROOT & KRUTZSCH, 1967
Pseudoplicapollis peneserta PFLUG, 1953, nov. ssp. 1
Pseudoplicapollis peneserta PFLUG, 1953, nov. ssp. 2
Quedlinburgipollis altenburgensis KRUTZSCH, 1959
Retitricolporopollenites sp.
Schulzipollis pannonicus GÓCZÁN, 1967
Suemegipollis triangularis GÓCZÁN, 1964
Tetracolporopollenites globosus GÓCZÁN, 1964
Triatriopollenites (cf. *Thouiniapollenites*) sp.
Tricolpopollenites suemegensis GÓCZÁN, 1964
Triporopollenites robustus PFLUG, 1953
Trudopollis sp.

Phytoplankton:

Botryococcus sp.
Cladopyxidium sp.
Hystrichosphaeridium sp.
Odontochitina sp.
Pterospermella australiensis (DEFLANDRE & COOKSON, 1955) EISENACK, 1972
Veryhachium cruciatum (WETZEL, 1932) LEJUNE-CARPENTER & SARJEANT, 1981

Redeposited (Triassic and Permian) sporomorpha:

Circumpolles div. sp.
Classopollis sp.
Duplicisporites granulatus LESCHIK, 1956
Enzonalasporites vigens LESCHIK, 1956
Klausipollenites schaubergeri (POTONIE & KLAUS, 1954) JANSONIUS, 1962
Limitisporites sp.
Limitisporites cf. *rectus* LESCHIK, 1955
Lueckisporites virkkiae POTONIE & KLAUS, 1954
Nuskoisporites klausi GREBE, 1957
Ovalipollis lunzensis KLAUS, 1964
Ovalipollis ovalis KLAUS, 1964
Ovalipollis sp.
Patinasporites iustus KLAUS, 1964
Partitisporites maljawkinae (KLAUS, 1960) VAN DEREEM, 1983
Rhaetipollis germanicus SCHULZ, 1967
cf. *Stellapollenites* sp.
Striatoabieites aytugii VISSCHER, 1966
Triadispora cf. *crassa* KLAUS, 1964
Vitreisporites pallidus (REISS, 1950) NILSOON, 1958
Oraveczia hungarica GÓCZÁN, 1997
cf. *Vadaszia* sp.

Zoofossils:

Foraminifera tissue
Scolecodonta (Annelidae)

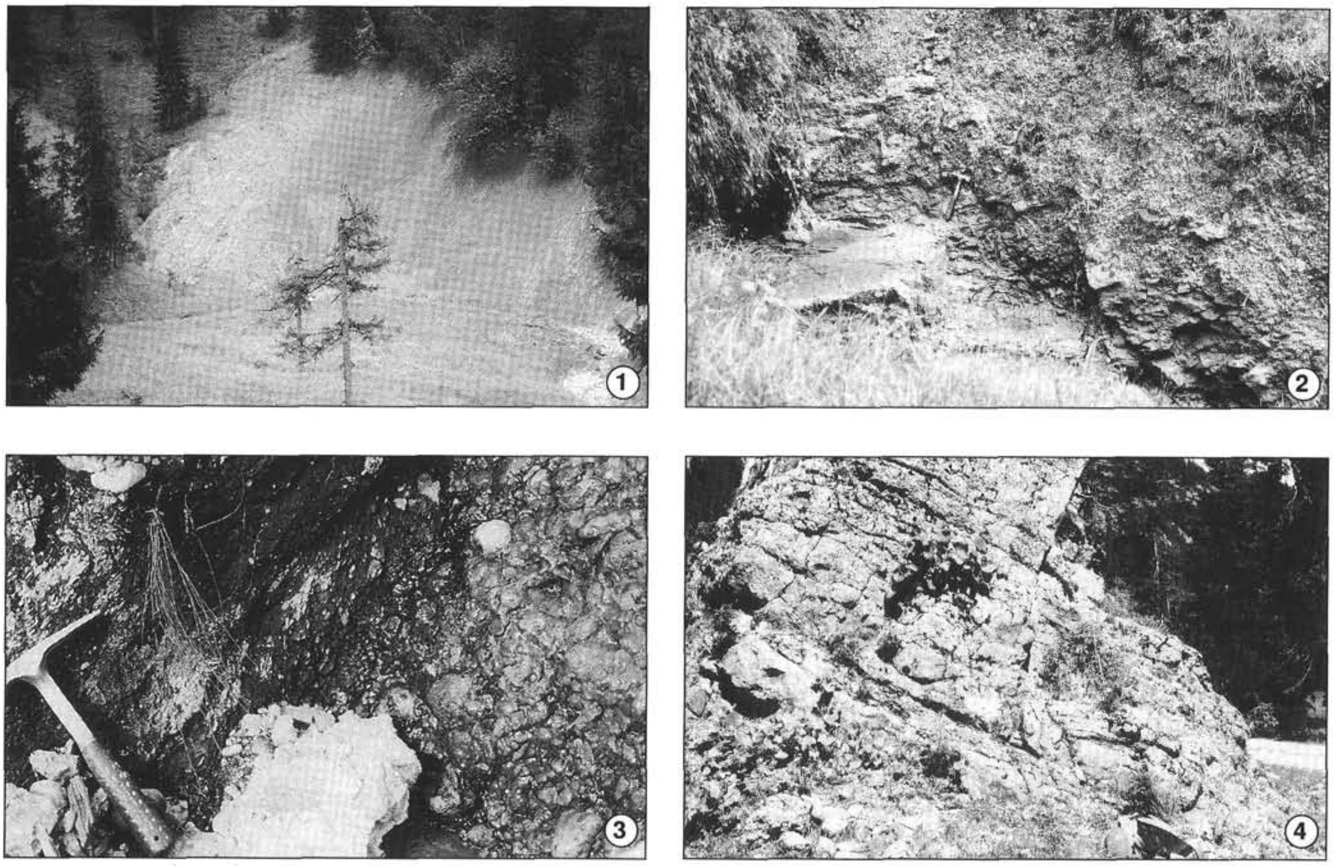

Plate 1

Fig. 1: 25 m high outcrop of grey marls (Grabenbach-Formation) along Weißenbach stream. The marl wall represents the sample localities Nos. 3-7 of Tollmann (1960b), respectively samples of this work: No. WB6 (base of outcrop, right hand side), Nos. WB17 and WB18 (middle part of outcrop with tempestite layers) and No. WB16 (top of the outcrop). Downstream of Weißenbach (right) follow outcrops Nos. WB4 and WB15 (not in the picture).
Fig. 2: Outcrop in coral marls (sample Nos. WB1 and WB1A) where the coral assemblage described by Baron-Szabo (1999) has been collected.
Fig. 3: Coal seam (left) overlying ?basal conglomerate (samples Nos. WB20A and WB20B).
Fig. 4: Well bedded and comparatively well sorted conglomerate dipping towards south. Weißenbach forestroad, SE of Weißenbachalm.

Plate 2

Fig. 1: *Tritaxia tricarinata* (Reuss); sample No. WB2, x 45
Fig. 2: *Triplasia murchissoni* Reuss; sample No. WB2, x 80
Fig. 3: *Gaudryina pyramidata* Cushman; sample No. WB16, x 70
Fig. 4: *Gaudryina rugosa* D'Orbigny; sample No. WB16, x 90
Fig. 5: *Dorothia pupa* (Reuss); sample No. WB3, x 140
Fig. 6: *Bolivinopsis praelonga* (Reuss); sample No. WB2, x 70
Fig. 7: *Glomospira irregularis* (Grzybowski); sample No. WB9, x 36
Fig. 8: *Bolivinopsis praelonga* (Reuss); sample No. WB8, x 60
Fig. 9: *Lenticulina marcki* (Reuss); sample No. WB8, x 40
Fig. 10: *Nodosaria zippei* Reuss; sample No. WB2, x 50
Fig. 11: *Pleurostomella viperinea* Hercogová, sample No. WB16, x 60
Fig. 12: *Frondicularia bicornis* Reuss; sample No. WB2, x 33
Fig. 13: *Frondicularia inversa* Reuss; sample No. WB8, x 20
Fig. 14: *Saracenaria triangularis* (D'Orbigny); sample No. WB2 , x 70
Fig. 15: *Lenticulina marcki* (Reuss); sample No. WB8, x 40
Fig. 16: *Quadrimorphina allomorphinoides* (Reuss); sample No. WB2, x 90
Fig. 17: *Globorotalites michelinianus* (D'Orbigny); sample No. WB16, x 130.

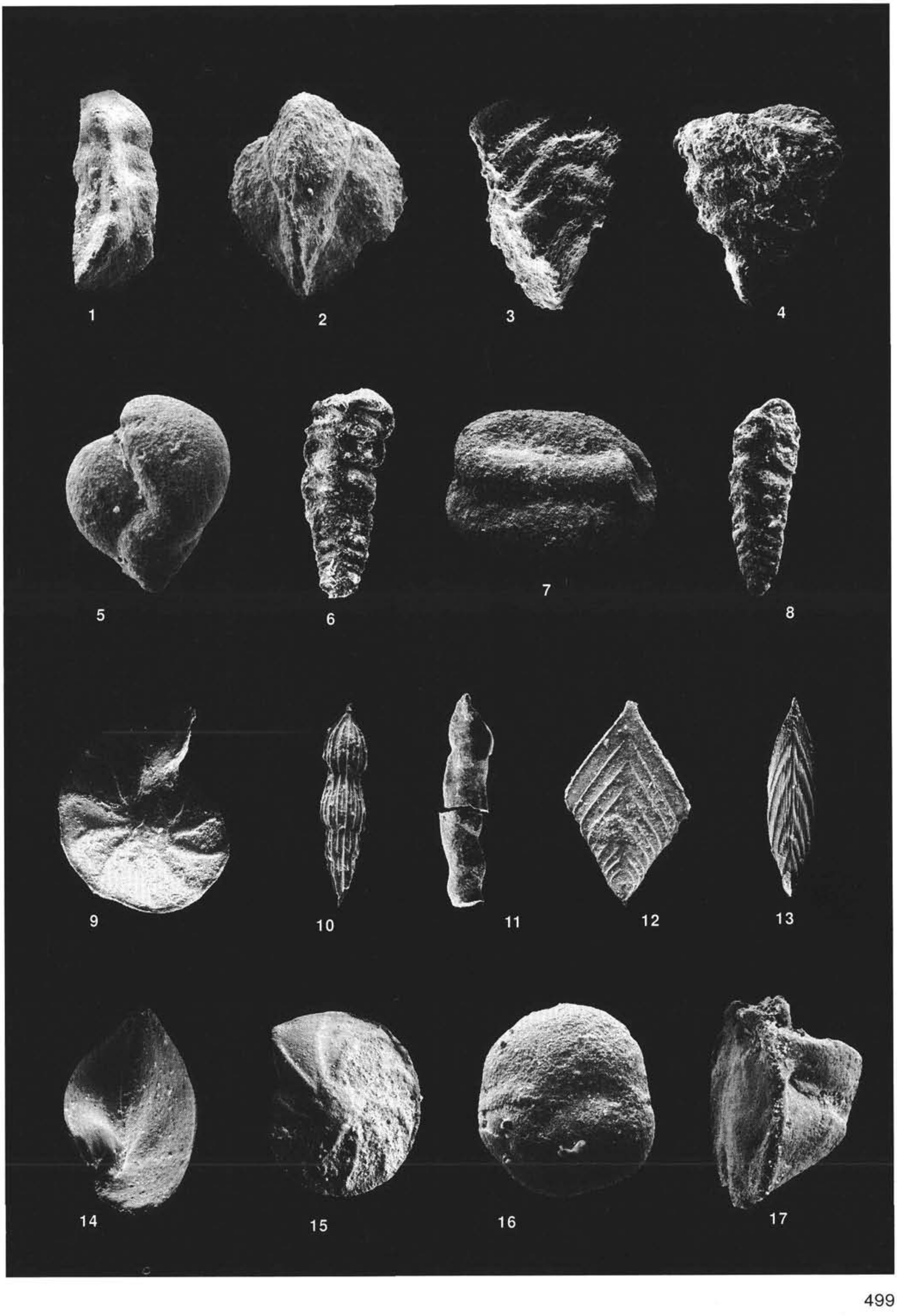
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Plate 3

Fig. 1: *Epistomina scalaria* FRANKE; sample No. WB4, x 120
Fig. 2: *Osangularia biconvexa* (MARIE); sample No. WB4, x 100
Fig. 3: *Quinqueloculina angusta* (FRANKE); sample No. WB4, x 90
Fig. 4: *Pyramidina kelleri* (VASILENKO); sample No. WB6, x 60
Fig. 5: *Praebulimina reussi* (MORROW); sample No. WB16, x 170
Fig. 6: *Praebulimina intermedia* (REUSS); sample No. WB2, x 120
Fig. 7: *Vaginulina trilobata* (D'ORBIGNY); sample No. WB11, x 32
Fig. 8: *Vaginulina gosae* (REUSS); sample No. WB11, x 45
Fig. 9: *Spiroloculina fassistomata* GRZYBOWSKI; sample No. WB8, x 60
Fig. 10: *Neoflabellina* sp.; sample No. WB8, x 70
Fig. 11: *Neoflabellina laterecompressa* TOLLMANN; sample No. WB11, x 33
Fig. 12: *Neoflabellina suturalis suturalis* (CUSHMAN); sample No. WB2, x 23
Fig. 13: *Neoflabellina suturalis praecursor* (WEDEKIND); sample No. WB2, x 31
Fig. 14: *Gavelinella ukrainica* (VASILENKO); sample No. WB9, x 90
Fig. 15: *Gavelinella pertusa* (MARSSON); sample No. WB16, x 90
Fig. 16: *Gavelinella lorneiana* (D'ORBIGNY); sample No. WB5, x 100
Fig. 17: *Dentalina communis* D'ORBIGNY; sample No. WB 8, x 45

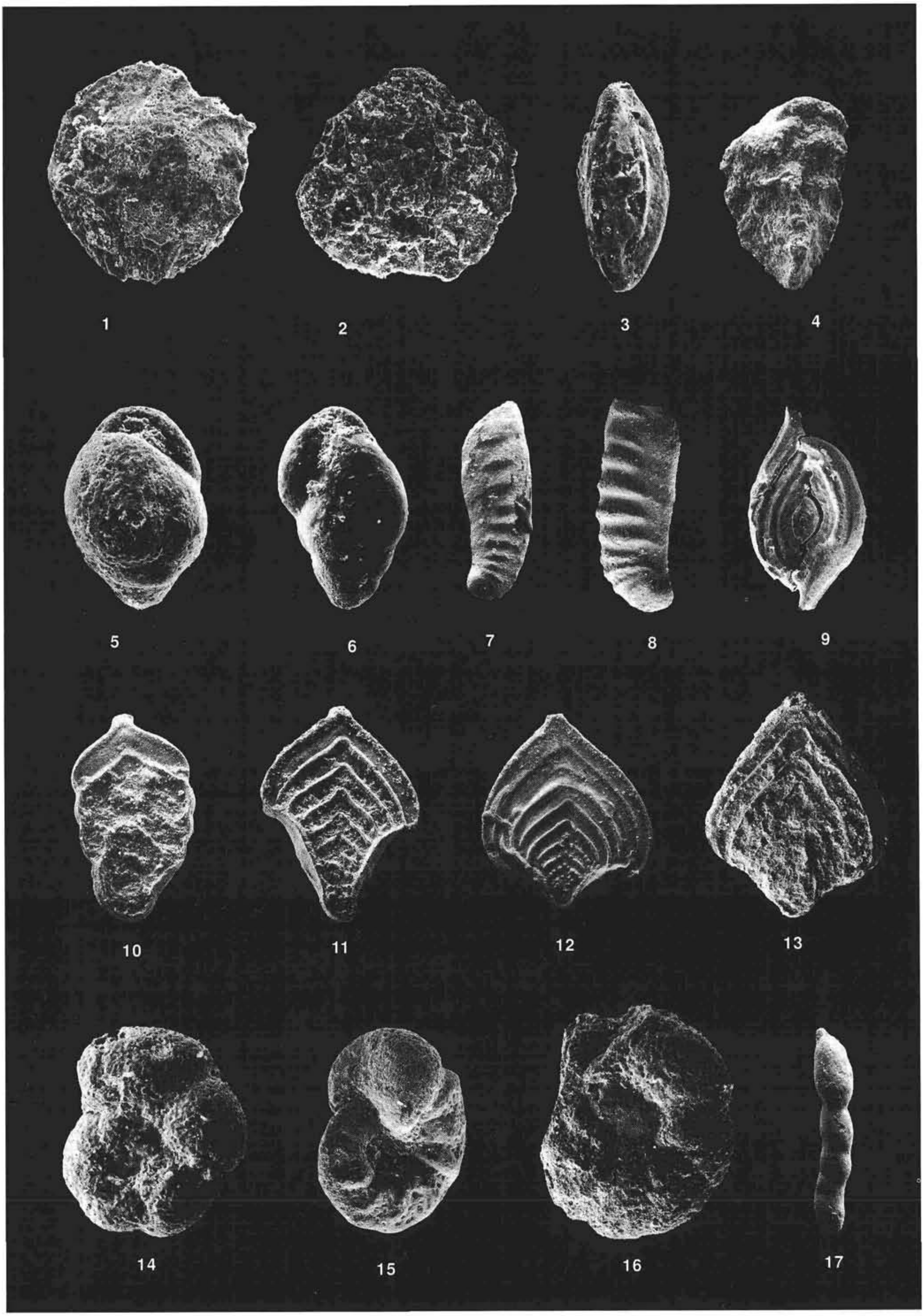
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Plate 4

Fig. 1: *Gavelinella praeinfrasantonica* MJATLJUK; ventral view, sample No. WB4, x
Fig. 2: *Gavelinella lorneiana* (D'ORBIGNY); dorsal view, sample No. WB16, x 80
Fig. 3: *Gavelinella tumida* BROTZEN; dorsal view, sample No. WB17, x 170
Fig. 4: *Gavelinella stelligera* (MARIE); ventral view, sample No. WB11, x 120
Fig. 5: *Archaeoglobigerina cretacea* (D'ORBIGNY); sample No. WB11, x 90
Fig. 6: *Marginotruncana tricarinata* (QUEREAU); sample No. WB11, x 90
Fig. 7: *Dicarinella concavata* (BROTZEN); sample No. WB11, x 60
Fig. 8: *Globotruncana linneiana* (D'ORBIGNY); sample No. WB2, x 90
Fig. 9: *Marginotruncana schneegansi* (SIGAL); sample No. WB11, x 70
Fig. 10: *Marginotruncana pseudolinneiana* (PESSAGNO); sample No. WB11, x 90
Fig. 11: *Marginotruncana angusticarinata* (GANDOLFI); sample No. WB11, x 140
Fig. 12: *Hedbergella flandrini* PORTHAULT; sample No. WB16, x 200
Fig. 13: *Heterohelix moremani* (CUSHMAN); sample No. WB9, x 220
Fig. 14: *Heterohelix globulosa* (EHRENBERG); sample No. WB16, x 210

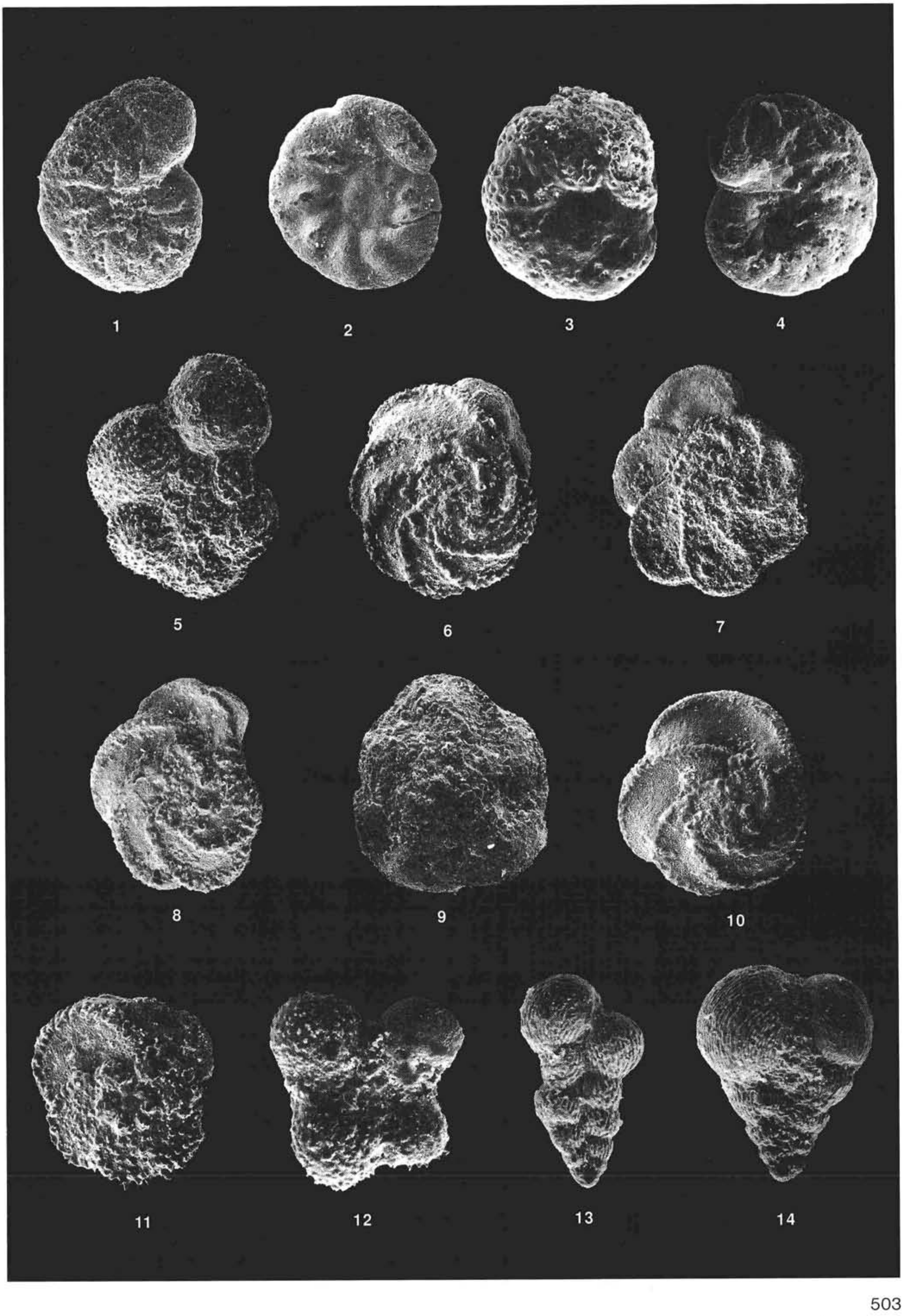
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Plate 5

Fig. 1: *Bairdia* sp.; sample No. WB1A, x 65
Fig. 2: *Cytherella leopolitana* (REUSS, 1854), right valve; sample No. WB4, x 100
Fig. 3: *Cytherella leopolitana* (REUSS, 1854), left valve; sample No. WB4, x 90
Fig. 4: *Cytherella leopolitana* (REUSS, 1854), carapax from the left side; sample No. WB4, x 90
Fig. 5: *Cytherella* sp. A, left valve; sample No. WB2, x 120
Fig. 6: Ostracoda gen. et sp. inc., carapax from the right side; sample No. WB9, x 120
Fig. 7: *Paracypris* sp., left valve; sample No. WB2, x 90

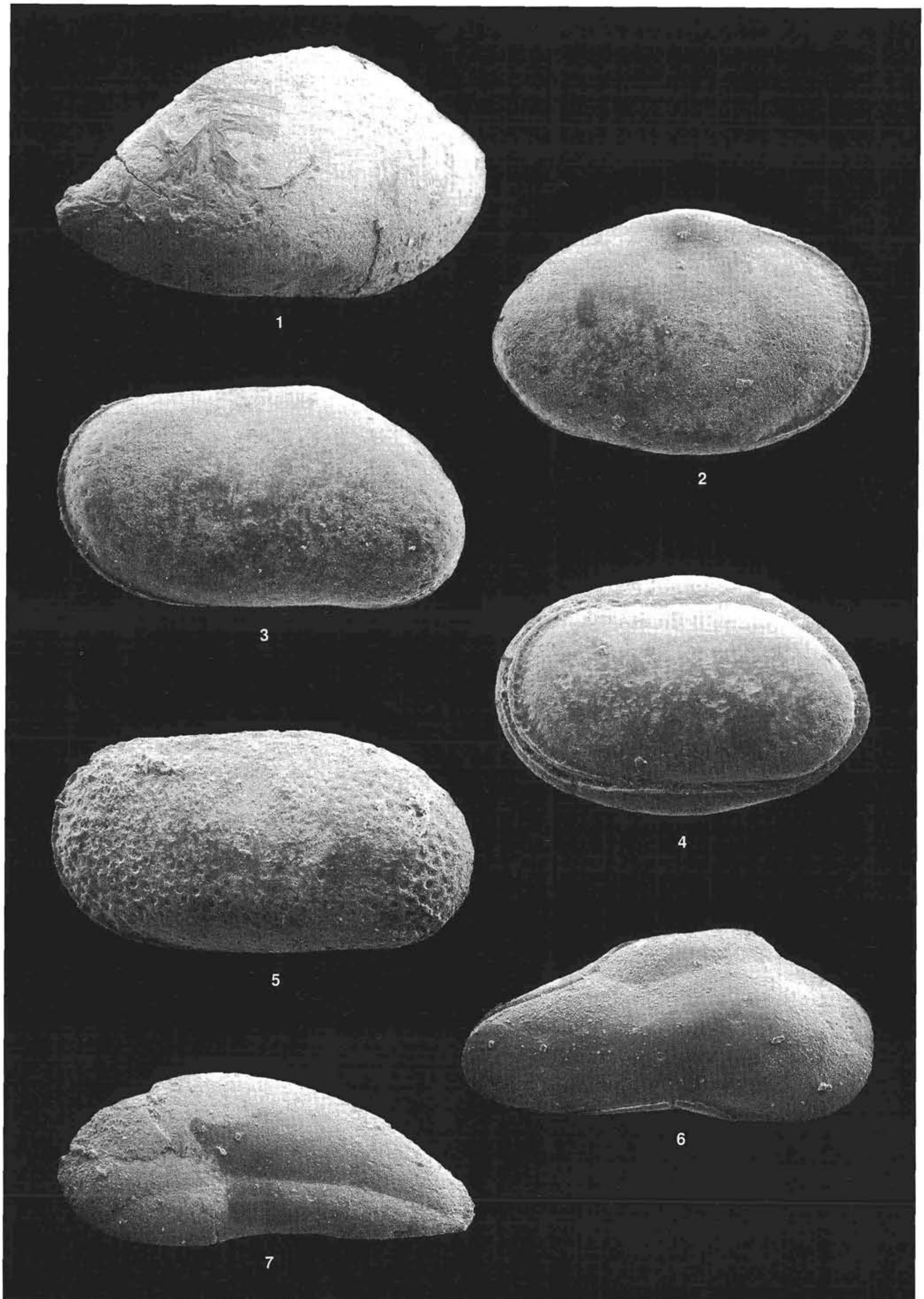
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Plate 6

Fig. 1: *Dolocytheridea* ? sp., left valve; sample No. WB16, x 120
Fig. 2: *Schuleridea neglecta* (Reuss, 1854), right valve; sample No. WB23, x 120
Fig. 3–4: *Neocythere* ? sp., carapax from the right side (Fig. 3) and from ventral (Fig. 4); sample No. WB4, x 160
Fig. 5: *Parvacythereis* sp., right valve; sample No. WB4, x 120
Fig. 6: *Oertliella* sp., left valve; sample No. WB3, x 100
Fig. 7–8: *Diogmopteron* ? sp., carapax from the right side (Fig. 6) and from dorsal (Fig. 7); sample No. WB9, x 90

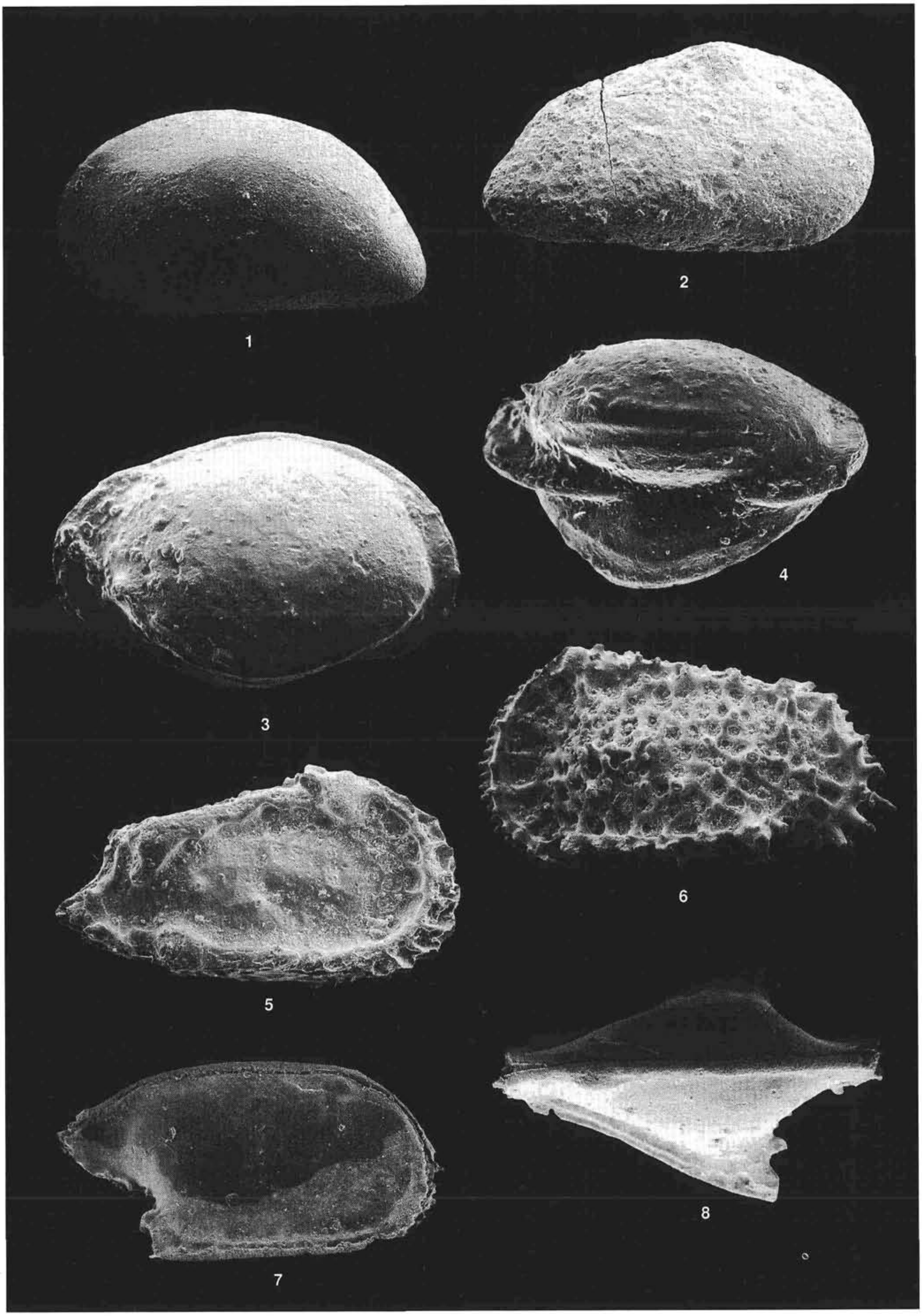
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Plate 7

Figs. 1, 2: *Eiffellithus eximius* (STOVER) PERCH-NIELSEN; sample No. WB16
Figs. 3, 4: *Eiffellithus gorkae* REINHARDT; sample No. WB16
Fig. 5: *Eiffellithus turriseiffelii* BUKRY; sample No. WB16
Fig. 6: Amphizygus brooksii BUKRY, sample No. WB16
Figs. 7, 8: Marthasterites furcatus (DEFLANDRE) DEFLANDRE; 7 – sample No. WB16; 8 – sample No. WB17
Figs. 9–12: *Micula staurophora* (GARDET) STRADNER; 9, 10 – sample No. WB17; 11, 12 – sample No. WB23
Fig. 13: *Tegumentum stradneri* THIERSTEIN; sample No. WB17
Fig. 14: *Broinsonia signata* (NOËL) NOËL; sample No. WB3
Figs. 15, 16: *Broinsonia enormis* (SHUMENKO) MANIVIT; sample No. WB16
Figs. 17, 18: *Broinsonia parca expansa* WISE & WATKINS; sample No. WB17
Figs. 19, 20: *Helicolithus turonicus* VAROL & GIRGIS, 1994; sample No. WB1
Figs. 21, 22: *Chiastozygus litterarius* (GÓRKA) MANIVIT; sample No. WB16
Figs. 23, 24: *Prediscosphaera ponticula* (BUKRY) PERCH-NIELSEN; sample No. WB23
Figs. 25–27: *Zeugrhabdotus biperforatus* (GARTNER) BURNETT; 25, 26 – sample No. WB16, 27 – sample No. WB17
Fig. 28: *Eprolithus floralis* (STRADNER) STOVER; sample No. WB17
Figs. 29, 30: *Eprolithus* sp. (side view); sample No. WB17
Figs. 31–33: *Lithastrinus septenarius* FORCHHEIMER; sample No. WB17
Figs. 34–36: *Lithastrinus grillii* STRADNER; sample No. WB17i
Figs. 37, 38: *Rhagodiscus angustus* (STRADNER) REINHARDT; sample No. WB17
Figs. 39, 40: *Zeugrhabdotus diplogrammus* (DEFLANDRE) BURNETT; sample No. WB17
Figs. 41, 42: *Gartnerago obliquum* (STRADNER) NOËL, sample No. WB16

Magnification x 2,000.

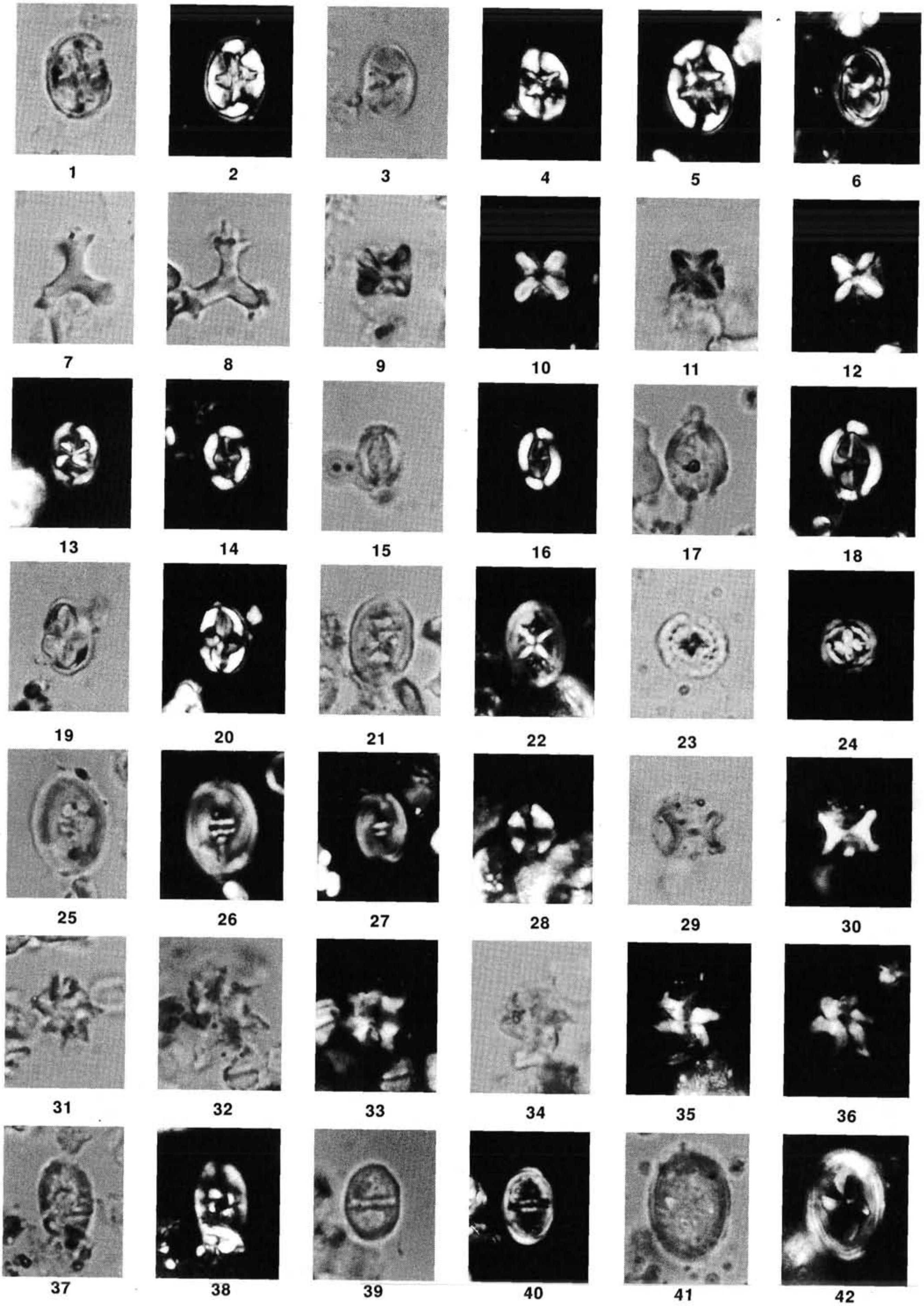
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Plate 8

Figs. 1, 2: *Cribrosphaerella ehrenbergii* (ARKHANGELSKY) DEFLANDRE; sample No. WB17
Figs. 3, 4: *Retacapsa crenulata* (BRAMLETTE & MARTINI) GRÜN; sample No. WB17
Figs. 5, 6: *Calculites ovalis* (STRADNER) PRINS & SISSINGH; sample No. WB16
Figs. 7, 8, 31, 32: *Braarudosphaera bigelowii* (GRAN & BRAARUD) DEFLANDRE; 7, 8 – small specimens (5–7 μm), sample No. WB4; 31,32 - specimens of „normal size" (12–14 μm), sample No. WB17
Fig. 9: *Rotelapillus crenulatus* (STOVER) PERCH-NIELSEN; sample No. WB16
Figs. 10–12: *Corollithion* sp., sample No. WB16
Figs. 13–16: *Micrantholithus quasihoschulzii* BURNETT; sample No. WB17
Figs. 17, 18: *Conusphaera mexicana mexicana* TREJO, reworked specimen from the Kimmeridgian – Lower Aptian interval; sample No. WB17
Fig. 19: *Conusphaera mexicana minor* BOWN & COOPER, reworked specimen from the Upper Kimmeridgian – Tithonian interval, sample No. WB17
Fig. 20: *Nannoconus truitti ? rectangularis* DERSE & ACHÉRITEGUY, reworked species from the Albian-Cenomanian interval, sample No. WB17
Figs. 21, 22, 27, 28: *Lucianorhabdus quadrifidus* FORCHHEIMER; 21, 22 – sample No. WB16; 27, 28 – sample No. WB17
Figs. 23, 24: *Lucianorhabdus cayeuxii* DEFLANDRE; sample No. WB17
Figs. 25, 26: *Lucianorhabdus maleformis* REINHARDT; sample No. WB17
Figs. 29, 30: *Lucianorhabdus cayeuxii* DEFLANDRE and *Lithastrinus septenarius* FORCHHEIMER; sample No. WB16

Magnification x 2,000.

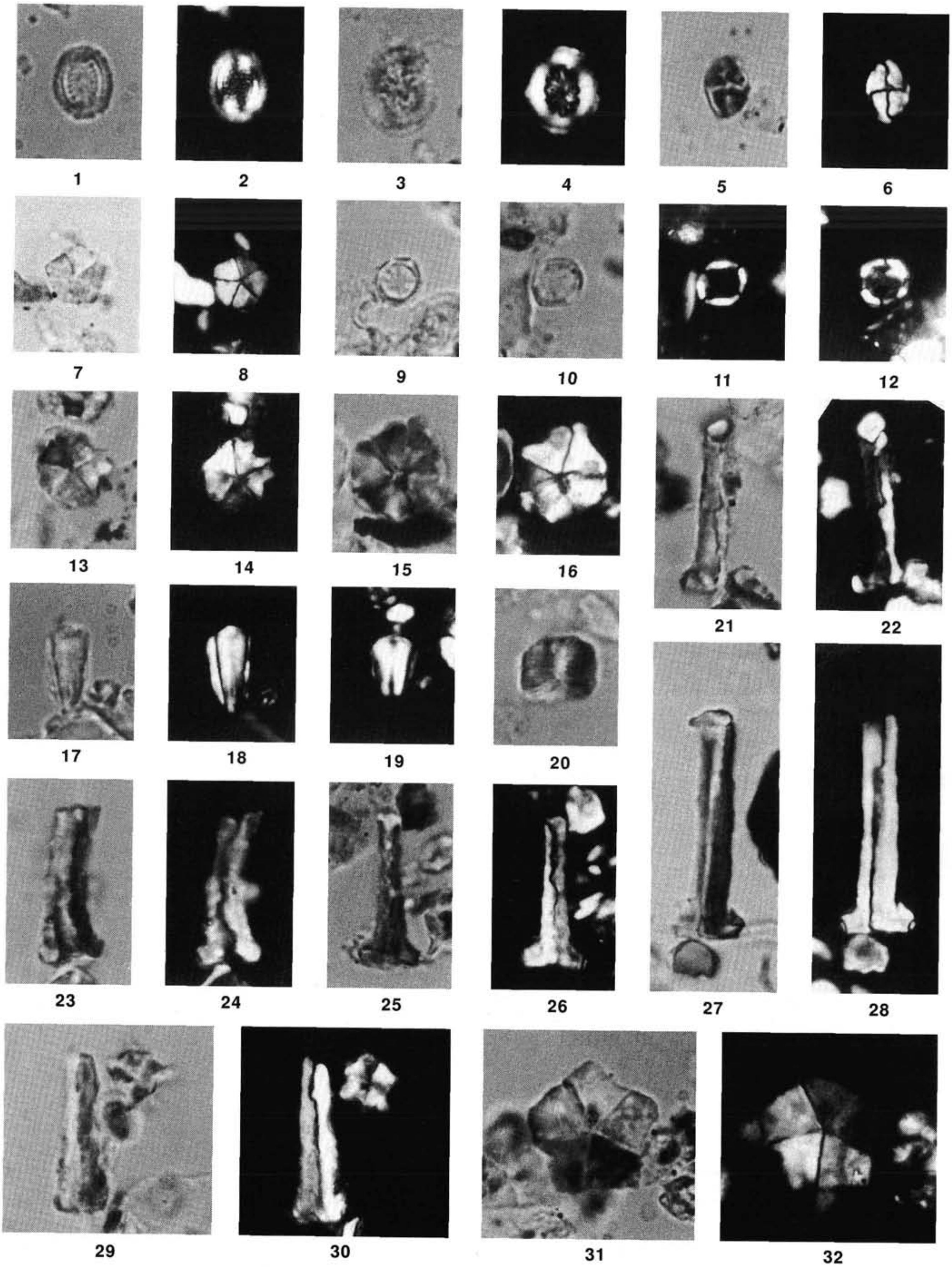
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Plate 9

Figs. 1, 2: *Phlebopterisporites equiexinus* COUPER, 1958; sample No. WB1A, slide No. 100639/1, crosstable: 17,88/100,2
Figs. 3, 4: *Camarozonosporites concinnus* SRIVASTAVA, 1972; sample No. WB11, slide No. 100663, crosstable:11,3/113,8
Figs. 5, 6: *Devecserisporites goczani* SIEGL-FARKAS, 1986; sample No. WB22A, slide No. 100650, crosstable: 14,5/101,7
Fig. 7: *Dictyophyllidites harrisii* COUPER, 1958; sample No. WB1A, slide No. 100639/1, crosstable: 188,9/109,1
Fig. 8: *Toroisporites* sp.; sample No. WB3, slide No. 100644, crosstable: 13,3/117,0
Figs. 9, 10: *Complexiopollis* cf. *vulgaris* (GROOT & GROOT, 1962) GROOT & KRUTZSCH, 1967; sample No. WB3, slide No. 100644, crosstable: 6,9/108,9
Figs. 11, 12: *Complexiopollis funiculus* TSCHUDY, 1973; sample No. WB1A, slide No. 100639/1, crosstable: 21,4/117,8
Figs. 13, 14: *Complexiopollis microrugulatus* KEDVES, 1980; sample No. WB2, slide No. 100657, crosstable: 17,4/100,8
Fig. 15: *Complexiopollis complicatus* GÓCZÁN, 1964; sample No. WB2, slide No. 100657, crosstable: 8,0/113,4
Figs. 16, 17: *Complexiopollis funiculus* TSCHUDY, 1973; sample No. WB9, slide No. 100665, crosstable: 11,3/115,3
Figs. 18, 19: *Complexiopollis microrugulatus* KEDVES, 1980; sample No. WB20B, slide No. 100645, crosstable: 10,6/109,7
Figs. 20–25: *Complexiopollis vulgaris* (GROOT & GROOT, 1962) GROOT & KRUTZSCH, 1967; 20, 21 – sample No. WB5, slide No. 100660, crosstable: 18,5/110,0; Figs. 22, 23 – sample No. WB2, slide No. 100657, crosstable: 14,3/98,2; 24, 25 – sample No. WB1A, slide No. 100639/1, crosstable: 14,1/106,3
Figs. 26, 27: *Bakonyipollis galerus* GÓCZÁN, 1967; sample No. WB1A, slide No. 100639/1, crosstable:10,9/113,2
Fig. 28: *Complexiopollis labilis* (GÓCZÁN, 1964) GÓCZÁN & KRUTZSCH, 1967; sample No. WB1A, slide No. 100639/1, crosstable: 17,5/98,8
Fig. 29: *Complexiopollis* sp.; sample No. WB5, slide No. 100660, crosstable: 14,1/95,8
Fig. 30: *Complexiopollis* cf. *helmigii* (VAN AMEROM, 1965) SOLE DE PORTA, 1977; sample No. WB2, slide No. 100657, crosstable: 14,3/110,9
Figs. 31, 32: *Complexiopolliis labilis* (GÓCZÁN, 1964) GÓCZÁN & KRUTZSCH, 1967; sample WB1A, slide No. 100639/1, crosstable:22,9/111,5

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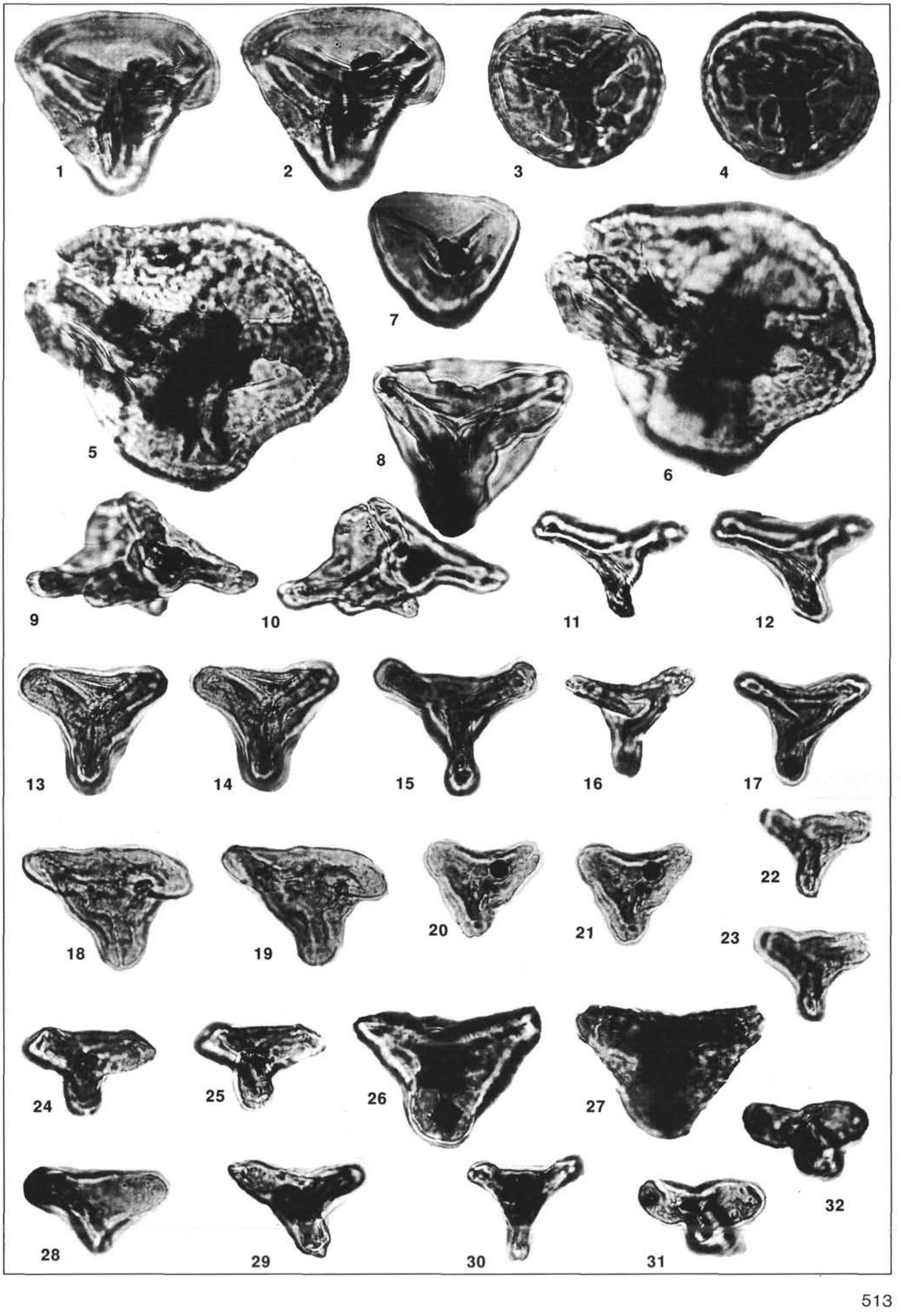
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Plate 10

Figs. 1–4: *Bakonyipollis galerus* GÓCZÁN, 1967; 1, 2 – sample WB4/1, slide No. 100658/1, crosstable: 5,8/111,3; 3, 4 – sample No. WB11, slide No. 100663, crosstable: 14,1/108,0

Figs. 5–13: *Pseudoplicapollis peneserta* (PFLUG, 1953) KRUTZSCH, 1967, ssp.1; 5, 6 – sample No. WB10, slide No. 100661, crosstable: 11,9/106,8; 7 – sample No. WB2, slide No. 100657, crosstable 9,3/98,0; 8, 9 – sample WB1A, slide No. 100639/1, crosstable 16,2/110,2; 10 – sample No. WB10, slide No. 100661, crosstable 9,3-104,0; 11 – sample No. WB1A, slide No.100639/1, crosstable 12,6/106,5; 12, 13 – sample No. WB1A, slide No.100639/1, crosstable 11,0/101,3

Figs. 14, 15: *Pseudoplicapollis peneserta* (PFLUG, 1953) KRUTZSCH, 1967, ssp. 2; 14 – sample No. WB1A, slide No. 100639/1, crosstable: 14,3/105,7; 15 – sample No. WB5, slide No. 100660, crosstable 20,8/111,8

Figs. 16–20: *Schulzipollis pannonicus* GÓCZÁN, 1967; 16–18 – sample No. WB1A, slide No. 100639/1, crosstable: 10,4/102,8; 19, 20 – sample No. WB17/1, slide No. 100643/1, crosstable 22,3/99,8

Figs. 21–23: *Oculopollis zaklinskaiae* GÓCZÁN, 1964; 21, 22 – sample No. WB5, slide No. 100660, crosstable: 3,7/106,0; 23 – sample No. WB6, slide No. 100666, crosstable 13,2/110,7

Fig. 24: *Oculopollis* sp.; sample No. WB1A, slide No. 100639/1, crosstable: 13,4/109,3

Fig. 25: *Oculopollis zaklinskaiae* GÓCZÁN, 1964; sample No. WB4A, slide No. 100640, crosstable: 5,2/101,1

Fig. 26: *Extratriporopollenites* sp.; sample No. WB2, slide No. 100657, crosstable: 8,1/111,0

Fig. 27: *Oculopollis orbicularis* GÓCZÁN, 1964; sample No. WB2, slide No. 100657, crosstable: 9,8/108,6

Fig. 28: cf. *Trudopollis* sp.; sample No. WB1A, slide No. 100639/1, crosstable: 5,9/103,5

Fig. 29: *Cycadopites fragilis* SINGH, 1964; sample No. WB7, slide No. 100662, crosstable: 14,8/108,0

Figs. 30, 31: *Subtriporopollenites* sp.; sample No. WB11, slide No.100663, crosstable: 15,9/114,8

Fig. 32: cf. *Trudopollis* sp.; sample No. WB9, slide No. 100665, crosstable: 10,5/105,8

Fig. 33: *Triporopollenites robustus* PFLUG, 1953; sample No. WB1A, slide No. 100639/1, crosstable:18,4/118,0

Fig. 34: *Oculopollis* cf. *sibiricus* ZAKLINSKAIA, 1963; sample No. WB4A, slide No. 100640, crosstable: 14,3/99,0

Figs. 35, 36: *Praebasopollis praebasalis* GROOT & KRUTZSCH, 1967; sample No. WB17, slide No. 100643, 10,5/108,5

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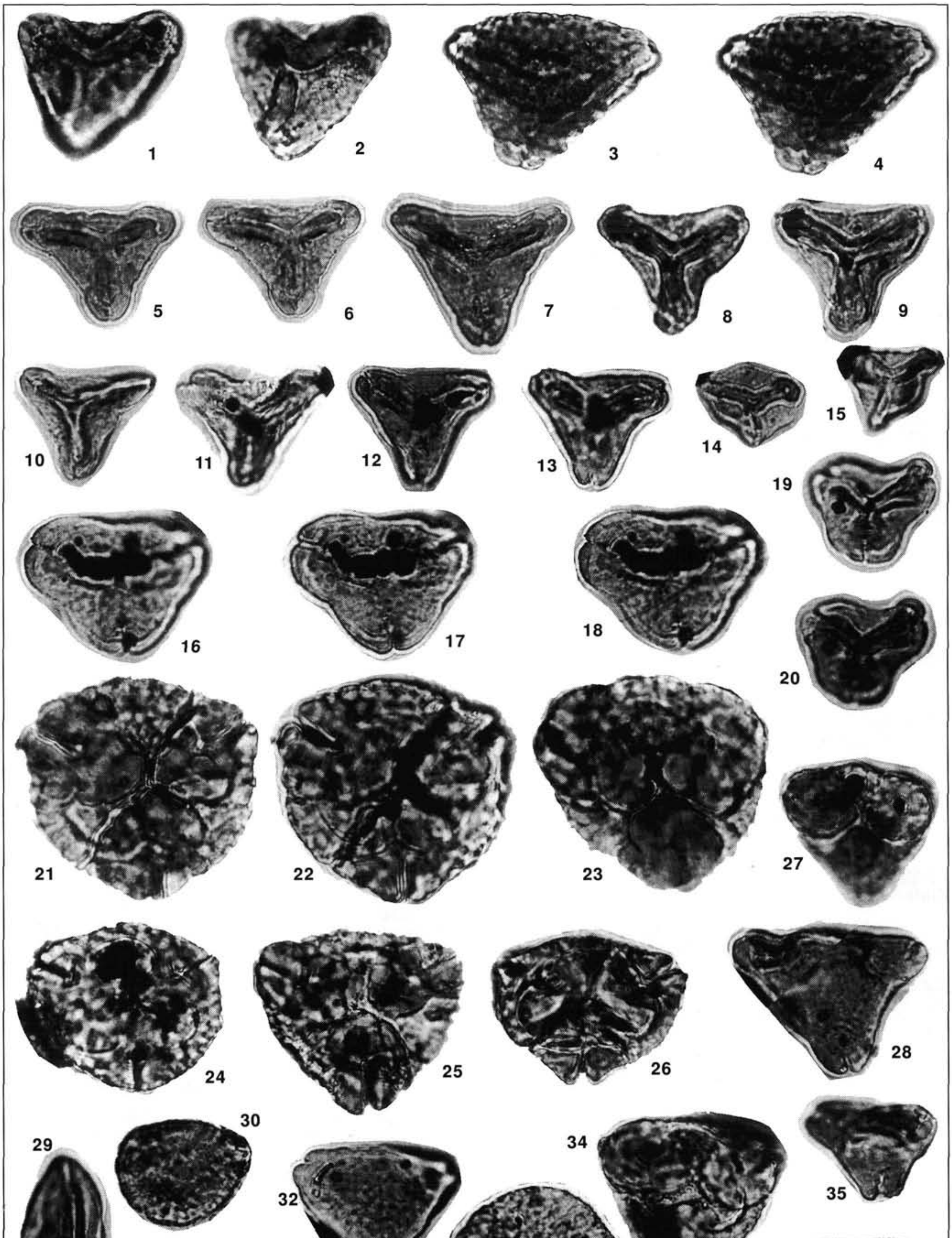
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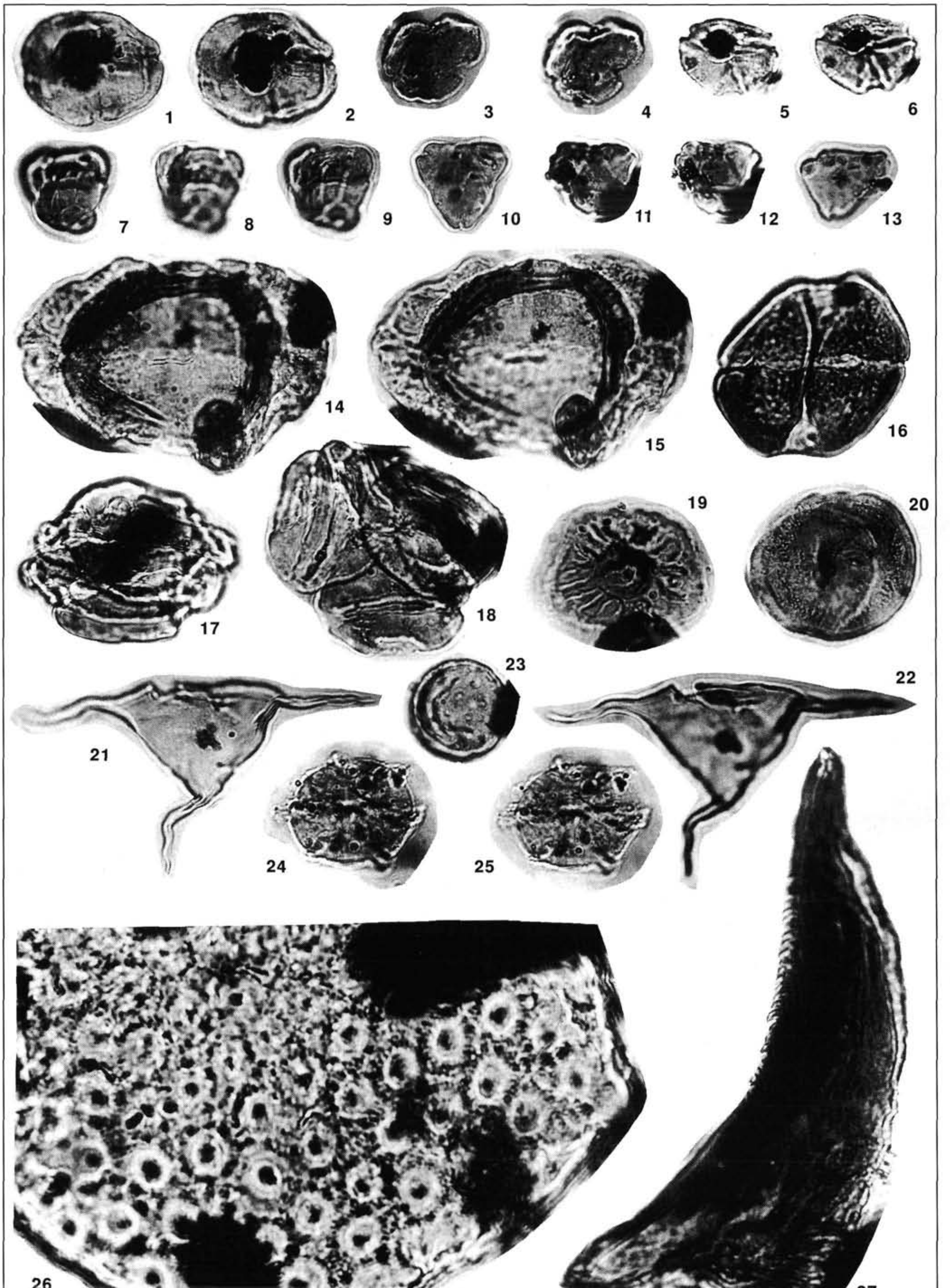
Plate 11

Figs. 1, 2: *Tetracolporopollenites (Brecolpites) globosus* GÓCZÁN, 1964; sample No. WB5, slide No. 100660, crosstable: 13,1/111,8
Figs. 3, 4: *Retitricolporopollenites* sp.; sample No. WB5, slide No. 100660, crosstable: 7,6/99,8
Figs. 5, 6: *Retitricolporopollenites* sp.; sample No. WB6, slide: 100666, crosstable: 19,0/115,6
Figs. 7–9: *Quedlinburgipollis altenburgensis* KRUTZSCH, 1959; sample No. WB6, slide No. 100666, crosstable: 17,3/112,0
Fig. 10: *Triatriopollenites* sp.; sample No. WB5, slide No. 100660, crosstable: 15,4/113,5
Figs. 11, 12: *Suemegipollis triangularis* GÓCZÁN, 1964; sample No. WB5, slide No. 100660, crosstable: 21,4/102,5
Fig. 13: *Triatriopollenites* sp.; sample No. WB5, slide No. 100660, crosstable: 14,9/101,5
Figs. 14, 15: *Limitisporites* sp. (Triassic redeposited pollen grain); sample No. WB1A, slide No. 100639/1, crosstable: 16,5/115,8
Fig. 16: cf. *Stellapollenites* sp. (Permian redeposited pollen grain); sample No. WB6, slide No. 100666, crosstable: 18,5/102,0
Fig. 17: *Rhaetipollis germanicus* SCHULZ, 1967 (Late Triassic redeposited pollen grain); sample No. WB6, slide No. 100666, crosstable: 25,0/112,4
Fig. 18: *Classopollis* sp. (tetrade, Late Triassic redeposited pollen grains); sample No. WB-5, slide: 100660, crosstable: 22,0/114,8
Fig. 19: *Pterospermella australiensis* (DEFLANDRE & COOKSON, 1955) EISENACK, 1972; sample No. WB10, slide No. 100661, crosstable: 17,8/111,5
Fig. 20: *Classopollis* sp. (Late Triassic redeposited pollen grain); sample No. WB1A, slide No. 100639/1, crosstable: 12,2/114,4
Figs. 21, 22: *Veryhachium cruciatum* (WETZEL, 1932) LEJUNE-CARPENTER & SARJEANT, 1981, sample No. WB11, slide No. 100663, crosstable: 22,7/102,3
Fig. 23: *Periporopollenites* sp.; sample No. WB6, slide No. 100666, crosstable: 14,8/104,7
Figs. 24, 25: *Cladopyxidium* sp.; sample No. WB-17, slide No. 18,9-103,2, crosstable:18,9/103,2
Fig. 26: *Oraveczia hungarica* GÓCZÁN, 1997 (fragment of a redeposited Rhaetian grain); sample No. WB9, slide No. 100665, crosstable: 11,9/103,4
Fig. 27: Scolecodonta (Annelidae); sample No. WB9, slide No. 100665, crosstable: 12,0/103,4

Magnification x 1,000.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