| Ann. Naturhist. Mus. Wien | 100 A | 39–79 | Wien, Juli 1999 |
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G E O L O G I E U N D P A L Ä O N T O L O G I E

# New palaeontological and biostratigraphical data on the Klement and Pálava Formations (Upper Cretaceous) in Austria (Waschberg-Ždánice Unit)

by Herbert SUMMESBERGER[1], Lilian ŠVÁBENICKÁ[2] Stanislav ČECH[2], Lenka HRADECKÁ[2] & Thomas HOFMANN[3]

(With 6 plates, 2 text-figures and 3 tables)

Manuscript submitted on February 10th 1999.
the revised manuscript on May 3rd 1999

## 1. Abstract

Re-investigation of macrofossils and samples from the type yielded a Late Turonian age of the Klement Formation at its type section Klement (Lower Austria). The nannofossil assemblage is representative for the basal part of the CC13 Zone, which is correlated with the UC9 Zone (BURNETT 1998) and corresponds to the interval from the upper part of Middle Turonian to lower part of Late Turonian. The planktic foraminifera indicate the *Marginotruncana schneegansi* Zone of Late Turonian - Early Coniacian age, the Inoceramidae the interval between the *Mytiloides incertus* Zone (Late Turonian) and the *Cremnoceramus crassus* Zone (Early Coniacian) of the European Temperate Province. The ammonites *Subprionocyclus hitchinensis* BILLINGHURST and *Subprionocyclus* cf. *neptuni* (GEINITZ) are markers for a Late Turonian age. Microfaunas and nannofloras from selected localities in the Austrian Waschberg Unit which corresponds to the Ždánice Unit) indicate Middle Coniacian to Late Maastrichtian age of the Pálava Formation.

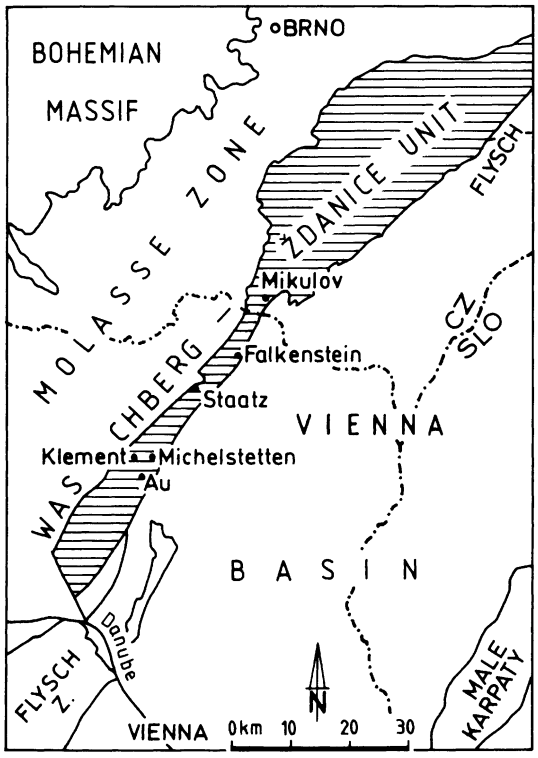
## 2. Zusammenfassung

Die Revision von Makrofossilien und Proben von der Typuslokalität Klement in Niederösterreich ergab ein oberturones Alter der Klement Formation am Typusprofil. Die Nannofloren kennzeichnen den tieferen Abschnitt der Nannozone CC13 (oberes Mittelturonium bis unteres Oberturonium; UC9a Zone sensu BURNETT 1998). Oberturonium bis Unterconiacium wird durch Foraminiferen der Zone der *Marginotruncana schneegansi* angezeigt. Die Inoceramen sprechen für eine Einstufung zwischen der *M. incertus* Zone (Oberturonium) und der *C. crassus* Zone (Unterconiacium). Die Ammoniten *Subprionocyclus hitchinensis* BILLINGHURST und *Subprionocyclus* cf. *neptuni* (GEINITZ) sind auf die oberturone *Neptuni* Zone beschränkt. Mikrofaunen und Nannofloren von ausgewählten Lokalitäten in der Waschberg Zone belegen eine Reichweite der Pálava Formation von Mittelconiacium bis Obermaastrichtium.

[1] Naturhistorisches Museum, A-1014 Wien, Burgring 7, Austria.
e-mail: herbert.summesberger@nhm-wien.ac.at

[2] Czech Geological Survey, Klárov 3, CZ-118 21 Prague 1, Czech Republic.
e-mail: svab@cgu.cz, cech@cgu.cz, hradecka@cgu.cz

[3] Geologische Bundesanstalt, A-1031 Wien, Rasumofskygasse 23, Austria.
e-mail: thofmann@cc.geolba.ac.at

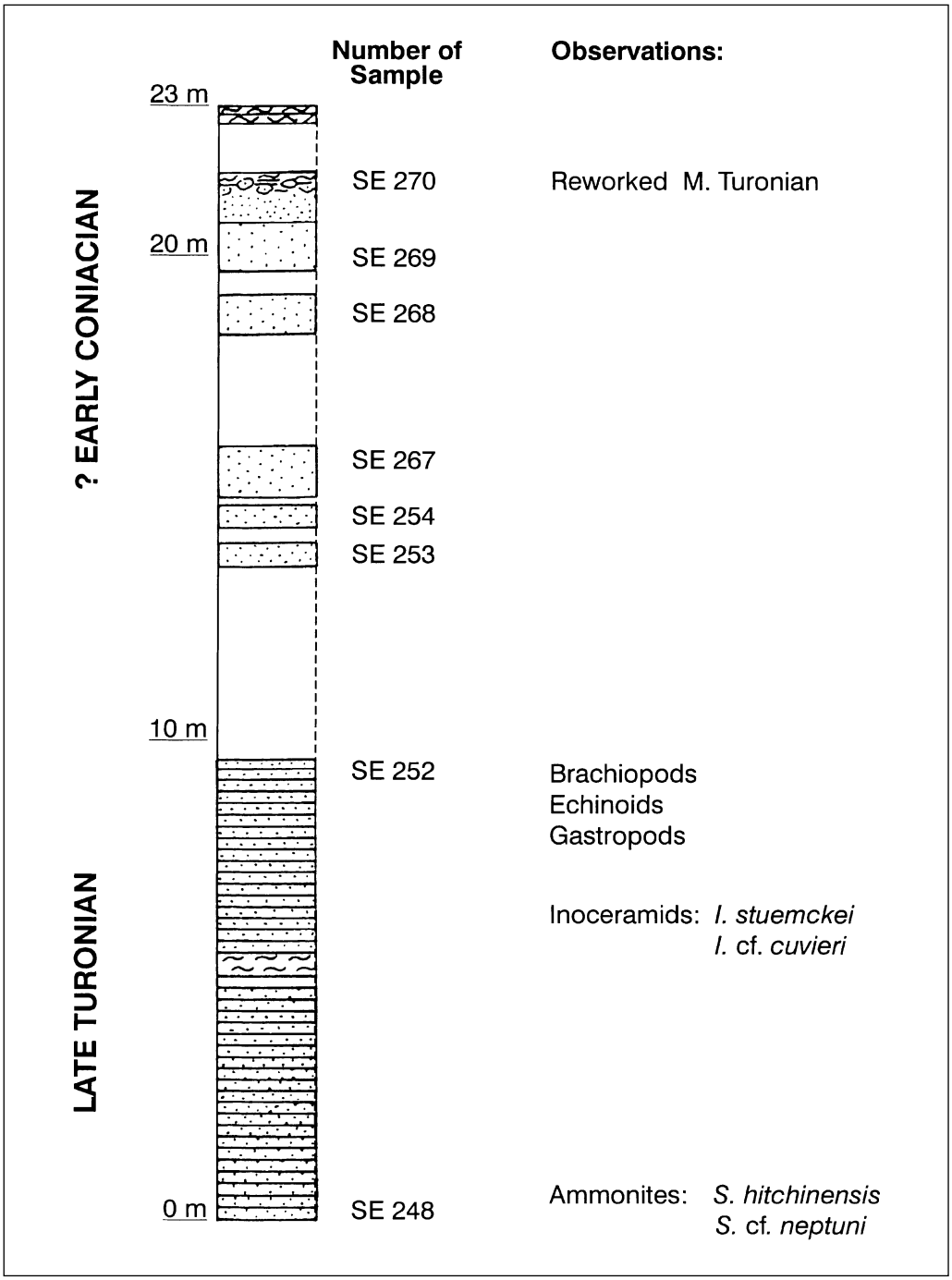



Text-fig. 1: Sketch map of the area investigated in the Austrian Waschberg Unit, Lower Austria. 1. Klement, 2. Michelstetten, 3. Au, 4. Falkenstein.

## 3. Introduction (Thomas HOFMANN)

The area of investigation (Text-fig. 1) is situated in the Austrian Waschberg Klippen Belt, which extends from the NE spur of the Eastern Alps towards the Carpathians. The corresponding tectonic equivalent in southern Moravia (Czech Republic) is the Ždánice Unit.

Overthrusting the undisturbed sediments of the Molasse basin, the Waschberg Klippen Belt comprises a Jurassic to Miocene sequence. The Late Jurassic shallow marine limestone grades laterally into a marly basinal series. Already JÜTTNER (1922) mentioned the glauconitic breccia in the Klippen Belt of the Pavlovské vrchy Hills (Pollauer Mountains) near Mikulov (Nikolsburg). The term "Klementer Schichten" for transgressive glauconitic sediments of the Upper Turonian age was introduced by GLAESSNER (1931a: 4). Following NIEDERMAYR (in KOLLMANN et al. 1977: 408) the sediment is a coarse sandstone to clayey siltstone with predominating quartz and calcite. The glauconite content was used for radiometric dating by ODIN (in KOLLMANN et al. 1977: 418, KENNEDY & ODIN 1982: 751). The "Klementer Schichten" (Klement Formation) are overlain by "Mucronatenkreide" (= "Mucronatenschichten"; ABEL 1897: 362) of late Senonian age (GLAESSNER 1931a: 6, 8). This term is now abandoned and replaced by "Pálava Formation" (STRÁNÍK et al. 1996: 8, text-fig. 4) in the allochthonous Waschberg-Ždánice Unit. According to STRÁNÍK et al. (1996) the localities Klement West, Au, Michelstetten/East, Michelstetten/West/1 and West/2 investigated in the present paper belong to the Pálava Formation, the revised type locality Klement to the Klement Formation.




Text-fig. 2: Type-section of the Klement Formation at Klement, Lower Austria, Waschberg Unit. With modifications after BACHMAYER & KOLLMANN (1977); sample numbers according to SCHMID (1977).

From boreholes in the autochthonous cover of the Bohemian Massif, FUCHS & WESSELY (1977: 426) described the coarse clastic transgressive "Ameiser Komplex" (?Cenomanian / Turonian-Santonian), corresponding to the surface exposures of the Klement Formation in the Waschberg Unit. The stratigraphically overlying Campanian - Maastrichtian "Poysdorfer Komplex" (FUCHS & WESSELY 1977: 430) seems to be equivalent to the "Pálava Formation" (STRÁNÍK et al. 1996) in the Waschberg Unit.

BACHMAYER (1959) presented a list of fossils from various localities of the Waschberg Unit and inferred a Middle Turonian age. GRILL (1961) separated Klementer Schichten (Middle Turonian) and "Mergel und glaukonitische Mergel des Senon". The type locality Klement (Lower Austria) was investigated by KOLLMANN et al. (1977). A Coniacian age was proposed by SCHMID (1977: 411) on the basis of foraminifera, by KENNEDY & KOLLMANN (1977: 416) on the basis of ammonites, a conclusion followed with some doubt by STRADNER & PRIEWALDER (1977: 423/424) on the basis of nannoplankton.

## 4. Stratigraphic revision of the type section of the Klement Formation ("Klementer Schichten") at Klement, Lower Austria.

### 4.1.1. Calcareous nannofossils (Lilian ŠVÁBENICKÁ)

Calcareous nannofossils from the Klement Formation were first studied by STRADNER (1962). STRADNER and PRIEWALDER (in KOLLMANN et al. 1977) investigated 16 samples from the type locality Klement and assigned the whole section to the *Marthasterites furcatus* Zone, regarded after ROTH (1973) as extending from the Turonian/Coniacian boundary to the Early Santonian. Although the marker species *Marthasterites furcatus* and *Micula staurophora* were not found here, the authors followed the conclusions of contemporaneous investigations of the macro- and microfauna and correlated the nannofossil associations with the Coniacian Stage.

For this revision original samples from the type Klement section (Nos. 250, 255, 257) were provided by the Austrian Geological Survey. Additional material was obtained from the ammonite specimen *Subprionocyclus* cf. *neptuni* (GEINITZ) that was also collected at the type locality Klement and stored in the Museum of Natural History at Vienna (NHMW 1977/1890/15).

Re-examination of the samples from the Klement section confirmed more or less STRADNER & PRIEWALDER's (1977) observations. The sediments yielded poorly preserved nannofossils, including:

*Lithastrinus septenarius*
*Marthasterites furcatus* (very rare)
*Eiffellithus eximius*
*Kamptnerius magnificus*
*Quadrum gartneri*
*Quadrum intermedium*

This association indicates the basal part of the CC13 Zone of the standard nannoplankton zonation of SISSINGH (1977) and PERCH-NIELSEN (1985) that is correlated with the basal Coniacian. According to the nannoplankton zonation introduced by BURNETT (1998), the first occurrence of *Lithastrinus septenarius* defines the base of the UC9a

Zone, that is correlated with the interval from the upper part of the Middle Turonian to the lower part of the Late Turonian (see Table 2).

The relatively coarse matrix taken from *Subprionocyclus* cf. *neptuni* (NHMW 1977/1890/15) yielded a poorly preserved nannofossil association represented by the following species:

*Biscutum constans*
*Braarudosphaera bigelowii*
*Broinsonia enormis*
*Broinsonia signata*
*Chiastozygus litterarius*
*Cretarhabdus conicus*
*Eiffellithus eximius*
*Eiffellithus turriseiffelii*
*Eprolithus floralis*
*Eprolithus moratus*
*Gartnerago obliquum*
*Helicolithus trabeculatus*
*Lucianorhabdus maleformis*
*Microrhabdulus belgicus*
*Prediscosphaera cretacea*
*Quadrum gartneri*
*Retacapsa crenulata*
*Thoracosphaera* sp.
*Tranolithus phacelosus*
*Watznaueria barnesae*
*Watznaueria fossacincta*
*Zeugrhabdotus bicrescenticus*
*Zeugrhabdotus diplogrammus*

This assemblage gives an indication for the UC8 Zone, which is correlated with the lower part of the Middle Turonian sensu BURNETT (1998). Nevertheless, nannofossil specimens show both mechanical damage and secondary dissolution, so that the absence of other stratigraphically important and very rare species such as *Marthasterites furcatus* or *Lithastrinus septenarius* is presupposed here. This biostratigraphic conclusion can therefore be considered as being very general and no exact dating can be given in terms of nannofossil zonations.

Discussion: STRADNER & PRIEWALDER (1977) mentioned the nannofossil species *Lithastrinus grillii* with "6 ray-like elements" (1977: pl. 3, fig. 6) from the type section Klement but without locality details and sample number. The species *L. grillii* was first described by STRADNER (1962) as "Sternförmige Kalkkörperchen aus 6 stark gedrehten, gegabelten, sich überdachenden Sektoren bestehend", type level: Klementer Schichten (Höheres Turon - Emscher), type locality: "Graben nordwestlich Klafterbrunn, Niederösterreich". The first appearance of *L. grillii* was noted by WAGREICH (1992) approximately together with the appearance of *Micula staurophora* in the *Tridorsatum* Zone (Middle Coniacian) in the Gosau Group, Austria. BURNETT (1998) correlates the first occurrence of *L. grillii* with the upper part of the Coniacian. Nevertheless, MANIVIT (in ROBASZYNSKI et al. 1982) reported *L. grillii* already from the upper part of the Middle

and Upper Turonian of Touraine, France but without any photodocumentation or morphological notes. This find can thus only be considered as a doubtful record.

*Lithastrinus grillii* was not observed by the present author in material from the type locality Klement studied. *L. septenarius,* which was present in the studied material, has 7 ray-like elements and is known in the interval from the Middle Turonian to Early Santonian (BURNETT 1998).

The nannofossil association from the type section at Klement can be compared with that from Turold of the Ždánice Unit, in the Outer West Carpathians (ŠVÁBENICKÁ, STRÁNÍK and BUBÍK 1991, STRÁNÍK et al. 1996) and Březno in the Bohemian Cretaceous Basin (ČECH & ŠVÁBENICKÁ 1992), where the first occurrences of *Lithastrinus septenarius* and *Marthasterites furcatus* were recorded in the Late Turonian before the first appearance of the bivalve *Cremnoceramus waltersdorfensis*. These observations are also in accordance with the observations of WAGREICH (1992), who described the first occurrence of *M. furcatus* from the Late Turonian in the earliest marine sediments of the Gosau Group of the Gosau Valley**.**

### 4.2. Revision of the foraminifera from the type locality Klement (Lower Austria)
(Lenka HRADECKÁ)

Planktic foraminifera were studied by SCHMID (1977: 409-411). He investigated about 20 samples from the section and inferred an Early Coniacian age. Reinterpretation of the planktic foraminifera record leads to the conclusion, that at least two different faunas were present in his samples, the older one with *Heterohelix reussi* (CUSHMAN), *Globotruncana coronata* BOLLI, *Globotruncana* cf. *renzi* GANDOLFI, *Globotruncana* cf. *sigali* indicating Middle Turonian to basal Campanian, the younger one with *Globotruncana angusticarinata* GANDOLFI and *Globotruncana* aff. *fornicata* PLUMMER representing Late Coniacian and even younger ages. This is in accordance with the reinterpretation of the nannofossil data of STRADNER & PRIEWALDER (1977: 424).

Three samples (SE 250, SE 255, SE 257) from the Klement Formation at the type locality, Klement, collected in 1975 and stored at the Austrian Geological Survey, were at our disposal. The samples were washed in 1994. The numbers are identical with those listed by SCHMID (1977: 409). SCHMID (1977) summarized the results based on twenty samples in a list of 21 benthic and 9 planktic species and proposed Coniacian age. The revised interpretation is that the samples probably stem from different stratigraphic levels.

Fossil assemblages from samples SE 250 and SE 255 are identical. The predominant planktic species are:

*Marginotruncana pseudolinneiana* PESSAGNO
*Marginotruncana coronata* (BOLLI)
*Marginotruncana angusticarinata* (GANDOLFI)
*Marginotruncana* cf. *renzi* GANDOLFI
*Marginotruncana marginata* (REUSS)
*Hedbergella delrioensis* (CARSEY)
*Hedbergella simplex* (MORROW)
*Whiteinella brittonensis* (LOEBLICH & TAPPAN)
*W. aprica* (LOEBLICH & TAPPAN)

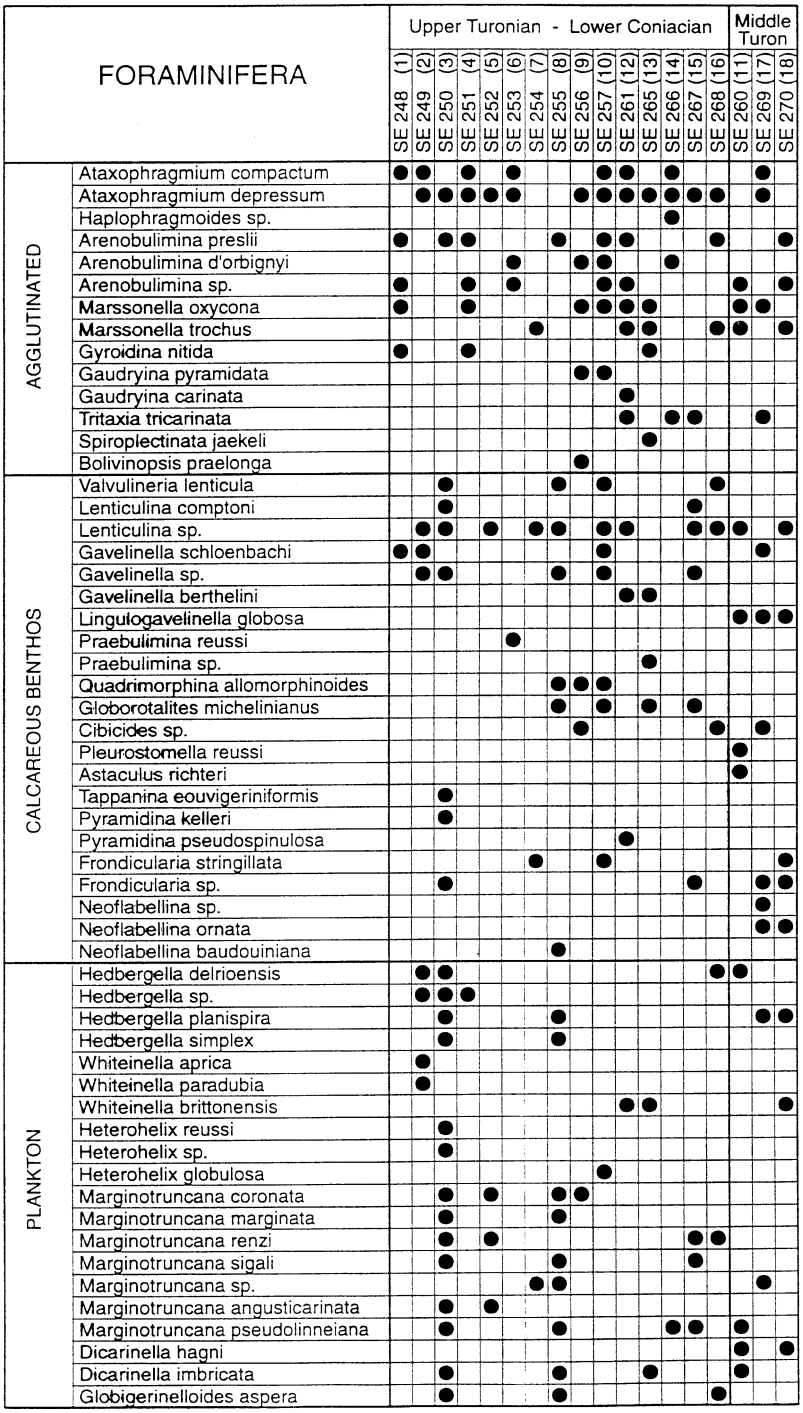



Table 1: Foraminifera from the samples SE 248 - 270 (M.E. SCHMID collection, Geologische Bundesanstalt Wien).

*Dicarinella imbricata* (MORNOD)
*Heterohelix reussi* (CUSHMAN)
*Heterohelix* sp.
*Globigerinelloides aspera* (EHRENBERG)

The benthos is represented by:

*Ataxophragmium compactum* BROTZEN
*Tritaxia tricarinata* (REUSS)
*Gaudryina pyramidata* CUSHMAN
*G. carinata* FRANKE
*Globorotalites micheliniana* (D'ORBIGNY)
*Quadrimorphina allomorphinoides* (REUSS)
*Gyroidina nitida* (REUSS)
*Lenticulina comptoni* (SOWERBY)
*Valvulineria lenticula* (REUSS)
*Marssonella trochus* (D'ORBIGNY)
*Frondicularia* sp.
*Dentalina* sp.
*Dorothia oxycona* (REUSS)
*Gavelinella schloenbachi* (REUSS)
*G. moniliformis* (REUSS)
*Arenobulimina preslii* (REUSS)
*Frondicularia strigillata* REUSS
*Cibicides* sp.
*Tappanina* cf. *eouvigeriniformis* (KELLER)

Samples SE 250 and SE 255 also yielded fish teeth, radiolaria and frequently sponge spicules. The same horizon was observed in the Klement Formation of the Turold quarry (vicinity of Mikulov) and in borehole Pavlov-5 in South Moravia (STRÁNÍK et al. 1996).

Sample SE 257 yielded a poorly preserved but comparable fauna with a smaller number of planktic species, scarce radiolaria and few sponge spicules.

Typical Coniacian or younger species listed by SCHMID [(1977: 411-412): *Stensioeina exsculpta gracilis* BROTZEN, *Vaginulina trilobata* (D'ORBIGNY), *Neoflabellina ovalis* (WEDEKIND), *N. suturalis* (CUSHMAN), *Pseudotextularia* aff. *elegans* (RZEHAK)] are absent in the samples investigated.

Planktic foraminifera indicate the *Marginotruncana schneegansi* Zone sensu SALAJ & GASPARIKOVA (1979) and WONDERS (1979, 1980) for the Western Tethys and the Alpine area (CARON 1985). This zone is characterized by "grand *Marginotruncana*" (SIGAL 1977). Large specimens of *Marginotruncana marginata, M. angusticarinata* and *M. coronata* are present in the 0.400 mm fraction. A Late Turonian age is indicated by the *Marginotruncana schneegansi* Zone according to WEIDICH (1984) and CARON (1985).

Correlation seems likely with the interval from 177.0 - 132.0 metres of the Pavlov-5 borehole (STRÁNÍK et al. 1996).

The investigation of these three samples leads to the conclusion that the time interval from the Late Turonian to the Early Coniacian may be represented. No typical Coniacian foraminifers were found and foraminiferal assemblages have a Late Turonian character.

### 4.3. Revision of the Inoceramidae (Stanislav ČECH)

Previous work: GLAESSNER (1931a: 5) mentioned inoceramid bivalves from several localities of the Klippen Belt in northern Lower Austria and southern Moravia. Based on inoceramids he was uncertain whether to correlate the Klementer Schichten with the "oberen Scaphitenschichten" or "*Schloenbachi* Zone" and preferred the former. BACHMAYER (1959) and GRILL (1968) mentioned Middle to Late Turonian inoceramids (*Inoceramus monstrum* HEINZ and *I. latus* MANTELL) from the sandstones of the locality in Klement. In their revision of the type locality in Klement. KOLLMANN et al. (1977: 418) reported inoceramid bivalves of the *cuvieri* - group. The Klementer Schichten of the type locality have been regarded as Early Coniacian by KOLLMANN et al. (1977: 418). The inoceramid bivalves were not figured by previous authors.

Material: The NHMW collections contain several fragments of inoceramids from the type locality Klement, labelled as being of the *Inoceramus cuvieri* group, and as *I. latus* MANTELL (non SOWERBY). They are apparently from a level 8 m above the ammonite horizon (BACHMAYER & KOLLMANN 1977: 404, sample nr. 24 on text-fig. 1). Fragments labelled *I. latus* are unidentifiable in our opinion. Fragments of large shells of inoceramids can be attributed **only** to *Inoceramus* sp. of the *cuvieri*- group (pl. 4, figs. 1 and 2). The fragment of a thick hinge plate (pl. 5, figs. 1 and 2) corresponds to *Inoceramus hercules* (HEINZ). A single specimen (NHMW A/3901), apparently collected by GLAESSNER in Falkenstein, was determined by SUMMESBERGER as *Inoceramus* cf. g*ermanobohemicus* HEINZ (pl. 5, figs. 3, 4).

Discussion: The name *Inoceramus cuvieri* SOWERBY is firmly linked to the species figured by SOWERBY (1822: pl. 25, figs. 1-3) (ICZN Opinion 473, Article 10). The two specimens figured by SOWERBY (1822) clearly belong to two different species representing different stratigraphic horizons. The larger, gigantic, shell (SOWERBY 1822: pl. 25, fig. 1) with thick (1.8 cm) hinge plate and prismatic shell layer (0.86 cm) preserved, corresponds to the original concept of *I. cuvieri* of SOWERBY (1814, 1822). The adult, much smaller shell (SOWERBY 1822: pl. 25, figs. 2, 3) with a thin prismatic shell layer, thin hinge plate and anterior "lobe", was designated lectotype of *I. cuvieri* SOWERBY by Cox (see Opinion 473, Article 8), a species occurring in the Middle Turonian *lata* Zone. The large shell with typically thick hinge plate of SOWERBY's syntype of *I. cuvieri* can be compared with *I. hercules* (HEINZ) of TRÖGER (1984), elsewhere occurring in the Late Turonian *Neptuni* Zone. The hinge fragment from the type section at Klement (pl. 5, figs. 1, 2) well corresponds with hinge characteristics of *I. hercules*.

The specimen from the Klement Formation of Falkenstein (pl. 5, figs. 3, 4) is similar to the concept of *Inoceramus germanobohemicus* Heinz of WALASZCZYK 1992. The type specimen of this species (ANDERT 1911: pl. 1, fig. 1) is more prosocline. *Inoceramus costellatus* WOODS of FIEGE (1930: pl. 5, fig. 4) has a similar shape and ornamentation but without visible deep auricular sulcus separating the umbo from the posterior auricle. *Inoceramus frechi* FLEGEL has broader interspaces between concentric ribs.

Correlation with other areas: The Klement Formation of the Waschberg-Ždánice Unit of Southern Moravia (STRÁNÍK et al.: 1996) can be correlated with the Klement Formation of Lower Austria (Waschberg Zone).

Inoceramids were recently collected by ČECH and STRÁNÍK from surface outcrops (localities Turold and Dìvín) and from the borehole PV-5 (Pavlov) in southern Moravia.

Stratigraphically significant inoceramid bivalves were obtained from siliciclastic sediments of the Klement Formation (STRÁNÍK et al.: 1996). *Mytiloides carpathicus* (SIMIONESCU) (pl. 5, fig. 6) and *M. labiatoidiformis* TRÖGER occur in the lower part of the siliciclastic member of the Klement Formation (Late Turonian), while *Cremnoceramus waltersdorfensis* (ANDERT) (pl. 5, fig. 5), *C. rotundatus* (FIEGE) and *C. brongniarti* (MANTELL) characterize the middle part of the member (Early Coniacian). *C.* cf. *crassus* appears at the top of the Klement Formation (Early Coniacian).

A collection made by ABEL and cited by GLAESSNER (1931a: 5) from the Klippen Belt of the Pavlov hills in southern Moravia could not be traced in the Austrian Geological Survey. It is quoted again without revision here: *Inoceramus cuvieri* Sow. var. (locality Turold), *I. latus* FIEGE non MANTELL, *I. inconstans* WOODS var., *I. inconstans rotundatus* FIEGE and *I.* cf. *vancouverensis* SHUMARD (locality Maydenberg = Dìvín). With respect to the subsequent subdivision of FIEGE's *I. latus* into the two subspecies *I. waltersdorfensis hannovrensis* and *I. dresdensis dresdensis* by TRÖGER (1967), GLAESSNER's faunal content corresponds with the newly collected material.

Occurrence: According to the inoceramid zonation (WALASZCZYK 1992) the glauconitic calcareous sandstones of the Klement Formation of the Waschberg - Ždánice Unit represent a sequence from the *M. incertus* Zone (Late Turonian) to the *C. crassus* Zone (Early Coniacian) of the European Temperate Province.

### 4.4. Revision of the ammonites from the type locality Klement, Lower Austria
(Herbert SUMMESBERGER)

Ammonites from the type locality Klement of the Klement Formation were first described by KENNEDY & KOLLMANN (1977: 411 ff.). Re-examination of the material was undertaken when Czech colleagues and co-authors of this paper (ČECH, ŠVÁBENICKÁ, 1994 pers. comm.) questioned the Coniacian age resulting from the identification of the ammonites. Additional material from the collection of KOLLMANN & BACHMAYER, not for disposal to KENNEDY & KOLLMANN (1977), was investigated by the present author.

Order Ammonoidea ZITTEL, 1884

Suborder Phylloceratina ARKELL, 1950

Family Phylloceratidae ZITTEL, 1884

Subfamily Phylloceratinae ZITTEL, 1884

**Phylloceratinae gen. et sp. indet.**
(Pl. 6, fig. 1)

Material: a single specimen NHMW 1998z0058/0001.

Description and Discussion: The specimen is a poor fragment of an internal mould 19 mm in maximum diameter, preserved in coarse sandstone. The umbilicus seems to have been very small. The whorls increase rapidly in height. The surface is totally covered with fine and dense ribs indicating that the specimen is probably a representative of the Phylloceratinae. The specimen was not discussed by KENNEDY & KOLLMANN (1977).

Suborder Lytoceratina HYATT, 1889

Superfamily Tetragonitaceae HYATT, 1900

Family Tetragonitidae HYATT, 1900

Subfamily Tetragonitinae HYATT, 1900

**Tetragonitinae gen. et sp. indet.**
(Pl. 6, fig. 2)

Material: A single specimen NHMW 1998z0058/0002 from the basal Klement Formation of Klement, Lower Austria.

Description and Discussion: The specimen is a small (D 20) internal mould with corroded surface and is in our opinion specifically unidentifiable. Rapidly increasing whorl height and breadth together with a smooth surface without constrictions recalls the genus *Pseudophyllites*.

Suborder Ammonitina HYATT, 1889

Superfamily Desmoceratacеae ZITTEL, 1895

Family Desmoceratidae ZITTEL, 1895

Subfamily Desmoceratinae ZITTEL, 1895

**Desmoceratinae gen. et sp. indet.**
(Pl. 6, fig. 3)

Material: A single specimen NHMW 1998z0058/0003 from the basal Klement Formation of Klement, Lower Austria.

Description and Discussion: The specimen measures 30 mm in diameter. It is generically and specifically unidentifiable.

Family Pachydiscidae SPATH, 1922

Subfamily Pachydiscinae SPATH, 1922

**Pachydiscinae gen. et sp. indet.**
(Pl. 6, figs. 4, 5)

Material: NHMW 1977/1890/9, the original of KENNEDY & KOLLMANN (1977: pl. 1, fig. 2), NHMW 1977/1890/11 the original of KENNEDY & KOLLMANN (1977: pl. 1, fig. 11) and NHMW 1977/1890/12, the original of KENNEDY & KOLLMANN (1977: pl. 1, fig. 6a,b), all from Klement, Lower Austria.

Discussion: As already discussed by KENNEDY & KOLLMANN (1977: 413) the specimens probably belong to the genus *Tongoboryceras* HOUŠA.

Superfamily Acanthocerataceae GROSSOUVRE, 1894

Family Collignoniceratidae WRIGHT & WRIGHT, 1951

Subfamily Collignoniceratinae WRIGHT & WRIGHT, 1951

Genus *Subprionocyclus* SHIMIZU, 1932

***Subprionocyclus hitchinensis* (BILLINGHURST, 1927)**
(Pl. 6, fig. 11)

Synonymy:

1988 *Subprionocyclus hitchinensis* BILLINGHURST; KAPLAN:17; pl. 4, figs. 1-3 (with synonymy).

Material: a single specimen NHMW 1998z0099/0001

Description: The poor fragment of an internal mould comprises approximately one third of a whorl. It is preserved in a glauconitic siltstone with well-rounded quartz grains up to 1 mm in diameter. The specimen seems to be high-whorled (Wh 8,3 mm) with a narrow umbilicus. Primary ribs arise singly or in twos or threes with a tubercle at the umbilical edge, flex backwards below mid-flank and forward again in the outer third of the flank. Intercalatories appear in the outer third of the flank. Ribs thicken at the ventrolateral shoulder. The inner row of ventrolateral tubercles is almost invisible due to corrosion; the outer one is a distinct clavus, terminating the rib. The keel is corroded.

Discussion: Despite poor preservation, specific identification is reliable due to the characteristic ornamentation. The above-described specimen differs from co-occurring *Subprionocyclus* cf. *neptuni* by the much coarser ribbing of the latter, and from other representatives of the genus by its higher whorls. The specimen was not described by KENNEDY & KOLLMANN (1977).

Occurrence: According to WRIGHT (1979: 319) *Subprionocyclus hitchinensis* is widespread in the *Holaster planus* Zone of the English Chalk Rock, which is equivalent to the *Neptuni* Zone sensu WRIGHT & KENNEDY (1981: 8). Following KAPLAN (1988: 17; text-fig. 2) *S. hitchinensis* appears in N Germany in the early Late Turonian *Allocrioceras/Orbirhynchia* event and has its main occurrence in the *Hyphantoceras* event. This is *Neptuni* Zone sensu KAPLAN 1988, below the top Turonian *Germari* Zone sensu KAPLAN & KENNEDY (1996: text-fig. 20).

***Subprionocyclus* cf. *neptuni* (GEINITZ, 1850)**
(Pl. 6, figs. 8,9)

Compare:

1977 *Paratexanites (Parabevahites)* cf. *serratomarginatus* (REDTENBACHER); KENNEDY & KOLLMANN: 414; pl. 1, fig. 1.
1979 *Subprionocyclus neptuni* GEINITZ; WRIGHT: 319, pl. 5, fig. 2,3. With synonymy.
1988 *Subprionocyclus neptuni* GEINITZ; KAPLAN: 17; pl. 4, figs. 4-7 (with additional synonymy).

Material: A single specimen, NHMW 1977/1890/15 figured by KENNEDY & KOLLMANN (1977: pl. 1, figs. 1a-c.).

Description: NHMW 1977/1890/15 is a badly corroded inner mould preserved in a coarse sandstone matrix with perfectly rounded and polished quartz grains. The specimen is

described at length by KENNEDY & KOLLMANN (1977: 414). Two rows of ventrolateral tubercles, the outer one clavate, are visible despite poor preservation.

Discussion: Bad preservation of the specimen makes separation from the younger but morphologically similar *P. serratomarginatus* (REDTENBACHER) difficult. Co-occurring *Subprionocyclus hitchinensis* indicates Late Turonian. As *P. serratomarginatus* is a Late Coniacian taxon (KENNEDY 1984: 153, tab. 4; KENNEDY, KLINGER & SUMMESBERGER 1981: 126) reference to *Subprionocyclus* cf. *neptuni* is regarded as more probable.

Occurrence: *Subprionocyclus neptuni* is a typical Late Turonian species that is widespread in the northern hemisphere and is also recorded from Madagascar. The nannosample taken from this specimen indicates Middle to Late Turonian nannozone UC 8 (see p. 57, tab. 2).

**Collignoniceratinae gen. et sp. indet.**
(Pl. 6, figs. 6,7)

Material: a single specimen (NHMW 1998z0099/0003) from the "Klementer Schichten" of Klement, ex GLAESSNER collection, labelled "*? Prionotropis*, Turonian" by SPATH in 1931.

Description: The specimen is a 50 mm fragment of an internal mould without adherent shell. The badly distorted quarter of a whorl bears strong and widely spaced prorsiradiate ribs arising in a pointed tubercle at the umbilical edge, crossing the flanks with a concavity. No bifurcations are visible. Ribs terminate at the ventrolateral edge in two strong ventrolateral tubercles which are almost fused into a single one. The keel is destroyed except for two clavate undulations. Measurements are meaningless due to distortion.

Discussion: The specimen is believed to be a large fragment of a body-chamber of *Subprionocyclus*. Widely spaced ribbing without intercalations, combined with strong tuberculation, make it likely that this is a coarsely ornamented variant of *Subprionocyclus neptuni* as described by OBATA, TANABE & FUTAKAMI (1979: text-fig. 12, pl. 4, figs. 1a-d) from Japan. Comparable ornamentation is also present in Middle Turonian *Collignoniceras woollgari regulare* (HAAS) from North America (COBBAN & HOOK 1979: pl. 3, figs. 1-8; KENNEDY & COBBAN 1988, figs. 7-9). Due to its poor preservation the specimen remains unidentified generically and specifically.

Occurrence: Upper Turonian Klement Formation of Klement, Lower Austria.

Suborder Ancyloceratina WIEDMANN, 1960

Superfamily Turrilitaceae GILL, 1871

Family Baculitidae GILL, 1871

**Baculitidae gen. et sp. indet.**

Material: NHMW 1977/1890/1-6; NHMW 1998z0099/0004 and several poor fragments with a maximum length of 29 mm.

Compare:

1977 *Baculites* sp. indet.; KENNEDY & KOLLMANN: 411-412; pl. 1, figs. 7-10; text-fig. 5.

Discussion: The poor fragments could well belong to *Sciponoceras*, which is indistinguishable from *Baculites* in this state of preservation, unless constrictions are preserved.

Occurrence: Upper Turonian Klement Formation of Klement.

Superfamily Scaphitaceae GILL, 1871

Family Scaphitidae GILL, 1871

Subfamily Scaphitinae GILL, 1871

Genus *Scaphites* PARKINSON, 1811

***Scaphites* sp. indet.**
(Pl. 6, fig. 10)

Material: two poor fragments: NHMW 1977/1890/7-8.

Compare:

1977 *Scaphites (Scaphites)* sp. indet.; KENNEDY & KOLLMANN: 412; pl. 1, figs. 3 a,b; 5 a-c.

Discussion: The material is described and discussed at length by KENNEDY & KOLLMANN: 413.

Occurrence: Upper Turonian Klement Formation of Klement.

Conclusion:

The poor ammonite fauna from Klement is comparable to that of the Upper Turonian English Chalk Rock (WRIGHT 1979). Stratigraphic evidence is given by representatives of the worldwide occurring genus *Subprionocyclus*. *Subprionocyclus* does not occur in the Late Turonian of the Austroalpine Gosau-Group (SUMMESBERGER & KENNEDY 1996).

### 4.5. Fish remains

A single shark tooth from Klement Formation of Klement from the BACHMAYER collection was identified as *Cretolamna appendiculata* (AGASSIZ, 1843) by Dr. Ortwin SCHULTZ (NHMW). The specimen is labelled: 500 metres from the church of Klement on the road to the village Au. There is no doubt about its origin from the Klement Formation. The species was originally described from the Turonian chalk of Lewes, England. The total known range is from Albian to Early Eocene.

### 4.6. Stratigraphic conclusions

There is good accordance between the investigated fossil groups, indicating that the type section of the Klement Formation at Klement belongs at least partially to the Late Turonian *Neptuni* Zone. Stratigraphically higher parts of the now inaccessible type section may belong to the Coniacian, too. Calcareous nannofossils from the matrix of *S. neptuni* indicated Middle to Late Turonian (sensu SISSINGH, 1977 and PERCH-NIELSEN

1985; UC8 Zone sensu BURNETT 1998). Samples 250, 255 and 257 yielded specimens of *Lithastrinus septenarius* and rare *Marthasterites furcatus* indicating the UC9a Zone (BURNETT 1998) which is correlated with the interval between the upper part of the Middle Turonian and the lower part of the Late Turonian. These results are in accordance with STRADNER & PRIEWALDER's (1977: 421) study of the nannoflora of the type locality Klement. In their discussion of the age of the formation they mentioned *Marthasterites furcatus* to be so rare (1977: 424), that it was not found in the sample, having possibly lost in the preparation process. Alternatively it might have its first occurrence above the base of the Klement type section. On the basis of the occurrence of *M. furcatus* in surrounding outcrops of the Klement Formation they concluded Coniacian age for the whole formation, apparently based on the misleading age of the ammonites given by KENNEDY & KOLLMANN (1977: 416). Text-fig. 1 of BACHMAYER & KOLLMANN (1977) illustrates that the ammonites and in consequence the nanno-sample described above are from the base of the 23 m measuring section, which was investigated in 1977 by KOLLMANN et al. Overlying Coniacian strata cannot be excluded by the reinterpretation of the basal exposed strata.

The foraminiferal assemblages from the type section of Klement are Late Turonian. Foraminifera typical for the Coniacian are absent.

In terms of inoceramid zonation (WALASZCZYK 1992) the glauconitic calcareous sandstones of the Klement Formation of the Waschberg-Ždánice Unit represent a time interval from the *M. incertus* Zone (Late Turonian) to the *C. crassus* Zone (Middle Coniacian) of the European Temperate Province.

The ammonite fauna is Late Turonian too. Stratigraphic evidence is given by the occurrence of representatives of the worldwide occurring genus *Subprionocyclus* indicative for the Late Turonian.

### 4.7. Radiomatric data

ODIN (in KOLLMANN 1977: 418; and pers. comm.) investigated the glauconite and calculated an age of 84.5 +-3.8 ma. 1982 KENNEDY & ODIN (in ODIN, ed.: 751) gave a revised data of 86.8 +-3.3 ma and a revised stratigraphical dating of "Lower part of Lower Coniacian" referring to the ammonites described in 1977. Turonian/Coniacian boundary is taken into consideration too.

Dr. Susanna SCHARBERT (Austrian Geological Survey, pers. comm.) recalculated the original data and came to the same result as KENNEDY & ODIN (1982). However, both ages are outside all modern dating of Late Turonian and even Coniacian.

## 5.0. Samples from the Pálava Formation in the Austrian Waschberg Belt

(Lenka HRADECKA and Lilian ŠVÁBENICKÁ)

Samples were taken from the following localities (text-fig.1) in the Austrian Waschberg Belt:

1/ W of Klement village

2/ Au village, just behind the Gasthaus Riepl (outcrop in Klement Formation, 4 samples)

3/ E of Michelstetten village

4/ W of Michelstetten village (2 samples)

## 5.1. Calcareous nannofossils (Lilian ŠVÁBENICKÁ)

STRÁNÍK et al. (1996) gave a lithostratigraphic definition for the Pálava Formation (Middle Coniacian - Late Campanian) in the tectonic Ždánice Unit, replacing ABEL's (1899) term "Mucronatenschichten". The predominately pelitic Pálava Formation overlies the Klement Formation. The gradual transition from the Klement Formation to the Pálava Formation was observed in the Pavlov-5 borehole (ŠVÁBENICKÁ 1992). According to nannofossils, this transition is situated within the upper part of the CC13 Zone (ŠVÁBENICKÁ in STRÁNÍK et al. 1996). This interval can be compared with the UC9b-c Zone (sensu BURNETT 1998); this is supported by the presence of nannofossil species *Zeugrhabdotus biperforatus*, *Lithastrinus septenarius* and *Marthasterites furcatus.*

### 5.1.1. Locality Au

Four samples were investigated from the outcrop behind the Gasthaus Riepl in the village of Au. Rich and well-preserved nannofossil assemblages contained the following stratigraphically significant species: *Micula staurophora, Lithastrinus grillii, L. septenarius, Arkhangelskiella ethmopora, Marthasterites furcatus* and *Zeugrhabdotus biperforatus*. In addition, sample No. 4 taken from the lowermost part of the section yielded an isolated specimen of *Rucinolithus hayi.*

Discussion: *Rucinolithus hayi* seems to be a stratigraphically important species for the lower part of the Santonian stage. DOEVEN (1983) mentioned its first occurrence in the upper part of the Early Santonian and used it as a marker species for this interval. PERCH-NIELSEN (1985) correlated its appearance within the CC15 Zone and CRUX (1982) correlated its first occurrence approximately with the appearance of *Reinhardtites anthophorus* in the Early Santonian. According to the nannofossil zonation by BURNETT (1998), *R. hayi* occurs for the first time within the upper part of the UC11c Zone.

The absence of *R. anthophorus* in the Au section not regarded as a reliable marker in the Gosau Group by WAGREICH (1992) is possibly due to the moderate to poor preservation of the coccoliths. WAGREICH (l.c.) preferred not to use any nannofossil marker in the interval between the first occurrence of *Lithastrinus grillii* and the first occurrence of *Lucianorhabdus cayeuxii*.

Conclusion: The Au section can be correlated with the upper part of the UC11c Zone, i.e. with the early part of the Early Santonian. This conclusion is supported by the coexistence of the species *Rucinolithus hayi* and *Lithastrinus septenarius.* BURNETT (1998) correlates this interval with the upper part of the macrofossil *Micraster coranguinum* Zone of the Anglo-Paris Basin.

High frequences of specimens of the genera *Lucianorhabdus, Calculites* and *Kamptnerius* provide evidence for the marine nearshore and epicontinental conditions (PERCH-NIELSEN

1985). The presence of *Lithastrinus grillii* indicates warm to temperate waters of low- to mid-latitudes (VAROL 1992).

### 5.1.2. Locality West Michelstetten, sample No. 1

The sediments provided an association of moderately to poorly preserved nannofossils with the stratigraphically important species *Reinhardtites anthophorus, Orastrum campanensis, Uniplanarius gothicus, Biscutum coronum, B. dissimilis, Zeugrhabdotus biperforatus, Arkhangelskiella specillata, Marthasterites furcatus* (common) and *Lithastrinus grillii*.

BURNETT (1998) correlates the "consistent" occurrence of *Orastrum campanensis* with the base of the Boreal and Intermediate Province UC13b$^{BP}$ Zone, i.e. with the lowermost part of the Lower Campanian and compared it with the upper part of the *Gonioteuthis granulata-quadrata* Zone (SCHÖNFELD et al. 1996) or the *Baculites* sp.(smooth) interval sensu KENNEDY et al. (1992).

### 5.1.3. Locality West Michelstetten, sample No. 2

The sample yielded qualitatively and quantitatively rich and well-preserved nannofossils. The association was represented by the following stratigraphically important species*: Broinsonia parca parca, Staurolithites mielnicensis, S.* cf. *integer, Marthasterites furcatus, Lithastrinus grillii* and *Cylindralithus biarcus*. The above-mentioned nannofossils can be correlated with the lower part of the Boreal and intermediate Province UC14$^{BP}$ Zone, e.g. with the upper part of the lower Lower Campanian (sensu BURNETT 1998). This author correlates the first occurrence of *Staurolithites mielnicensis* with the base of the *Offaster pilula* Zone (SCHÖNFELD et al. 1996). In contrast with the sample W Michelstetten No. 1, rare specimens of the genus *Lucianorhabdus* (*L. inflatus, L. arcuatus, L. cayeuxii*) were present here.

### 5.1.4. Locality East Michelstetten

Rich and well-preserved calcareous nannofossils show the common occurrence of latitude-restricted species. Nannofossils confined to cold waters (Boreal/Austral areas) quantitatively prevail, such as *Prediscosphaera stoveri, Monomarginatus quaternarius, Orastrum campanensis, Biscutum magnum, B.coronum* and *Neocrepidolithus watkinsii.* Low-latitude (Mediterranean) species are present here only scarcely: *Ceratolithoides aculeus, C. sesquipedalis* and *Uniplanarius trifidus*. The nannofossil assemblage is completed, among others, by *Broinsonia parca constricta, Arkhangelskiella cymbiformis, Prediscosphaera arkhangelskyi* (relative common)*, Eiffellithus eximius*, *E. pospichalii, Angulofenestrellithus snyderi, Dodekapodorhabdus noeliae* and *Markalius inversus.* A significant component of the association is formed by specimens of the genera *Lucianorhabdus (L. cayeuxii, L. windii* and *L. arcuatus)* and *Kamptnerius* which provide evidence for marine nearshore and epicontinental environments.

Thanks to the co-existence of low- and high-latitude species, both Boreal and Tethyan-Intermediate Province zones sensu BURNETT (1998) were applied for stratigraphic eva-

luation. Hence, the nannofossil association can be correlated with the lower part of the Boreal Province UC15d$^{BP}$ Zone and with the upper part of the Tethyan-intermediate Province UC15d $^{TP}$ Zone, within the lower Late Campanian. Co-occurrence of low- and high-latitude nannofossil species in the Ždánice Unit was observed by ŠVÁBENICKÁ (1995a,b).

### 5.1.5. Locality West Klement

PRIEWALDER (1973) recorded a rich assemblage of Upper Maastrichtian calcareous nannofossils from the Reingruberhöhe (Waschberg Unit, Lower Austria), type locality of *Pseudotextularia elegans* (RZEHAK), containing *Nephrolithus frequens* and *Lithraphidites quadratus*. The highly diversified assemblage from the W Klement locality contained both long-ranging nannofossils typical for the Late Cretaceous and species known only from the Maastrichtian, such as *Micula prinsii* (low-latitude species), *Nephrolithus frequens* (high-latitude species), *Cribrosphaerella daniae, Psyktosphaera firthii*, *Lithraphidites quadratus* and *Eiffellithus parallelus*. Besides, "survivor coccoliths", e.g. species which pass the Cretaceous/ Tertiary boundary, are also present here: *Markalius apertus, M. inversus* and *Biscutum melaniae.* The extremely rare *Biantholithus sparsus* (double-cycled form having eight elements) indicates the proximity of the Cretaceous/Tertiary boundary. No enrichment of the "blooming species", *Braarudosphaera bigelowii*, *Thoracosphaera* sp. and *Cyclagelosphaera reinhardtii* (sensu SEYVE 1990) as described at the base of the Tertiary, was observed here.

Discussion: The first occurrence of *Biantholithus sparsus* is usually regarded as a marker species for the base of the Tertiary. VAROL (1998) used its first occurrence to define the NNTp1 Zone at the base of the Danian and BURNETT (1998) included it into the "incoming taxa" within significant K/T boundary nannofossil species. Nevertheless, HECK and PRINS (1987), POSPICHAL & WISE (1990) and POSPICHAL and BRALOWER (1992) have already drawn attention to the first appearance of *B. sparsus* in the uppermost Maastrichtian.

The presence of *B. sparsus* in an assemblage which otherwise is Maastrichtian was also observed and discussed by ŠVÁBENICKÁ (in BUBÍK et al., in press) in the Magura Group of nappes of the Outer West Carpathians.

Conclusion: Nannofossils provide evidence for the UC20d$^{TP}$ Zone, which represents the uppermost part of the Maastrichtian. Common occurrence of latitude-restricted nannofossils indicate that sediments were deposited in the transitional area between Tethyan and Boreal bioprovinces.

## 5.2. Late Cretaceous foraminifera from the Pálava Formation of the Waschberg Belt (Lenka HRADECKÁ)

### 5.2.1. Locality West Klement

The sample from the pit West of Klement yielded a well-preserved planktic assemblage:

*Abathomphalus mayaroensis* BOLLI
*Globotruncanita stuarti* (LAPPARENT)
*Pseudotextularia elegans* (RZEHAK)

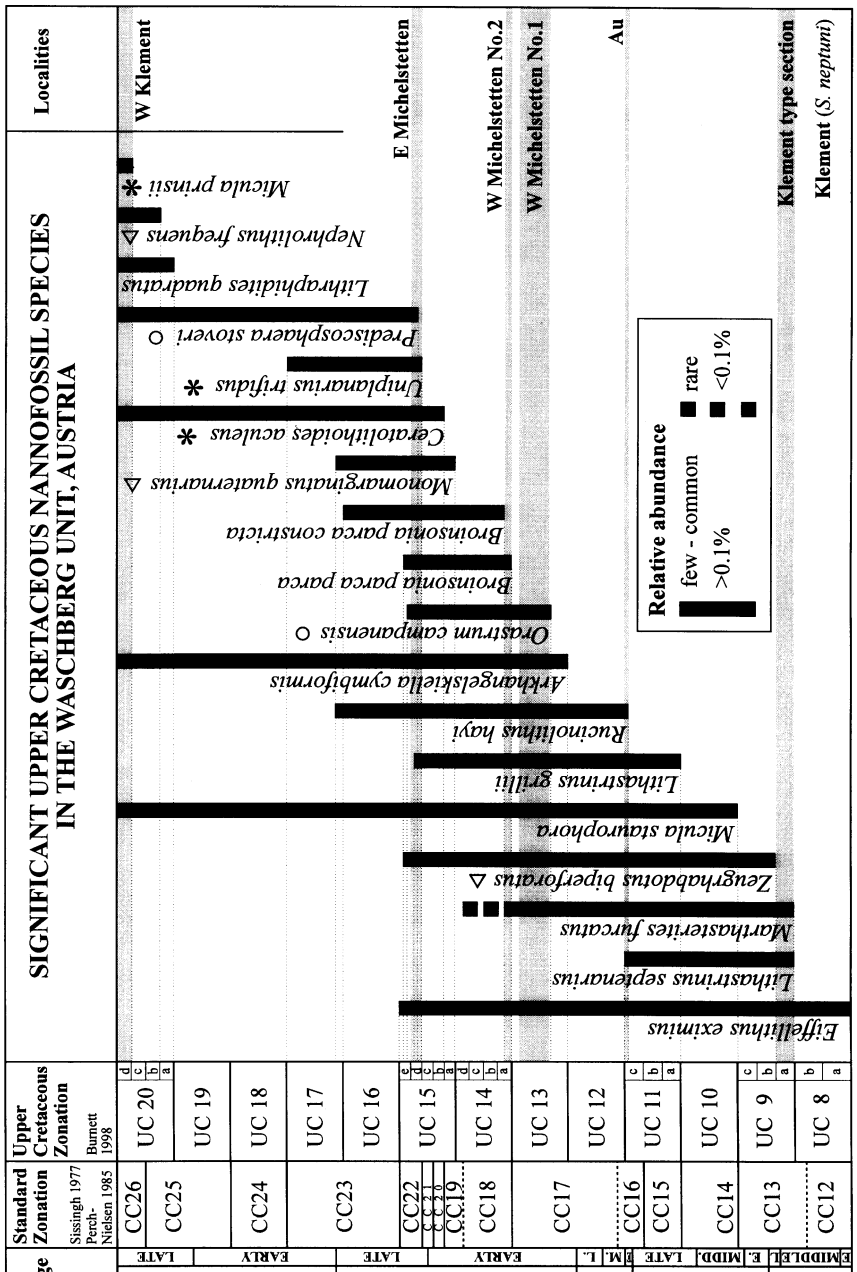



Table 2: Significant Upper Cretaceous nannofossil species in the Waschberg Unit, Lower Austria. Upper Cretaceous nannofossil biozonation introduced by BURNETT (1998) shown against the standard CC zones of SISSINGH (1977) and PERCH-NIELSEN (1985). Range and province appurtenance data were interpreted according to BURNETT (1990 and 1998) with exception of species *Marthasterites furcatus*: the first occurrence by ŠVÁBENICKÁ (1992) and the last occurrence by SISSINGH (1977).

*Ventilabrella eggeri* CUSHMAN
*V. glabrata* (CUSHMAN)

The latter species was described by WILLE-JANOSCHEK (1966) from the Late Maastrichtian of the Gosau Group (Austria). In Moravia, *Ventilabrella eggeri* CUSHMAN and *V. glabrata* (CUSHMAN) occur in the Maastrichtian of the Frydek Formation and in the Ždánice Unit (HANZLÍKOVÁ 1972). *Abathomphalus mayaroensis* BOLLI is indicative for the Late Maastrichtian *Mayaroensis* Zone.

The benthos supports a Late Maastrichtian age: *Bolivina incrassata crassa* VASILENKO-MJATLJUK occurs together with *Bolivinoides draco* (MARSSON), the latter being one of the most important markers in the boreal *Anomalinoides pinguis* Zone of Poland (GAWOR-BIEDOWA 1983).

### 5.2.2. Locality Au

Four samples taken from an exposure of one meter of sediment, contained a poorly preserved assemblage of foraminifera. The tests are often recrystallized and broken.

Plankton:
*Marginotruncana coronata* (BOLLI)
*M. pseudolinneiana* PESSAGNO
*M. marginata* (REUSS)
*M. renzi* (GANDOLFI)
*Globotruncana linneiana* (D'ORBIGNY)
*Archaeoglobigerina cretacea* (D'ORBIGNY)

Benthos:
*Gavelinella thalmani* (BROTZEN)
*G. stelligera* (MARIE)
*Neoflabellina suturalis suturalis* (CUSHMAN)
*Globorotalites michelinianus* (D'ORBIGNY)
*Stensioeina exsculpta gracilis* BROTZEN
*Praebulimina reussi* HOFKER
*Marginulina bullata* REUSS

Discussion: The assemblage is indicative of the *Dicarinella concavata* Zone. (Middle/Late Coniacian - Early Santonian; WEIDICH, 1984). Basal Santonian is proved by *Gavelinella stelligera* (MARIE) and *G. thalmanni* (BROTZEN) (EDWARDS 1981; HRADECKÁ 1989). *Stensioeina exsculpta gracilis* also occurs in the Late Coniacian of Poland (GAWOR-BIEDOWA 1983).

### 5.2.3. Locality East Michelstetten

The sample taken in the pit E of Michelstetten yielded a relatively well-preserved assemblage. The coarse fraction contained mostly large, recrystallized tests of *Lenticulina* and fragments of *Neoflabellina*. In the fine fraction benthic species prevail:

*Vaginulina trilobata* (D'ORBIGNY)
*Arenobulimina d'orbignyi* (REUSS)
*Stensioeina pommerana* BROTZEN
*Gaudryina pyramidata* (CUSHMAN)
*Gavelinella monterelensis* (MARIE)

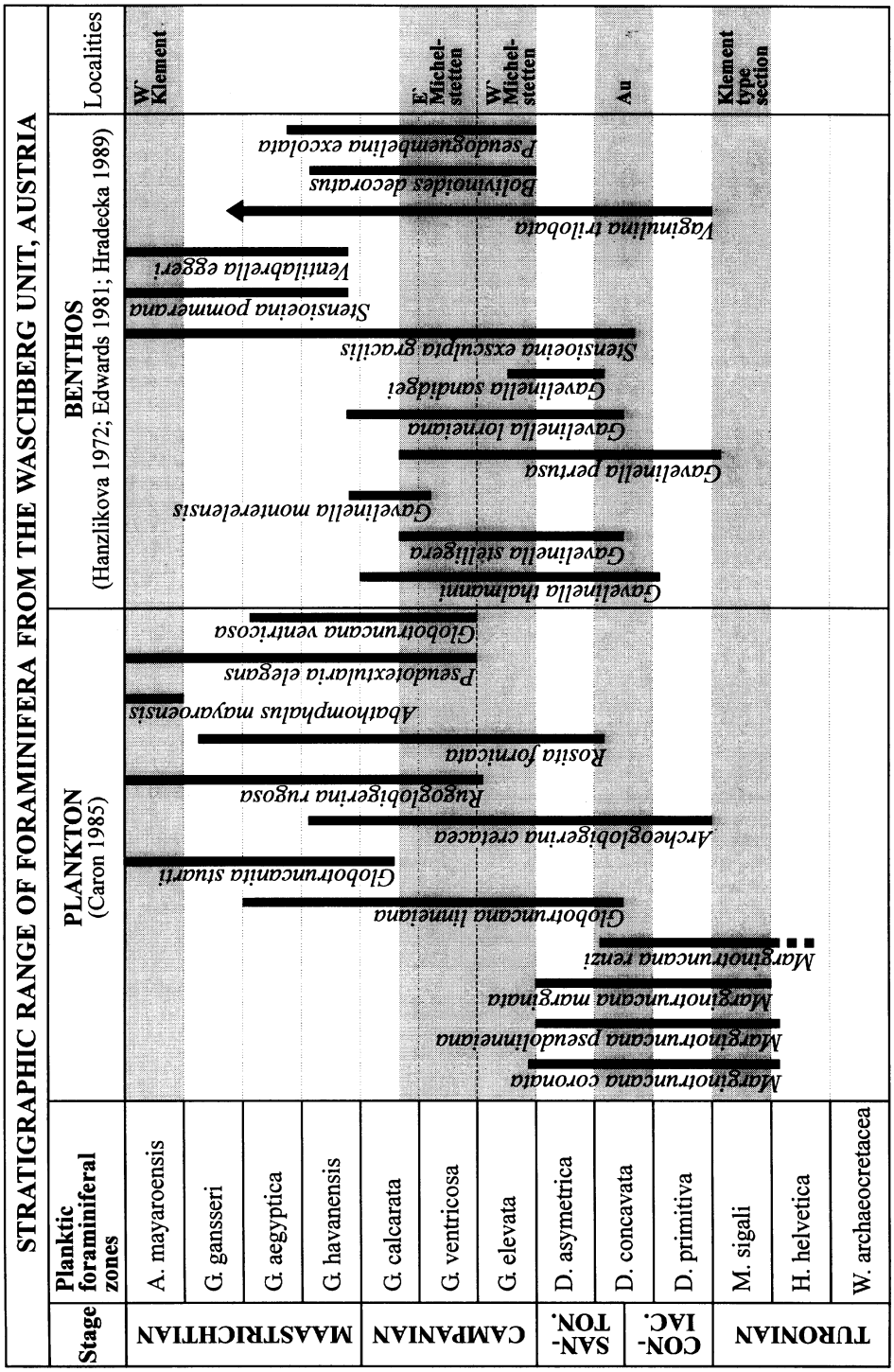



Table 3: Stratigraphic range of foraminifera from Au, W Klement, E Michelstetten, W Michelstetten in the Pávlova Fm. of the Austrian Waschberg Belt.

The stratigraphic range is from the upper part of the *Gonioteuthis quadrata* Zone to the uppermost part of the *B. mucronata* Zone (EDWARDS 1981). The planktic species are represented by

*Globotruncana linneiana* (D'ORBIGNY),
*G. ventricosa* WHITE
*Rugoglobigerina rugosa* (PLUMMER)
*Rosita fornicata* (PLUMMER)
*Globigerinoides* sp.

The age is Middle to Late Campanian (*Globotruncana ventricosa* Zone), which was determined by the occurrence of *Gavelinella monterelensis* (MARIE), *Stensioeina pommerana* BROTZEN and *Globotruncana ventricosa* WHITE (BOLLI 1985).

### 5.2.4. West Michelstetten

Two samples of claystones contained a moderately preserved assemblage with prevailing benthic species.

Benthos: *Gavelinella pertusa* (MARSSON)
*G. lorneiana* (D'ORBIGNY)
*G. schloenbachi* (REUSS)
*G. sandidgei* (BROTZEN)
*Pseudoguembelina excolata* (CUSHMAN)
*Allomorphina cretacea* REUSS
*Bolivinoides decoratus* (JONES)
*Marginulina curvatura* CUSHMAN
*Stensioeina exsculpta gracilis* BROTZEN
*Vaginulina trilobata* (D'ORBIGNY)

Plankton: *Globotruncana linneiana* (D'ORBIGNY)
*G. arca* (CUSHMAN)
*G. bulloides* VOGLER
*Rosita fornicata* (PLUMMER)
*Globotruncanita elevata* (BROTZEN)

Discussion: The genus *Gavelinella* dominates, *G. pertusa* (MARSSON) ranges from the basal *Coranguinum* Zone to the top of the Mucronata Zone (sensu EDWARDS 1981). *G. sandidgei* (BROTZEN) occurs in the Campanian - Maastrichtian of the Frydek Formation and in the Ždánice Unit in Moravia (HANZLÍKOVÁ 1972). *Bolivinoides decoratus* (JONES) occurs according to HILTERMANN (1956) in shallow water sediments of Early Campanian age.

Stratigraphic position: *Globotruncanita elevata* Zone, Early Campanian (sensu Caron 1985).

### 5.2.5. Conclusion

Relatively well-preserved assemblages of planktic foraminifera from the Austrian Waschberg Zone are described. The stratigraphic range is from lower Santonian up to uppermost Maastrichtian.

Many temperate species (e.g. *Arenobulimina, Gavelinella, Praebulimina*) indicate circulation of colder water currents (HANZLÍKOVÁ 1972) in the Campanian. The early Santonian assemblage from Au is dominated by the plankton. The keeled species of *Marginotruncana* indicate a relative deepening of the sea and normal marine salinity conditions (OLESEN 1991).

In the uppermost Maastrichtian assemblage only slight boreal influence is recorded. *Abathomphalus* is a Tethyan element since it occurs in the Boreal Province only sporadically (SOLAKIUS 1983).

**6. Acknowledgements**

Dr. Susanna SCHARBERT, Geological Survey, Vienna, for recalculating the radiometric data of ODIN, Dr. Franz STOJASPAL, Geological Survey, Vienna, for his help in the collections of the Geological Survey, Dr. HEINZ A. KOLLMANN, Museum of Natural History, Vienna, for his support in the collections of the Museum, his critical discussion of the age problem and his careful review if the paper. We are grateful to Dr. O. SCHULTZ for editorial support. Dr. C.W. WRIGHT (Beaminster) kindly provided a nannosample from Dr. GLAESSNER's unique crab collection.

Micropaleontological investigations were carried out within the project: "Late Cretaceous Stratotypes of Waschberg Zone and Helvetic Zone in Austria and comparison with the Gosau Formation". Microsamples of Dr. Manfred E. SCHMID (†), were kindly made accessible by the Austrian Geological Survey. Dr. Harald LOBITZER (Austrian Geological Survey), who supported local organisation, is also gratefully acknowledged. For assistance with drawings we are grateful to Leo LEITNER (Vienna), Jacek RUTHNER and Monika BRÜGGEMANN-LEDOLTER (both Austrian Geological Survey, Vienna). Photos of macrofossils were made by Alice SCHUMACHER, Naturhistorisches Museum Vienna.

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## 8. Appendix

List of calcareous nannofossils mentioned in this paper, in the alphabetical order of generic epithets (species concepts of PERCH-NIELSEN 1985 and BURNETT 1998 are generally applied):

*Angulofenestrellithus snyderi* BUKRY, 1969
*Arkhangelskiella cymbiformis* VEKSHINA, 1959
*Arkhangelskiella ethmopora* BUKRY, 1969
*Arkhangelskiella specillata* VEKSHINA, 1959
*Biantholithus sparsus* BRAMLETTE & MARTINI, 1964
*Biscutum constans* (GÓRKA, 1957) BLACK in MARTINI & BARNES, 1959
*Biscutum coronum* WIND & WISE in WISE & WIND, 1977
*Biscutum dissimilis* WIND & WISE in WISE & WIND, 1977
*Biscutum magnum* WIND & WISE in WISE & WIND, 1977
*Biscutum melaniae* (GÓRKA, 1957) BURNETT, 1997
*Braarudosphaera bigelowii* (GRAN & BRAARUD, 1935) DEFLANDRE, 1947
*Broinsonia enormis* (SHUMENKO, 1968) MANIVIT, 1971
*Broinsonia parca constricta* HATTNER et al., 1980
*Broinsonia parca parca* (STRADNER, 1963) BUKRY, 1969
*Broinsonia signata* (NOËL, 1969) NOËL, 1970
*Ceratolithoides aculeus* (STRADNER, 1961) PRINS & SISSINGH in SISSINGH, 1977
*Ceratolithoides sesquipedalis* BURNETT, 1998
*Chiastozygus litterarius* (GÓRKA, 1957) MANIVIT, 1971
*Cylindralithus biarcus* BUKRY, 1969
*Cretarhabdus conicus* BRAMLETTE & MARTINI, 1964
*Cribrosphaerella daniae* PERCH-NIELSEN, 1973
*Dodekapodorhabdus noeliae* PERCH-NIELSEN, 1968
*Eiffellithus eximius* (STOVER, 1966) PERCH-NIELSEN, 1968
*Eiffellithus parallelus* PERCH-NIELSEN, 1973
*Eiffellithus pospichalii* BURNETT, 1998
*Eiffellithus turriseiffelii* (DEFLANDRE in DEFLANDRE & FERT, 1954) REINHARDT, 1965
*Eprolithus floralis* (STRADNER, 1962) STOVER, 1966

*Eprolithus moratus* (STOVER, 1966) BURNETT, 1998
*Gartnerago obliquum* (STRADNER, 1963) NOËL, 1970
*Helicolithus trabeculatus* (GÓRKA, 1957) VERBEEK, 1977
*Kamptnerius magnificus* DEFLANDRE, 1959
*Lithastrinus grillii* STRADNER, 1962
*Lithastrinus septenarius* FORCHHEIMER, 1972
*Lithraphidites quadratus* BRAMLETTE & MARTINI, 1964
*Lucianorhabdus arcuatus* FORCHHEIMER, 1972
*Lucianorhabdus cayeuxii* DEFLANDRE, 1959
*Lucianorhabdus inflatus* PERCH-NIELSEN & FEINBERG in PERCH-NIELSEN, 1986
*Lucianorhabdus maleformis* REINHARDT, 1966
*Lucianorhabdus windii* HATTNER & WISE, 1980
*Markalius apertus* PERCH-NIELSEN, 1979
*Markalius inversus* (DEFLANDRE in DEFLANDRE & FERT, 1954) BRAMLETTE & MARTINI, 1964
*Marthasterites furcatus* (DEFLANDRE in DEFLANDRE & FERT, 1954) DEFLANDRE, 1959
*Microrhabdulus belgicus* HAY & TOWE, 1963
*Micula prinsii* PERCH-NIELSEN, 1979
*Micula staurophora* (GARDET, 1955) STRADNER, 1963
*Monomarginatus quaternarius* WIND & WISE in WISE & WIND, 1977
*Neocrepidolithus watkinsii* POSPICHAL & WISE, 1990
*Nephrolithus frequens* GÓRKA, 1957
*Orastrum campanensis* (CEPEK, 1970) WIND & WISE in WISE & WIND, 1977
*Prediscosphaera arkhangelskyi* (REINHARDT, 1965) PERCH-NIELSEN, 1984
*Prediscosphaera cretacea* (ARKHANGELSKY, 1912) GARTNER, 1968
*Prediscosphaera stoveri* (PERCH-NIELSEN, 1968) SHAFIK & STRADNER, 1971
*Psyktosphaera firthii* POSPICHAL & WISE, 1990
*Quadrum gartneri* PRINS & PERCH-NIELSEN in MANIVIT et al., 1977
*Quadrum intermedium* VAROL, 1992
*Reinhardtites anthophorus* (DEFLANDRE, 1959) PERCH-NIELSEN, 1968
*Reinhardtites levis* PRINS & SISSINGH in SISSINGH, 1977
*Retacapsa crenulata* (BRAMLETTE & MARTINI, 1964) GRÜN in GRÜN & ALLEMANN, 1975
*Rucinolithus hayi* STOVER, 1966
*Staurolithites integer* (BUKRY, 1969) BURNETT, 1998
*Staurolithites mielnicensis* (GÓRKA, 1957) PERCH-NIELSEN, 1968
*Tranolithus phacelosus* STOVER, 1966
*Watznaueria barnesae* (BLACK, 1959) PERCH-NIELSEN, 1968
*Watznaueria fossacincta* WIND & CEPEK, 1979
*Uniplanarius gothicus* (DEFLANDRE, 1959) HATTNER & WISE, 1980
*Uniplanarius trifidus* (STRADNER in STRADNER & PAPP, 1961) HATTNER & WISE, 1980
*Zeugrhabdotus bicrescenticus* (STOVER, 1966) BURNETT in GALE et al., 1996
*Zeugrhabdotus biperforatus* (GARTNER, 1968) BURNETT, 1998
*Zeugrhabdotus diplogrammus* (DEFLANDRE in DEFLANDRE & FERT, 1954) BURNETT in GALE et al., 1996

Plate 1

Fig. 1, 2: *Eprolithus moratus* (STOVER) BURNETT; Klement type section, NHMW 1977/1890/15 (*S.* cf. *neptuni)*, Late Turonian

Fig. 3, 4: *Eiffellithus eximius* (STOVER); PERCH-NIELSEN; Klement type section, Late Turonian

Fig. 5: *Lucianorhabdus* maleformis REINHARDT; Klement type section, sample NHMW 1977/1890/15 (*S.* cf. *neptuni)*; Late Turonian

Fig. 6, 7: *Orastrum* campanensis (CEPEK) WIND and WISE; W Michelstetten No. 1, Early Santonian

Fig. 8, 9: *Broinsonia parca constricta* HATTNER et al.; W Michelstetten No. 2; Early Campanian

Fig. 10: *Kamptnerius magnificus* DEFLANDRE; Klement type section, sample SE 255; Late Turonian

Fig. 11, 12: *Ceratolithoides aculeus* (STRADNER) PRINS and SISSINGH; E Michelstetten, upper part of Early Campanian

Fig. 13-15: *Prediscosphaera arkhangelskyi* (REINHARDT) PERCH-NIELSEN; E Michelstetten, one specimen in crossed-nicols at 0° and 45°, upper part of Early Campanian

Fig. 16, 17: *Lithraphidites quadratus* BRAMLETTE and MARTINI; W Klement, the uppermost part of Maastrichtian

Fig. 18, 19: *Markalius* apertus PERCH-NIELSEN; W Klement the uppermost part of Maastrichtian

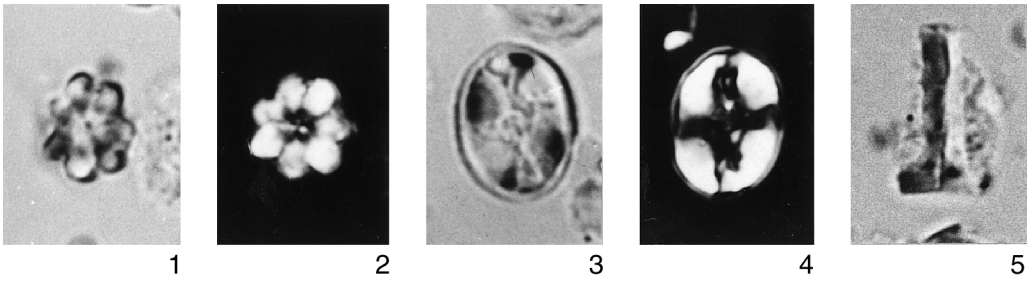
Fig. 20: *Biscutum magnum* WIND & WISE; E Michelstetten, early Campanian

Fig. 21, 22: *Micula prinsii* PERCH-NIELSEN; W Klement; the uppermost part of Maastrichtian

Fig. 23, 34: *Nephrolithus frequens* GÓRKA; W Klement, the uppermost part of Maastrichtian

Fig. 25: *Prediscosphaera grandis* PERCH-NIELSEN; W Klement, the uppermost part of Maastrichtian

All magnifications approximately x 2000, photomicrographs by Lilian ŠVÁBENICKÁ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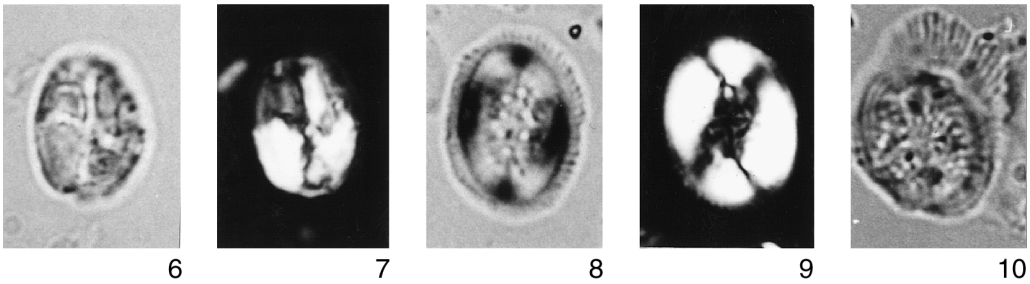
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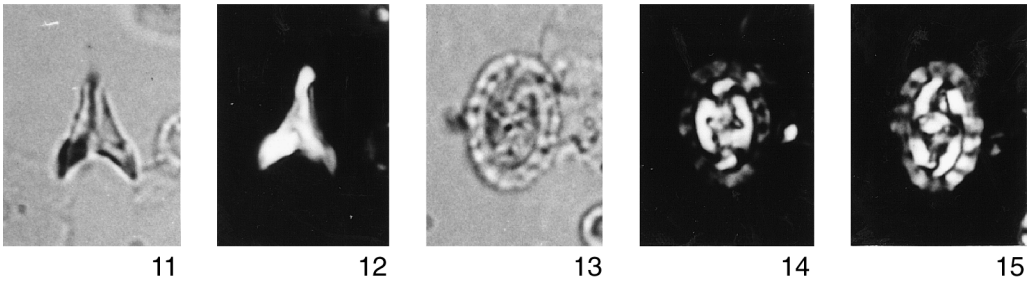
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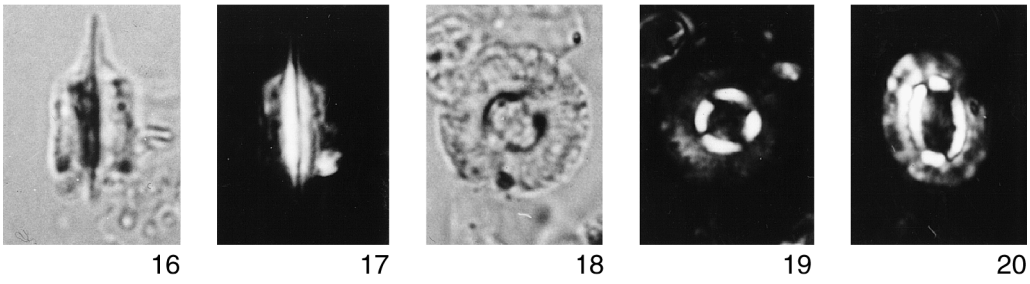
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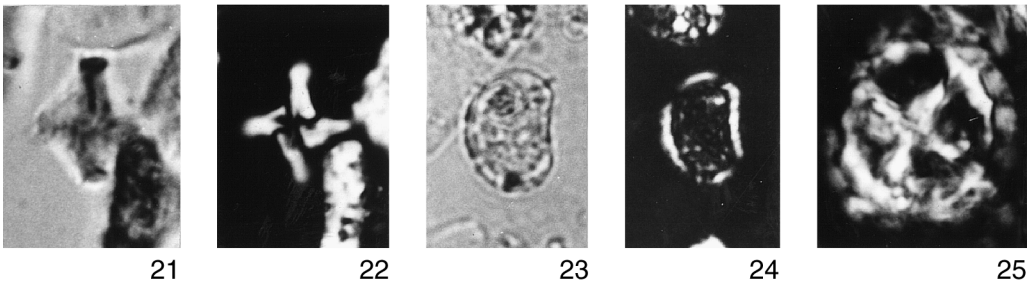
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Plate 2

Fig. 1: *Marssonella oxycona* (REUSS), Klement SE 257; Reg.No. 1999/64–1.

Fig. 2: *Gaudryina pyramidata* CUSHMAN, Klement SE 250; Reg.No. 1999/64–2.

Fig. 3: *Arenobulimina d'orbignyi* (REUSS), Klement SE 257; Reg.No. 1999/64–3.

Fig. 4: *Ataxophragmium depressum* (PERNER), Klement SE 250; Reg.No. 1999/64–4.

Fig. 5: *Tritaxia tricarinata* (REUSS), Klement SE 250; Reg.No. 1999/64–5.

Fig. 6: *Frondicularia* sp., Klement SE 250; x 60; Reg.No. 1999/64–6.

Fig. 7: *Tappanina eouvigeriniformis* (KELLER), Klement SE 250; Reg.No. 1999/64–7.

Fig. 8: *Globorotalites michelinianus* (D'ORBIGNY), Klement SE 250; Reg.No. 1999/64–8.

Fig. 9: *Arenobulimina* sp., Klement SE 255; Reg.No. 1999/64–9.

Fig. 10: *Lingulogavelinella globosa* (BROTZEN), Klement SE 260; Reg.No. 1999/64–10.

Fig. 11: *Gavelinella schloenbachi* (REUSS), Klement SE 257; Reg.No. 1999/64–11.

All magnifications but fig. 6 are x 150; fig 6 is x 60. All specimens figured are stored at the Austrian Geological Survey, Vienna.

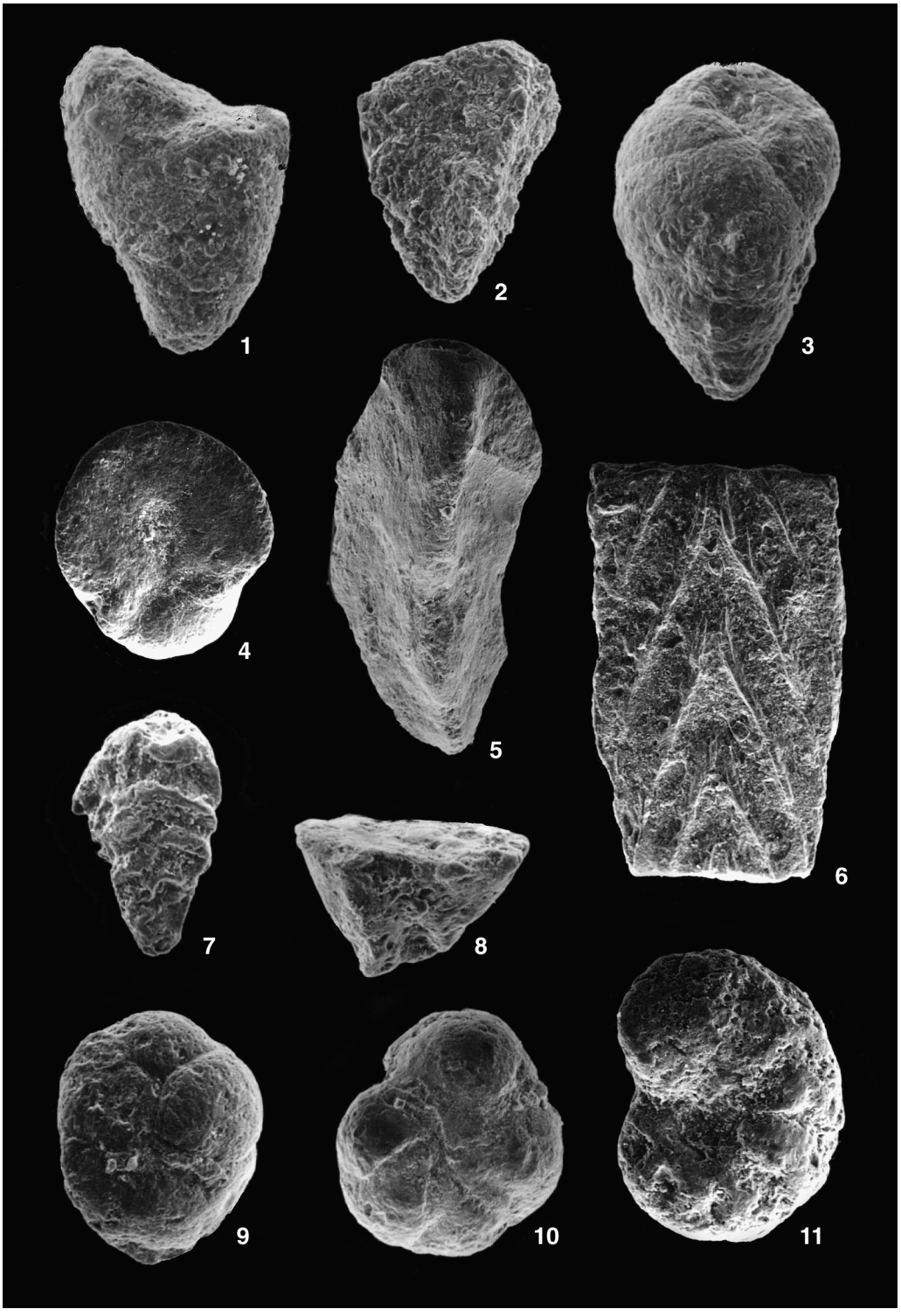
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Plate 3

Fig. 1: *Hedbergella delrioensis* (CARSEY), Klement SE 250, x 100; Reg.No. 1999/64–12.

Fig. 2: *Dicarinella imbricata* (MORNOD), Klement SE 255, x 100; Reg.No. 1999/64–13.

Fig. 3: *Hedbergella simplex* (MORROW), Klement SE 255, x 100; Reg.No. 1999/64–14.

Fig. 4: *Dicarinella* sp., Klement SE 250, x 100; Reg.No. 1999/64–15.

Fig. 5: *Marginotruncata angusticarinata* (GANDOLFI), Klement SE 250, x 80; Reg.No. 1999/64–16.

Fig. 6: *Marginotruncata pseudolinneiana* PESSAGNO, Klement SE 255, x 80; Reg.No. 1999/64–17.

Fig. 7: *Heterohelix* sp., Klement SE 250, x 150; Reg.No. 1999/64–18.

Fig. 8: *Globigerinelloides aspera* (EHRENBERG), Klement SE 255, x 200; Reg.No. 1999/64–19.

Fig. 9: *Marginotruncata coronata* (BOLLI), Klement SE 255, x 80; Reg.No. 1999/64–20.

Fig. 10: *Heterohelix globulosa* (EHRENBERG), Klement SE 257, x 150; Reg.No. 1999/64–21.

Fig. 11: *Marginotruncata marginata* (REUSS), Klement SE 250, x 80; Reg.No. 1999/64–22.

Fig. 12: *Heterohelix reussi* (CUSHMAN), Klement SE 250, x 150; Reg.No. 1999/64–23.

All specimens figured are stored at the Austrian Geological Survey, Vienna.

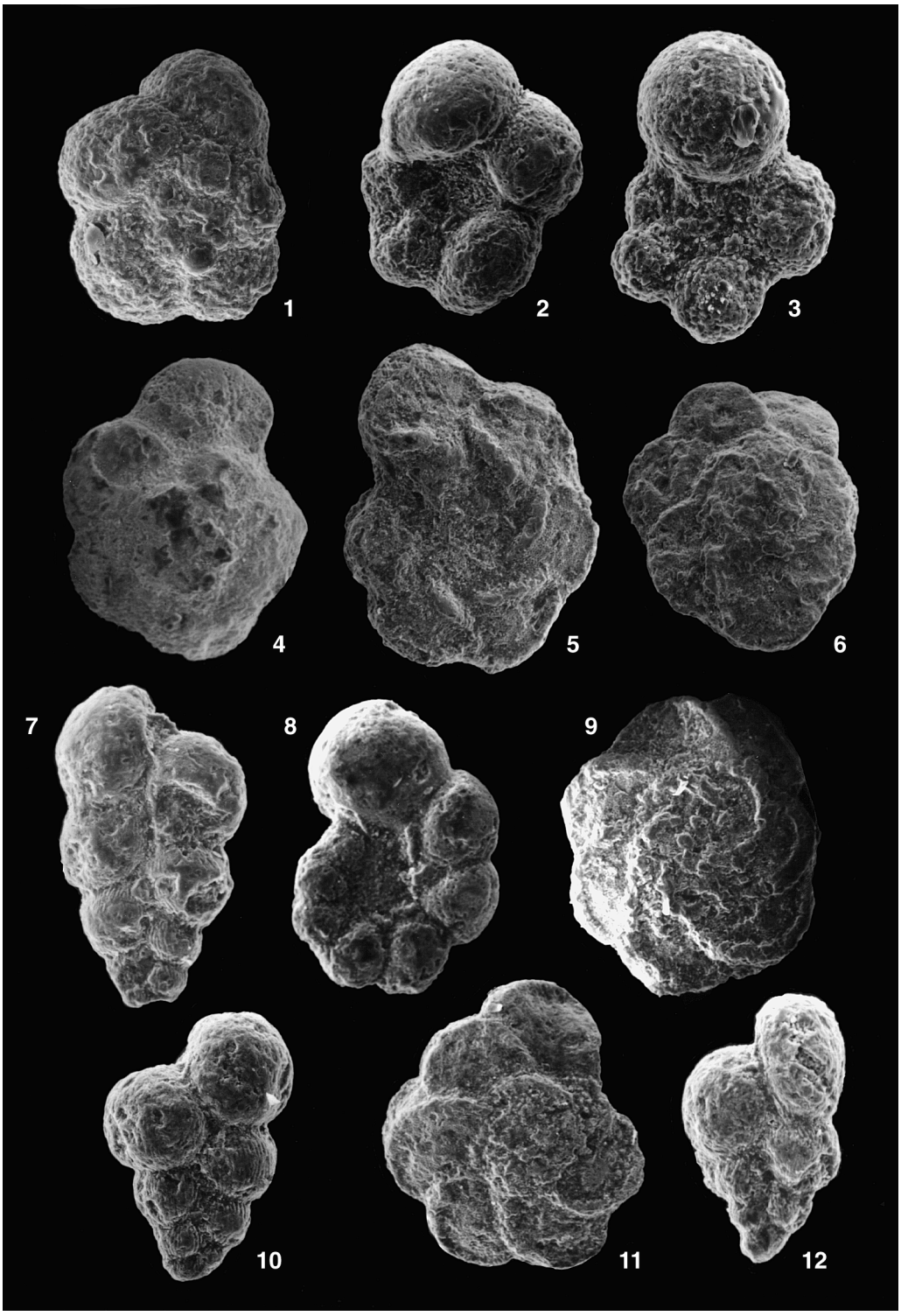
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Plate 4

Fig. 1: *Inoceramus* sp., *cuvieri* -group, large form; fragment of the prismatic shell layer with typical ornament; NHMW 1998z0058/0008

Fig. 2: *Inoceramus* sp., *cuvieri* -group; internal mold; NHMW 1998z0058/0007

All figures x 1; all are Upper Turonian, Klement Formation; Klement, Austria.

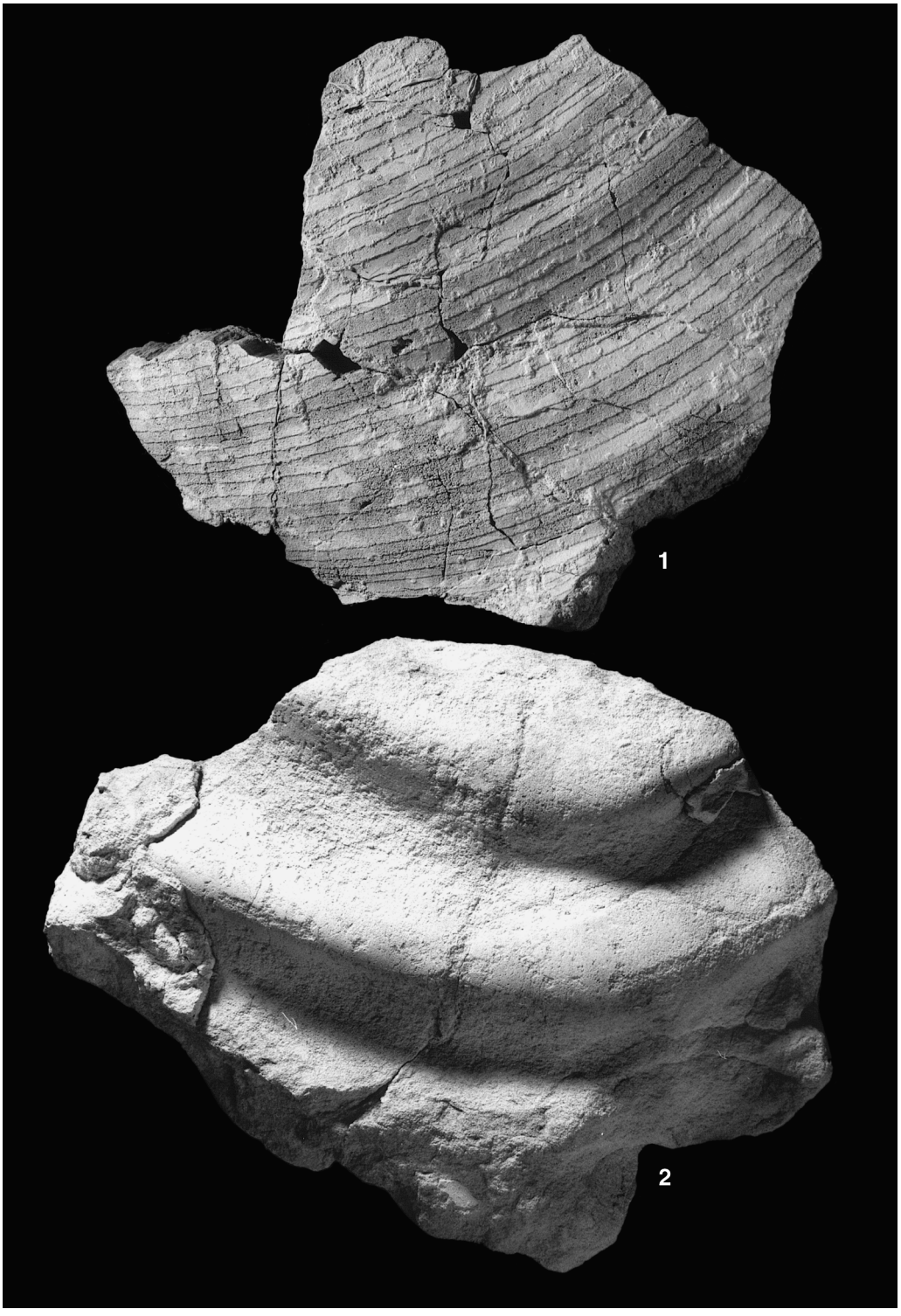
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Plate 5

Figs. 1, 2: *Inoceramus hercules* (HEINZ); 1. dorsal view of multiple resilifers on ligamental plate; 2. hinge plate, ventral view. NHMW 1998z0058/0010

Figs. 3, 4: *Inoceramus* cf. *germanobohemicus* HEINZ, Upper Turonian - Lower Coniacian, Klement Formation, Falkenstein, Austria. Klement, Austria. 3. Anterior view of right valve. 4. Lateral view of right valve. NHMW 1998z0058/0009

Fig. 5: *Cremnoceramus waltersdorfensis* (ANDERT); lateral view of left valve, Lower Coniacian, Klement Formation, Turold quarry near Mikulov, Czech Republic. CGÚ YA 2324.

Fig. 6: *Mytiloides carpathicus* (SIMIONESCU), lateral view of right valve; Upper Turonian, Klement Formation, Dìvín, locality no. 399; Czech Republic. CGÚ YA 2325.

All figures x 1

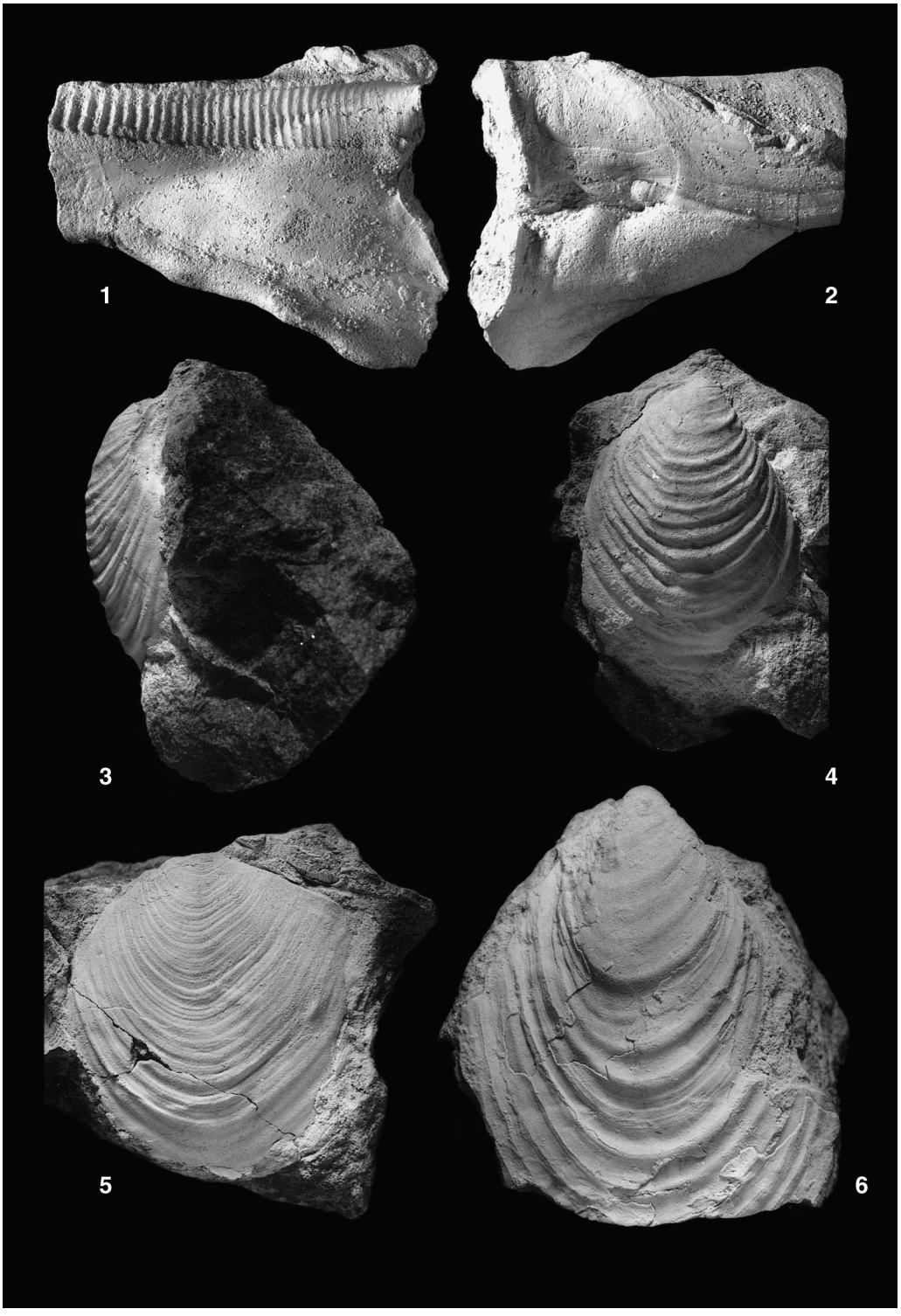
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Plate 6

Fig. 1: Phylloceratinae, gen. et sp. indet.; NHMW 1998z0058/0001; x 2

Fig. 2: Tetragonitinae gen. et sp. indet.; NHMW 1998z0058/0002; x 2

Fig. 3: Desmoceratinae, gen. et sp. indet.; NHMW 1998z0058/0003; x 2

Fig. 4: Pachydiscidae, gen. et sp. indet., juv.; NHMW 1977/1890/11; x 2

Fig. 5: Pachydiscidae, gen. et sp. indet., juv.; NHMW 1977/1890/10; x 2

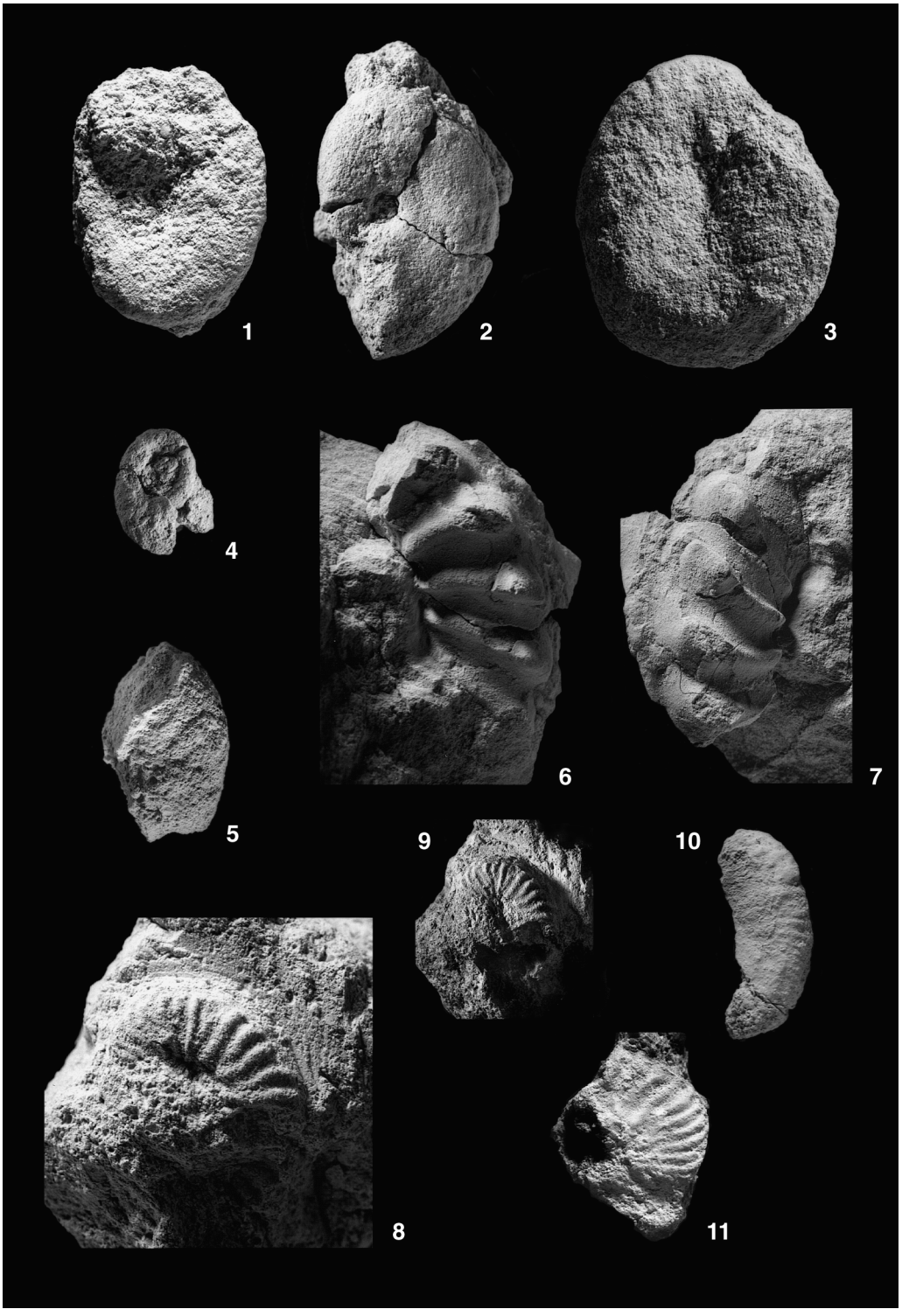
Fig. 6, 7: Collignoniceratinae gen. et sp. indet., NHMW 1998z0058/0004; x 1

Fig. 8, 9: *Subprionocyclus* cf. *neptuni* (GEINITZ); NHMW 1977/1890/15; 8 is x 2, 9 is x 1.

Fig. 10: Ammonoidea indet., NHMW 1977/1890/18; x 2

Fig. 11: *Subprionocyclus hitchinensis* BILLINGHURST; NHMW 1998z0058/0005; x 2

All figured specimens are from the Upper Turonian Klement Formation of Klement, Lower Austria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