Albian and Cenomanian microbiostratigraphy of the Manín Belt on the basis of foraminifera and nannofossils in the Belušské Slatiny – Slopná area

Mikro-Biostratigraphie des Alb und Cenoman der Manín-Zone im Gebiet Belušské Slatiny – Slopna auf der Grundlage von Foraminiferen und Nannofossilien

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Mit 4 Abbildungen und 4 Tafeln

Summary: In the Manín area, located between the Klippen and Central Belts of the Central Carpathians three sedimentation zones are distinguished: the Klape zone, the Manín zone and the Kostelec zone. The conditions of sedimentation during the middle Cretaceous are different in the individual zones. Beginning with the Lower-Middle Albian boundary five tectonic phases can be distinguished in the Manín area.

The litho- and biostratigraphic subdivision of the Middle Cretaceous of the Kostelec and the Manín zones is discussed in detail.

Zusammenfassung: Im Manín-Gebiet, das zwischen dem Klippen- und Zentralbereich der Karpathen liegt, werden drei Sedimentations-Zonen unterschieden: die Klape-Zone, die Manín-Zone und die Kostelec-Zone. In den Sedimentations-Zonen sind die Ablagerungsbedingungen während der Mittelkreide verschieden. Beginnend mit Grenze Unter-Mittelalb können fünf tektonische Phasen in der Manín-Zone unterschieden werden.

Die litho- und biostratigraphische Untergliederung der Kostelec- und Manín-Zonen werden im Detail besprochen.

1. Introduction

The profiles studied are situated in the Manín zone extending between Belušské Slatiny, Sverepec, Slopná, Dolný – Horný, Lieskov, and Trstie (Fig. 1). This area was mapped first by ANDRUSOV (1951) and later by SALAJ (BEGAN et al., 1963). The last

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author distinguished two sequences in the Middle Cretaceous on the basis of lithofacial differences and rich paleontological documentation (SALAJ in MAHEL et al., 1962; SALAJ, 1963, 1976). The geological sections are presented in Fig. 2. The first sequence is near Belušské Slatiny (Fig. 2, profile III), the second near Trstie – Slopná and Sverepec (Fig. 2, profiles I, II); in both sequences the foraminifera and nannoplankton have been studied and a detailed stratigraphy worked out.

2. Paleogeographical-tectonical development of the area studied in the Middle Cretaceous

In the Manín area (section Ilava – Považská Bystrica), located between the Klippen and Central Belts of the Central Carpathians to which SALAJ and SAMUEL (1966) called attention, three partial sedimentation zones are distinguished.

Their sequence from NW to SE is as follows:

1) Klape sedimentation zone (continuous to the Kysuce sedimentation zone of the Klippen Belt in the north);

2) Manín sedimentation zone;

3) Kostelec sedimentation zone (continuous to the Strážov sedimentation area in the south) (SALAJ, 1982).

A distinct differentiation of sedimentation conditions in the individual zones is evident in the Middle Cretaceous. In the Barremian – Lower Albian of the Manín zone distinct shallowing and sedimentation of the Urgonian limestone facies occurred. In the Kostelec basin, prevailingly marls with layers of dark or light-coloured limestones were deposited; locally layers of limestones of Urgonian facies are developed. In the Klape basin in the Barremian – Aptian grey marls, marly limestone (in the zone adjacent to the Klippen Belt), dark marls, and dark organodetrital limestones of Urgonian type as well as Upper Aptian – Middle Albian flysch sediments were deposited (in the zone adjacent to the Manín sedimentation area).

Beginning with the Lower – Middle Albian boundary in the Manín sedimentation area distinct synsedimentary tectonic activities took place (Manín phase of folding; ANDRUSOV, 1959), during which five rapidly following tectonic phases are evident (SALAJ, 1982):

First phase: formation of a hardground at the surface of the Urgonian limestones (cf. also ANDRUSOV, 1959; ANDRUSOVÁ & ANDRUSOV, 1971; RAKUŠ, 1977).

Second phase: formation of a horst system, accompanied by submarine volcanic activity (SALAJ, 1962 b; SAMUEL & SALAJ, 1962). The lava ascended along predisposed deep faults (MARSCHALKO & KYSELA, 1980) in the Kostelec, Manín and Klape sedimentation zones. In that time the Klape (or Ultrapieninic) ridge had already emerged (MAHEL, 1981; BEGAN & SALAJ, 1978), supplying pebble material into Upper Albian conglomerates of the Klape group.

Third phase: glauconitic limestones; in the Manín sedimentation zone breccias (ANDRUSOV & KOLLÁROVÁ-ANDRUSOVOVÁ, 1971; RAKÚS, 1977), conglomerates (SALAJ, 1962 b; BEGAN et al., 1963) and pelagic marls were deposited locally.

Fourth phase: emersion of the central part of the system in the Manín sedimentation zone coinciding with emersion of the Klape ridge, its subsequent destruction, locally erosion of glauconitic limestones and formation of breccias (Urgonian and Lower Albian glauconite limestones).

Fifth phase: termination of tectonic activity; deepening and development of a homogeneous Upper Albian – Lower Cenomanian marly sedimentation in the Manín sedimentation zone and of flysch sedimentation in the Klape and Kostelec sedimentation zone.

In the Manín and Kostelec zones homogeneous sedimentation took place beginning at the Middle Cenomanian. Stratigraphic division of the individual lithofacial complexes of the Kostelec and Manín groups is as follows:

3. Stratigraphy

3.1. Kostelec group

Aptian – Albian boundary

The microfauna of the Upper Gargasian and Clansayesian consists of a rich assemblage of foraminifera of the *Epistomina (Brotzenia) charlottae* zone (SALAJ & SAMUEL, 1966), in which besides *Epistomina (Brotzenia) charlottae* VIEAUX one finds *Discorbis wassoewizi* DJAFAROV & AGALAROVA, *Hedbergella globigerinelloides* SUBBOTINA, *Hedbergella trocoidea* (GANDOLFI), *Gaudryina dividens* GRABERT, *Anomalina (A.) agalarovae* VASILENKO, and *Epistomina (Brotzenia) spinulifera polypioides* (EICHBERG). Among the agglutinated foraminifera one finds *Rhizammina indivisa* BRADY, *Ammodiscus tenuissimus* GUEMBEL, *Glomospira gordialis* (JONES & PARKER) and *Dendrophrya robusta* GRZYBOWSKI. Agglutinated foraminifera are also represented in the Lower Albian. In this case the appearance of both the species *Haplophragmoides nonioninoides* (REUSS) and the planktonic species *Ticinella roberti* (GANDOLFI) are important for establishing the lower boundary of the Albian. In the Lower Albian foraminifera association (*Ticinella roberti* zone) (samples no. 30, 29) the following species may additionally be found: *Ammodiscus cretaceous* (REUSS), *Kalamopsis grzybowskii* DYLAŻANKA, *Glomospira irregularis* (GRZYBOWSKI), *Spiroplectinata complanata* (REUSS), *Spiroplectinata davidi* MOULLADE, *Spiroplectinata annectens* (PARKER & JONES), *Lenticulina (Lenticulina) gaultina* (BERTHELIN), and *Gyroidina infracretacea* MOROZOVA.

The establishment of the Aptian – Albian boundary on the basis of nannoplankton has not yet been possible because the distribution of species in the Upper Aptian foraminifera *Epistomina (Brotzenia) charlottae* foraminifera zone is equal to that of the

Lower Albian *Ticinella roberti* zone. The zone in question is the *Parhabdolithus angustus* zone, which extends into the Lower Albian.

The assemblage of calcareous nannoplankton is rich (Fig. 3).

Albian

The nannoplankton of the *Praediscosphaera cretacea* zone begins to appear in the upper part of the Lower Albian *Ticinella roberti* zone; its species composition is indicated in Fig. 3.

The Middle Albian, represented by flysch facies, predominantly contains the following agglutinated foraminifera: *Haplophragmoides walteri* GRZYBOWSKI, *Dendrophrya robusta* GRZYBOWSKI, and *Dendrophrya latissima* GRZYBOWSKI. The planktonic foraminifera corresponding to the *Thalmanninella ticinensis subticinensis* zone are very rare here. The nannoplankton is relatively rich (Fig. 3) and is still representing the *Praediscosphaera cretacea* zone. The uppermost part of the Middle Upper Albian which is also in a flysch facies, primarily contains agglutinated foraminifera with a composition similar to that in the Middle Albian. Among planktonic foraminifera representatives of the species *Thalmanninella ticinensis ticinensis* GANDOLFI were sporadically found. The lower boundary of the *Thalmanninella ticinensis ticinensis* zone is approximately identical with the lower boundary of the nannoplankton *Podorhabdus albianus* zone (Fig. 3).

The uppermost Albian, which corresponds to the *Whiteinella gandolfii* zone (= *Rotundina stephani* zone of SALAJ & SAMUEL, 1966) in association with *Planomalina (Planomalina) buxtorfi* (GANDOLFI) and *Thalmanninella balernaensis* GANDOLFI, is also uncommonly rich in agglutinated foraminifera.

The lower boundary of this re-named zone is determined by the first appearance of the species *Whiteinella gandolfi* n. sp. (syn. *Rotundina stephani* [GANDOLFI] sensu SALAJ & SAMUEL, 1963) and *Thalmanninella ticinensis conica* n. ssp. (syn. *Thalmanninella ticinensis stephani* [GANDOLFI] sensu MASSIN & SALAJ, 1970). For a description of the new species see below. The upper boundary is determined by the appearance of the species *Thalmanninella brotzeni* SIGAL.

In this part of the Albian, the nannoplankton species *Eiffelithus turriseiffeli* (DEFLANDRE & FERT) REINHARDT appears for the first time. This index species has given the zone its name and also characterizes the Lower Cenomanian flysch.

Cenomanian

From the standpoint of microfauna the Lower Cenomanian is defined in the sense of BEGAN, HAŠKO, SALAJ & SAMUEL (1978) by the *Thalmanninella brotzeni, Thalmanninella appenninica, Thalmanninella deeckei* zones and the lowermost part of the *Thalmanninella evoluta* zone. In these zones there is also a considerable representation of benthic foraminifera. The foraminifera associations of individual Lower Cenomanian zones are indicated in Fig. 3.

Remark: The species *Thalmanninella appenninica* (RENZ) is understood by the authors in the sense of the type species, designated by MARIE (1948; *Globotruncana appenninica* n. sp. in RENZ, 1936; p. 14, Fig. 2, section left). Corresponding to this conception are also the figures of

Robaszynski & Caron (1979; p. 63, pl. 5, Fig. 1a, b, c). These are individuals of considerable dimensions (diameter 0.65 – 0.70 mm) with large umbilicus, large supplementary extraumbilical and mainly sutural apertures. On the other hand we consider *Thalmanninella appenninica* RENZ in the conception of REICHEL (1949; designated as a holotype in RENZ, 1936; p. 14, Fig. 1, section right top) as *Thalmanninella gandolfii* (LUTERBACHER & PREMOLI SILVA, 1962) (cf. ROBASZYNSKI & CARON, 1979; p. 83, pl. 11, Figs. 1a–c, 2a–c). The individuals belonging to this species are completely identical in both their dimensions (0.62 – 0.718 mm) and morphology with RENZ's (1936) figure on p. 14, Fig. 2, section right top and illustration of individuals in Fig. 1 (Prof. I. Gubbio, Schicht 6). If we, however, accept the conception of the species *Thalmanninella appenninica* (RENZ) in the sense of SIGAL (1969, p. 633), who also designates as type species the specimen chosen by REICHEL (1949), we should consider the species *Thalmanninella gandolfii* (LUTERBACHER & PREMOLI SILVA, 1962) to be a synonym of *Thalmanninella appenninica* (RENZ) sensu REICHEL (1949) et SIGAL (1969) and choose a new name for *Thalmanninella appenninica* (RENZ) sensu MARIE (1948). This, however, would be against the rules of nomenclature.

Thalmanninella appenninica (RENZ, 1936) sensu MARIE (1948) as well as *Thalmanninella gandolfii* (LUTERBACHER & PREMOLI SILVA, 1962) are found neither in the Upper Albian nor in the lowermost Cenomanian in the West Carpathians.

We consider the individuals occurring in the uppermost Albian of the West Carpathians and still corresponding to *Thalmanninella appenninica* (RENZ) in the sense if the classification of ROBASZYNSKI & CARON (1979; p. 61, pl. 4, Figs. 2a, c, 3a–e) as *Thalmanninella balernaensis* GANDOLFI 1957. *Thalmanninella balernaensis* GANDOLFI is distinctly different from *Thalmanninella appenninica* (RENZ) sensu MARIE in its dimensions (0.47 – 0.56 mm), its smaller umbilicus and essentially its umbilical supplementary apertures, as well as its stratigraphical range. For these reasons, in agreement with SIGAL (1969), we cannot consider *Thalmanninella balernaensis* GANDOLFI as a synonym of *Thalmanninella appenninica* (RENZ) sensu MARIE (1948).

We consider other specimens found in the uppermost Albian of the West Carpathians, which in the sense of ROBASZYNSKI & CARON (1977; p. 62, Figs. 2a–c, 3a–c) should correspond to the species *Thalmanninella appenninica* (RENZ), to be *Thalmanninella ticinensis* (GANDOLFI). They have smaller dimensions (diameter 0.36 – 0.41 mm), a smaller umbilicus, and small supplementary extraumbilical to sutural apertures.

The last variety found in the West Carpathians in the lowermost Cenomanian is identical to *Thalmanninella appenninica* (RENZ), figured by ROBASZYNSKI & CARON (1977; p. 61, pl. 4, Fig. 1a–c). This variety, however, differs from *Thalmanninella balernaensis* GANDOLFI. We are inclined to believe that it is a new species.

The Middle Cenomanian, also in flysch facies, is characterized by microfaunas from the *Thalmanninella evoluta* (beginning in the Lower Cenomanian) and *Rotalipora bicarinata* zones. The rich nannoplankton already corresponds to the *Gartnerago obliguum* zone (Fig. 3). This nannoplankton zone is characteristic not only of the Upper Cenomanian, characterized by fine-rhythmical flysch of the Praznov beds, but also of the Turonian flysch with the *Dicarinella imbricata* zone and the lowermost part of the *Helvetoglobotruncana helvetica* zone (SALAJ & GAŠPARIKOVÁ, 1983).

In the uppermost Middle and Upper Cenomanian, a rich planktonic microfauna (SALAJ & SAMUEL, 1966) of the *Rotalipora cushmani* zone or *Rotalipora montsalvensis* and *Rotalipora turonica* subzones characterizes the development of the Praznov beds. We also note several horizons in the Upper Cenomanian with a prevalence of benthic, mainly agglutinated foraminifera; these attain greatest species diversity and numbers in the uppermost part of the *Rotalipora turonica* subzone. The ratio of benthic to planktonic foraminifera is 95 : 5. The associations of foraminifera is as follows:

Ammodiscus cretaceous (REUSS)
Ammodiscus tenuissimus GUEMBEL
Glomospira gordialis (JONES & PARKER)
Glomospira charoides (JONES & PARKER)
Glomospira irregularis GRZYBOWSKI
Hyperammina subnodosa BRADY
Rhabdammina discreta BRADY
Kalamopsis grzybowskii DYLAŹANKA
Rhizammina indivisa BRADY
Reophax splendidus GRZYBOWSKI
Ammobaculites alexanderi CUSHMAN
Dendrophrya excelsa GRZYBOWSKI
Dendrophrya robusta GRZYBOWSKI
Dendrophrya latissima GRZYBOWSKI
Trochammina umiatensis TAPPAN
Trochammina globigeriniformis (JONES & PARKER)
Thalmannammina subturbinata (GRZYBOWSKI)
Haplophragmoides kirki WICKENDEN
Haplophragmoides walteri GRZYBOWSKI
Plectorecurvoides irregularis GEROCH
Trochamminoides confortus (GRZYBOWSKI)
Hormosina ovulum ovulum (GRZYBOWSKI)
Dorothia crassa (MARSSON)
Dorothia oxycona (REUSS)
Dorothia pupa (REUSS)
Dorothia gradata (BERTHELIN)
Spiroplectammina semicomplanata (CARSEY)
Spiroplectammina navarroana CUSHMAN
Gaudryina serrata FRANKE
Clavulinoides gaultinus (MOROZOVA)
Arenobulimina aff. *frankei* (BROTZEN)
Anomalina (Gavelinella) baltica BROTZEN
Stensioeina praeexsculpta (KELLER)
Hedbergella brittonensis LOEBLICH & TAPPAN
Hedbergella portsdownensis (WILLIAMS & MITCHEL)
Thalmanninella greenhornensis (MORROW)
Thalmanninella reicheli (MORNOD)
Rotalipora cushmani (MORROW)
Rotalipora turonica BROTZEN
Praeglobotruncana marginaculata LOEBLICH & TAPPAN
Praeglobotruncana gibba KLAUS

If we compare this association of benthic foraminifera, which already appears in the Lower Albian, it is obvious that a similar microfauna is known from Rumania (NEAGU, 1962; ION, 1975). ION (1975) mentioned this microfauna from the Albian – Cenomanian zone of agglutinated foraminifera, which is defined from Rumania as the *Plectorecurvoides alternans, Haplophragmoides gigas minor, Recurvoides imperfectus* and *Glomospira irregularis* range zone (GR. ALEXANDRESCU & J. SANDULESCU, 1973).

It is necessary to note that throughout the Lower to Middle Cenomanian considerable facial changes were taking place in the Kostelec sedimentation area as a consequence of the emerged Kostelec ridge (SALAJ, 1982). In the strip between Moštenec and Praznov the flysch acquires the character of conglomeratic limestones to conglomerates; material from this cordiller was supplied into this strip. Therefore near Praznov these conglomerates also acquire a marginal character and their stratigraphic range is greater. It cannot be excluded that they even reach up into the Turonian. To the SW near Zemiansky Krašov the calcareous conglomerates are a fine-grained part of the flysch in which layers of variegated marls of Lower Middle Turonian age also occur. These were obviously deposited under conditions of raised basement after termination of the Kostelec cordiller at a time when gradual deepening took place in this zone.

Towards the SW in the strip south of Butkov and Kalište calcareous fine-grained conglomerates with *Exogyra columba silicea* (LAMARCK) occur in the Middle Cenomanian flysch. In the upper part the microfauna of the *Rotalipora montsalvensis* subzone is found in marls. The microfauna of the *Rotalipora turonica* subzone can be found in marls with layers of sandstone and fine-grained conglomerate limestones (about 250 m SE of elev. p. Kraličková and 600 m SW of elev. p. Kalište, in the cut of the forest road).

Cenomanian – Turonian boundary

According to present knowledge (SALAJ & SAMUEL, 1966) the *Rotalipora cushmani* zone extends up into the lowermost Turonian, while the higher Lower Turonian corresponds to the *Dicarinella imbricata* zone in the West Carpathians. SALAJ & GAŠPARIKOVÁ (1983) dealt more closely with this problem and we therefore refer to their work.

3.2. Manín group

Aptian – Albian boundary

The Aptian – Albian boundary in the Manín group lies within the facies of Urgonian limestones (SALAJ & SAMUEL, 1966). In the area of Záskalie, Manín, and Butkov, their uppermost part reaches the Lower Albian (SALAJ & SAMUEL, 1966; BORZA, KÖHLER & SAMUEL, 1979; BORZA, 1982). From the microfacial standpoint, BORZA (1982) distinguished several facies in the Urgonian.

In the Manín area we have a microfauna of the *Ticinella roberti* zone from dark marly cherty limestones. Here a rich nannoplankton of the *Parhabdolithus angustus* zone also exists. This zone is mainly characteristic of the Upper Aptian and also reaches the lowermost Albian. It is characterized by the following species:

Cretarhabdus biseriatus FORCHHEIMER
Cretarhabdus sp.
Cyclagelosphaera margereli NOËL
Chiastozygus ex gr. *litterarius* (GORKA) MANIVIT
Ellipsagelosphaera coronata (GARTNER) BLACK
Ellipsagelosphaera cf. *ovata* (BUKRY) BLACK
Parhabdolithus angustus (STRADNER) STRADNER
Stephanolithion sp.
Watznaueria barnesae (BLACK) PERCH-NIELSEN
Zygolithus diplogrammus DEFLANDRE
Zygolithus erectus DEFLANDRE
Nannoconus sp.

In the area of Butkov quarry the uppermost layers of the micritic limestones are light-coloured organodetrital limestones (about 3 m) overlying dark marly cherty limestones. In organodetrital limestones we found the species *Paracoskinolina sunnilandensis* (MAYNC) (Fig. 4). As a consequence of the Manín phase of folding, a brief break of sedimentation and a transgression of glauconite limestones containing a macrofauna of the *Protohoplites puzosianus* zone (ANDRUSOV & KOLLÁROVÁ-ANDRUSOVOVÁ, 1971; RAKUS, 1977) occurs in the area of the Skalica klippes.

Middle Albian – Cenomanian

The overlying Cement Marl Formation (ANDRUSOV, 1959) of the Middle Albian to Lower Cenomanian contains a predominantly planktonic microfauna of the *Thalmanninella ticinensis subticinensis, Thalmanninella ticinensis ticinensis, Whiteinella gandolfii, Thalmanninella brotzeni, Thalmanninella appenninica,* and *Thalmanninella deeckei* zones (Fig. 4). A rich nannoplankton also exists. Present are the *Praediscosphaera cretacea, Podorhabdus albianus,* and *Eiffelithus turriseiffeli* zones. The correspondence of the foraminifera and nannoplankton zones is shown in Fig. 4.

The Beluškė Slatiny Formation (SALAJ, 1982) is represented by coarse-rhythmical flysch (about 500 m); in the lower part coarse-grained calcareous sandstones with layers of fine-grained exotic conglomerates prevail over marls (2 : 1), whereas in the upper part marls are prevalent over sandstones (4 : 1). In this sequence foraminifera of the *Thalmanninella evoluta, Rotalipora bicarinata* zones are established and in the uppermost part of the sequence representatives of the *Rotalipora montsalvensis* subzone begin to appear.

The Praznov Beds Formation (ŠTÚR, 1860) of the Upper Cenomanian is represented by a fine-rhythmical flysch in which marls predominate. In these marls rich associations of planktonic foraminifera, representing the *Rotalipora montsalvensis* and the *Rotalipora turonica* subzones (SALAJ, 1962b; SALAJ & SAMUEL, 1966) are found. The nannoplankton found here represents the *Gartnerago obliquum* zone.

Benthic, calcareous and mainly agglutinated foraminifera are found in several horizons (Fig. 4), but are restricted to the Middle and Upper Cenomanian. These are the same species found in the Cenomanian of the Kostelec group which already begins in the Upper Albian.

The final horizon of agglutinated foraminifera appears in the uppermost part of the *Rotalipora turonica* subzone, underlying the Lower Turonian *Dicarinella imbricata* zone.

4. Paleontological description

Globotruncanidae BROTZEN, 1942
Genus: *Whiteinella* PESSAGNO, 1969
Whiteinella gandolfii n. sp.

1962 *Rotundina stephani* (GANDOLFI) – SALAJ 1962 a: Mikrobiostratigraphische Studien der Kreide in der Krízna – etc., p. 254.
1966 *Rotundina stephani* (GANDOLFI) – SALAJ & SAMUEL: Foraminifera der Westkarpaten – Kreide, p. 195, Tab. 33, Fig. 8 (cum. syn.).
1980 *Rotundina stephani* (GANDOLFI) – SALAJ: Microbiostratigraphie du Crétacé et du Paléogène de la Tunisie etc., p. 63, 68, 72; Figs. 11, 19, 21, 23, 25, 26, 27, 57, 58, 61; Tab. 1, 2; Pl. 4, Fig. 2; Pl. 5, Figs. 1, 2; Pl. 7, Figs. 1, 2.

Type species: The specimen figured in the publication by SALAJ & SAMUEL, 1963; pp. 103–104; Tab. VI; Fig. 1a–c.
Locus typicus: Lednické Rovné.
Stratum typicum: Lower Cenomanian of the Klape group.
Derivation nominis: In honour of Dr. R. GANDOLFI.
Material: About 20 specimens from sample No. 309.

Diagnosis:
Test trochoidally coiled, formed by 2½ to 3 whorls with 5–6 chambers at the last whorl. The chambers are globular, inflated to spherical, separated on the spiral side by deepened, slightly bent sutures, on the umbilical side by radial sutures. The margin is slightly lobate, with two indistinct pseudokeels or keels; the surface is smooth, papillar on the umbilical side; the umbilicus is large and deep, the aperture semicircular, interiomarginal, extraumbilical-umbilical, provided with lips reaching as far as the umbilicus.

Dimensions: diameter 0.35 – 0.42 mm, thickness 0.16 – 0.22 mm.

Stratigraphic range: In the West Carpathians in the Upper Albian to Middle Cenomanian of the Central, Manin, and Klippen zones.

Remark: From the phylogenetic standpoint this species is very important. Its origin should be sought in the genus *Ticinella* REICHEL 1950. We infer here the following phylogenetic lineage: *Ticinella roberti* (GANDOLFI) sensu REICHEL 1950 → *Whiteinella gandolfii* n. sp. → *Pseudoticinella bicarinata* (SAMUEL & SALAJ) → *Rotalipora montsalvensis* GANDOLFI. This is also one of the criteria we use to relate the genus *Rotalipora* BROTZEN 1952 with the species *Rotalipora montsalvensis* (MORNOD) and *Rotalipora turonica* BROTZEN (cf. SALAJ & SAMUEL, 1966).

Genus: *Thalmanninella* SIGAL 1948

Thalmanninella ticinensis conica n. ssp.

1970 *Thalmanninella ticinensis stephani* (GANDOLFI) — MASSIN & SALAJ: Contribution à l'etude stratigraphique de la région Nabeur, p. 819.

1980 *Thalmanninella ticinensis stephani* (GANDOLFI) — SALAJ:Microbiostratigraphie du Crétacé et du Paléogène de la Tunisie etc., pp. 58, 59, 63; Figs. 11, 21, 22, 23, 27, 32, 57, 61; Tab. 1; Pl. 4, Figs. 11–12, Pl. 5, Figs. 3–4.

Type species: The specimen figured in the publication by Salaj, 1980, Pl. 4, Fig. 12.
Locus typicus: Dj. Fguira Salah, Sample No. Z-1193/9.
Stratum typicum: Uppermost Albian.
Derivatio nominis: From Latin conica=conical.
Material: About 10 specimens from sample No. Z-1193/9 and 5 specimens from sample No. 27 Dolný Lieskov (Upper Albian of the Kostelec group).

Diagnosis:
We are dealing with highly vaulted forms of the species *Thalmanninella ticinensis* GANDOLFI, with 5–6 chambers ordered in 3–3½ whorls. The ventral side is plain. No distinct keel. The main aperture is interiomarginal, accessory apertures are typical as in the species *Thalmanninella ticinensis ticinensis* (GANDOLFI).

Dimensions: Diameter 0.33 – 0.45 mm, thickness 0.20 mm.

Stratigraphic range: In the uppermost Albian to the basal Cenomanian of the West Carpathians and Tunesia.

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FIG. 4

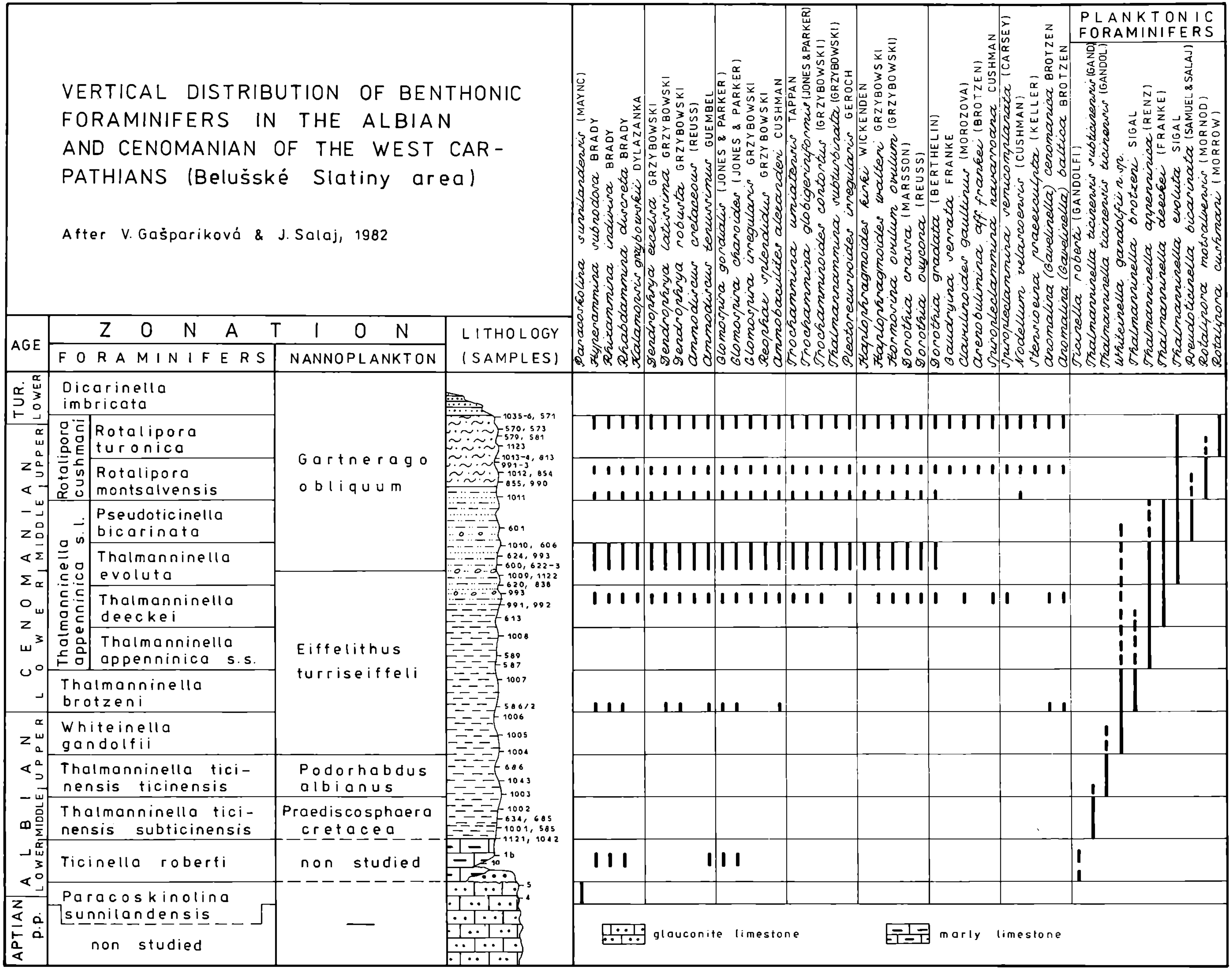
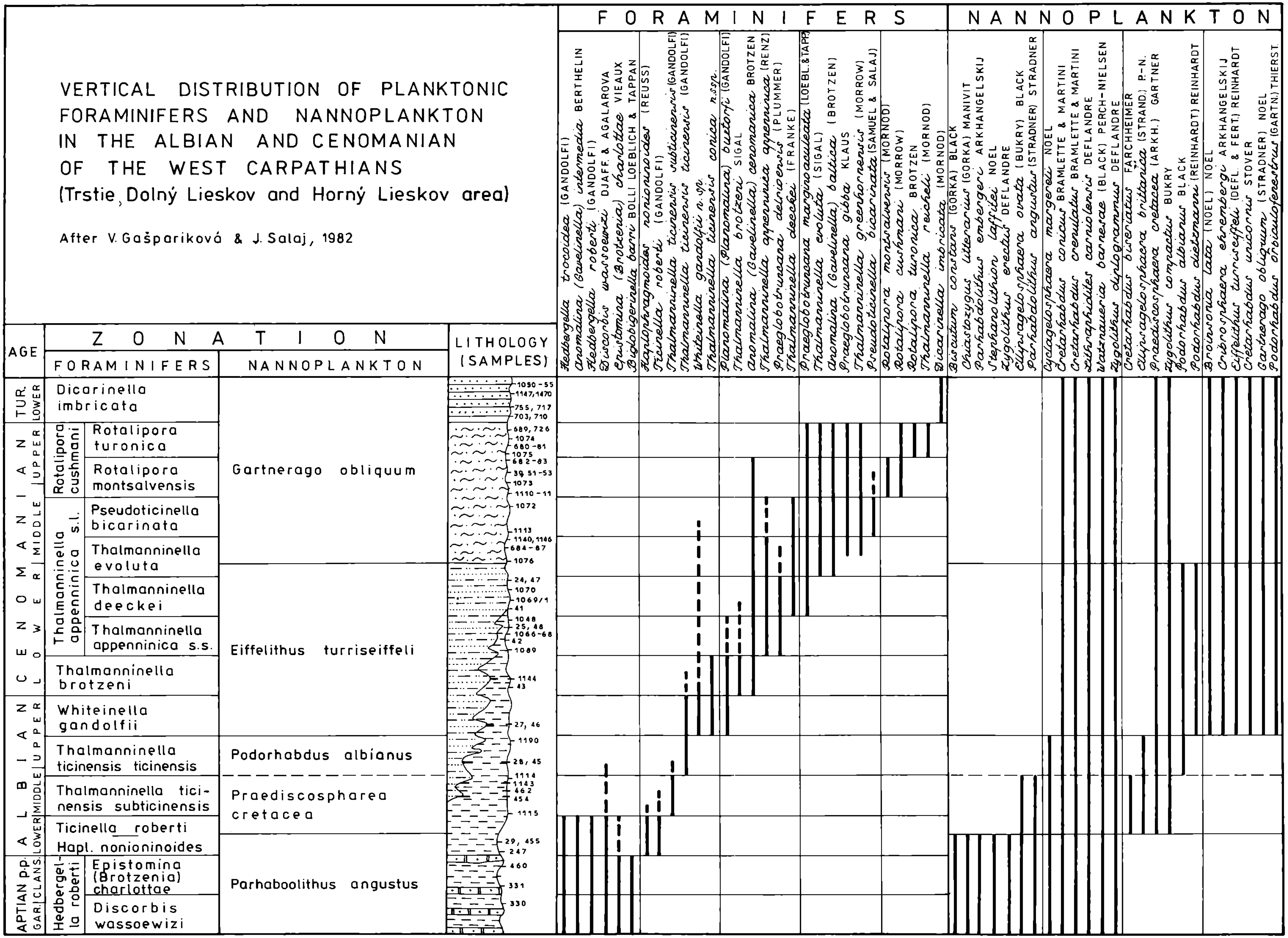

VERTICAL DISTRIBUTION OF BENTHONIC FORAMINIFERS IN THE ALBIAN AND CENOMANIAN OF THE WEST CARPATHIANS (Belušské Slatiny area)
After V. Gašparíková & J. Salaj, 1982
AGE
ZONATION
FORAMINIFERS
NANNOPLANKTON
LITHOLOGY (SAMPLES)
TUR. LOWER
CENOMANIAN UPPER MIDDLE LOWER
ALBIAN UPPER MIDDLE LOWER
APTIAN p.p.
Dicarinella imbricata
Rotalipora cushmani
Rotalipora turonica
Rotalipora montsalvensis
Thalmanninella appenninica s. l.
Pseudoticinella bicarinata
Thalmanninella evoluta
Thalmanninella deeckei
Thalmanninella appenninica s.s.
Thalmanninella brotzeni
Whiteinella gandolfii
Thalmanninella ticinensis ticinensis
Thalmanninella ticinensis subticinensis
Ticinella roberti
Paracoskinolina sunnilandensis
non studied
Gartnerago obliquum
Eiffelithus turriseiffeli
Podorhabdus albianus
Praediscosphaera cretacea
non studied
—
1035-6, 571
570, 573
579, 581
1123
1013-4, 813
991-3
1012, 854
855, 990
1011
601
1010, 606
624, 993
600, 622-3
1009, 1122
620, 838
993
991, 992
613
1008
589
587
1007
586/2
1006
1005
1004
686
1043
1003
1002
634, 685
1001, 585
1121, 1042
1b
10
5
4
Paracoskolina sunnilandensis (MAYNC)
Hyperammina subnodosa BRADY
Rhizammina indivisa BRADY
Rhabdammina discreta BRADY
Kalamopsis grzybowskii DYLAZANKA
Dendrophrya excelsa GRZYBOWSKI
Dendrophrya latissima GRZYBOWSKI
Dendrophrya robusta GRZYBOWSKI
Ammodiscus cretaceous (REUSS)
Ammodiscus tenuissimus GUEMBEL
Glomospira gordialis (JONES & PARKER)
Glomospira charoides (JONES & PARKER)
Glomospira irregularis GRZYBOWSKI
Reophax splendidus GRZYBOWSKI
Ammobaculites alexanderi CUSHMAN
Trochammina umiatensis TAPPAN
Trochamminoides globigeriniformis (JONES & PARKER)
Trochamminoides contortus (GRZYBOWSKI)
Thalmannammina subturbinata (GRZYBOWSKI)
Plectorecurvoides irregularis GEROCH
Haplophragmoides kirki WICKENDEN
Haplophragmoides walteri GRZYBOWSKI
Hormosina ovulum ovulum (GRZYBOWSKI)
Dorothia crassa (MARSSON)
Dorothia oxycona (REUSS)
Dorothia gradata (BERTHELIN)
Gaudryina serrata FRANKE
Clavulinoides gaultinus (MOROZOVA)
Arenobulimina aff. frankei (BROTZEN)
Spiroplectammina navarroana CUSHMAN
Spiroplectammina semicomplanata (CARSEY)
Nodellum velascoensis (CUSHMAN)
Stensioeina praeexculpta (KELLER)
Anomalina (Gavelinella) cenomanica BROTZEN
Anomalina (Gavelinella) baltica BROTZEN
PLANKTONIC FORAMINIFERS
Ticinella roberti (GANDOLFI)
Thalmanninella ticinensis subticinensis (GAND.)
Thalmanninella ticinensis ticinensis (GANDOL.)
Whiteinella gandolfii n. sp.
Thalmanninella brotzeni SIGAL
Thalmanninella appenninica (RENZ)
Thalmanninella deeckei (FRANKE)
Thalmanninella evoluta SIGAL
Pseudoticinella bicarinata (SAMUEL & SALAJ)
Rotalipora motsalvensis (MORNOD)
Rotalipora cushmani (MORROW)
glauconite limestone
marly limestone

FIG. 3


VERTICAL DISTRIBUTION OF PLANKTONIC FORAMINIFERS AND NANNOPLANKTON IN THE ALBIAN AND CENOMANIAN OF THE WEST CARPATHIANS
(Trstie, Dolný Lieskov and Horný Lieskov area)
After V. Gašparíková & J. Salaj, 1982
AGE
ZONATION
FORAMINIFERS
NANNOPLANKTON
LITHOLOGY (SAMPLES)
APTIAN p.p.
GAR.
CLANS.
ALBIAN
LOWER
MIDDLE
UPPER
CENOMANIAN
LOWER
MIDDLE
UPPER
TUR.
LOWER
Hedbergella roberti
Discorbis wassoewizi
Epistomina (Brotzenia) charlottae
Hapl. nonioninoides
Ticinella roberti
Thalmanninella ticinensis subticinensis
Thalmanninella ticinensis ticinensis
Whiteinella gandolfii
Thalmanninella brotzeni
Thalmanninella appenninica s.l.
Thalmanninella appenninica s.s.
Thalmanninella deeckei
Thalmanninella evoluta
Pseudoticinella bicarinata
Rotalipora cushmani
Rotalipora montsalvensis
Rotalipora turonica
Dicarinella imbricata
Parhaboolithus angustus
Praediscospharea cretacea
Podorhabdus albianus
Eiffelithus turriseiffeli
Gartnerago obliquum
1090-55
1147, 1470
755, 717
703, 710
689, 726
1074
680-81
1075
682-83
39, 51-53
1073
1110-11
1072
1113
1140, 1146
684-87
1076
24, 47
1070
1069/1
41
1048
25, 48
1066-68
42
1089
1144
43
27, 46
1190
28, 45
1114
1143
462
454
1115
29, 455
247
460
331
330
FORAMINIFERS
Hedbergella trocoidea (GANDOLFI)
Anomalina (Gavelinella) intermedia BERTHELIN
Hedbergella roberti (GANDOLFI)
Discorbis wassoewizi DJAFF. & AGALAROVA
Epistomina (Brotzenia) charlottae VIEAUX
Biglobigerinella barri BOLLI LOEBLICH & TAPPAN
Haplophragmoides nonioninoides (REUSS)
Ticinella roberti (GANDOLFI)
Thalmanninella ticinensis subticinensis (GANDOLFI)
Thalmanninella ticinensis ticinensis (GANDOLFI)
Whiteinella gandolfii n. sp.
Thalmanninella ticinensis conica n. ssp.
Planomalina (Planomalina) buxtorfi (GANDOLFI)
Thalmanninella brotzeni SIGAL
Anomalina (Gavelinella) cenomanica BROTZEN
Thalmanninella appenninica appenninica (RENZ)
Praeglobotruncana delrioensis (PLUMMER)
Thalmanninella deeckei (FRANKE)
Praeglobotruncana marginoaculeata (LOEBL. & TAPP.)
Thalmanninella evoluta (SIGAL)
Anomalina (Gavelinella) baltica (BROTZEN)
Praeglobotruncana gibba KLAUS
Thalmanninella greenhornensis (MORROW)
Pseudoticinella bicarinata (SAMUEL & SALAJ)
Rotalipora montsalvensis (MORNOD)
Rotalipora cushmani (MORROW)
Rotalipora turonica BROTZEN
Thalmanninella reicheli (MORNOD)
Dicarinella imbricata (MORNOD)
NANNOPLANKTON
Biscutum constans (GORKA) BLACK
Chiastozygus litterarius (GORKA) MANIVIT
Parhabdolithus embergeri ARKHANGELSKIJ
Stephanolithion laffitei NOEL
Zygolithus erectus DEFLANDRE
Ellipsagelosphaera ovata (BUKRY) BLACK
Parhabdolithus angustus (STRADNER) STRADNER
Cyclagelosphaera margereli NOEL
Cretarhabdus conicus BRAMLETTE & MARTINI
Cretarhabdus crenulatus BRAMLETTE & MARTINI
Lithraphidites carniolensis DEFLANDRE
Watznaueria barnesae (BLACK) PERCH-NIELSEN
Zygolithus diplogrammus DEFLANDRE
Cretarhabdus biseriatus FARCHHEIMER
Ellipsagelosphaera brittanica (STRAND.) P.-N.
Praediscosphaera cretacea (ARKH.) GARTNER
Zygolithus compactus BUKRY
Podorhabdus albianus BLACK
Podorhabdus dietzmanni (REINHARDT) REINHARDT
Broinsonia lata (NOEL) NOEL
Cribrosphaera ehrenbergi ARKHANGELSKIJ
Eiffelithus turriseiffeli (DEFL. & FERT.) REINHARDT
Cretarhabdus unicornis STOVER
Gartnerago obliquum (STRADNER) NOEL
Podorhabdus orbiculofenestrus (GARTN.) THIERST.

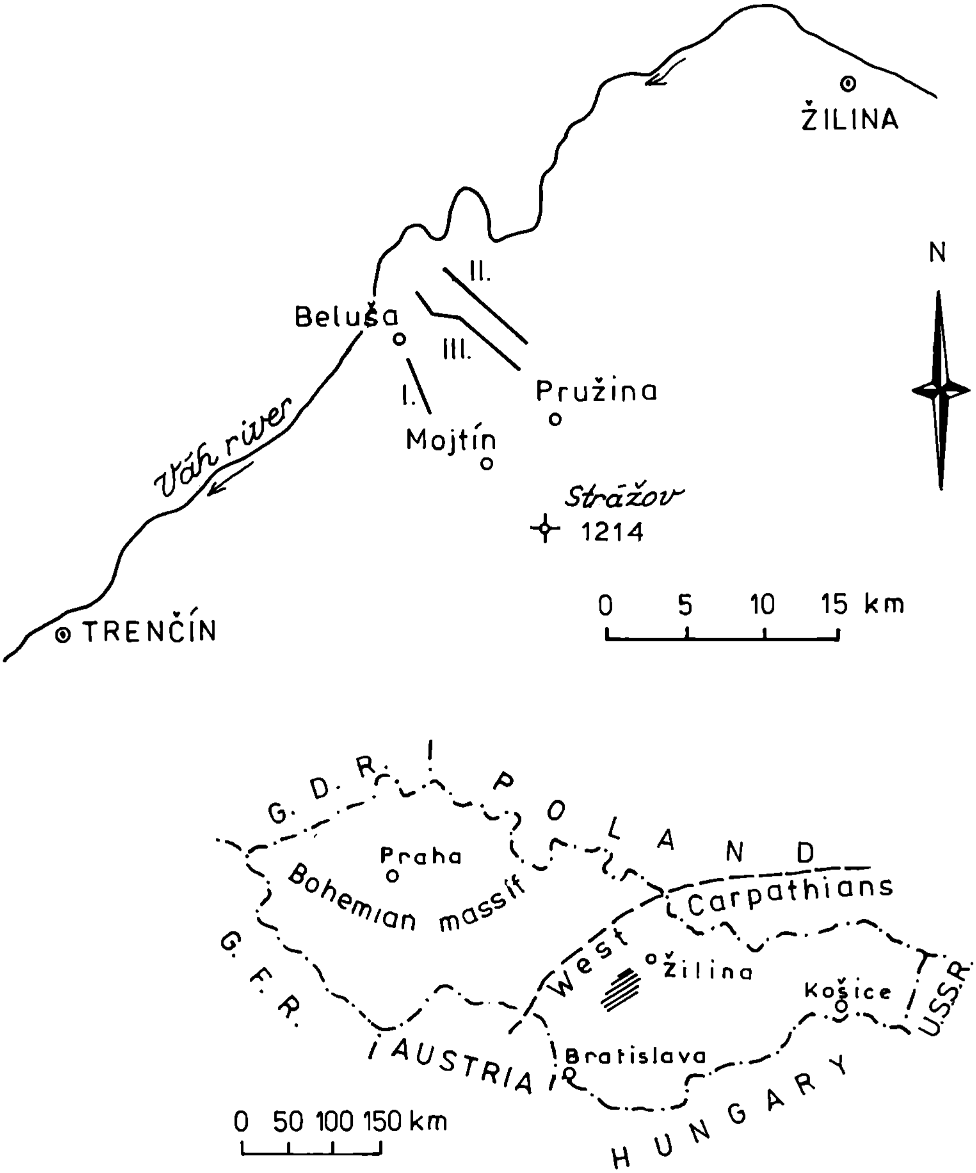
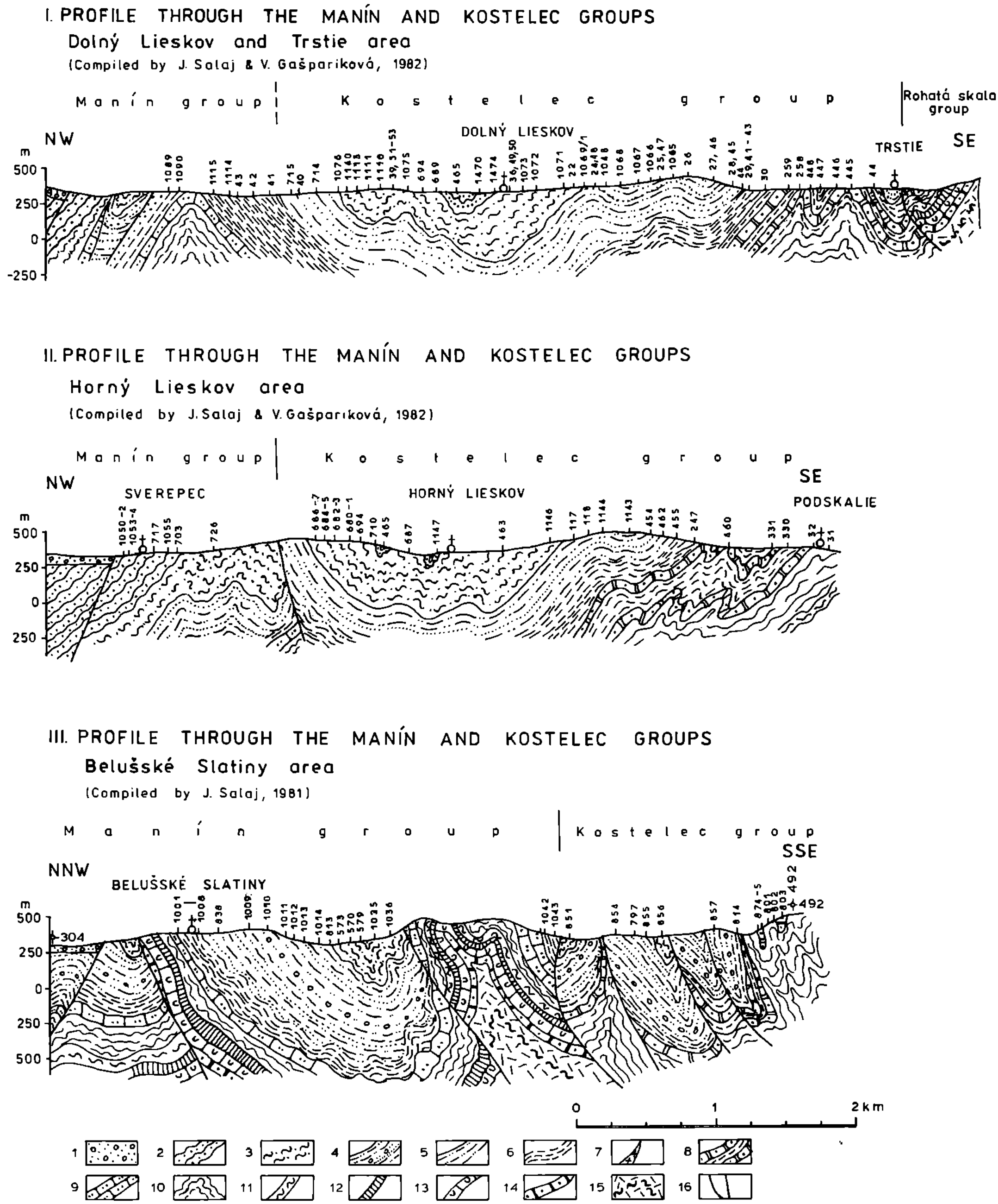


Fig. 1. Situation of selected profiles of the area under study

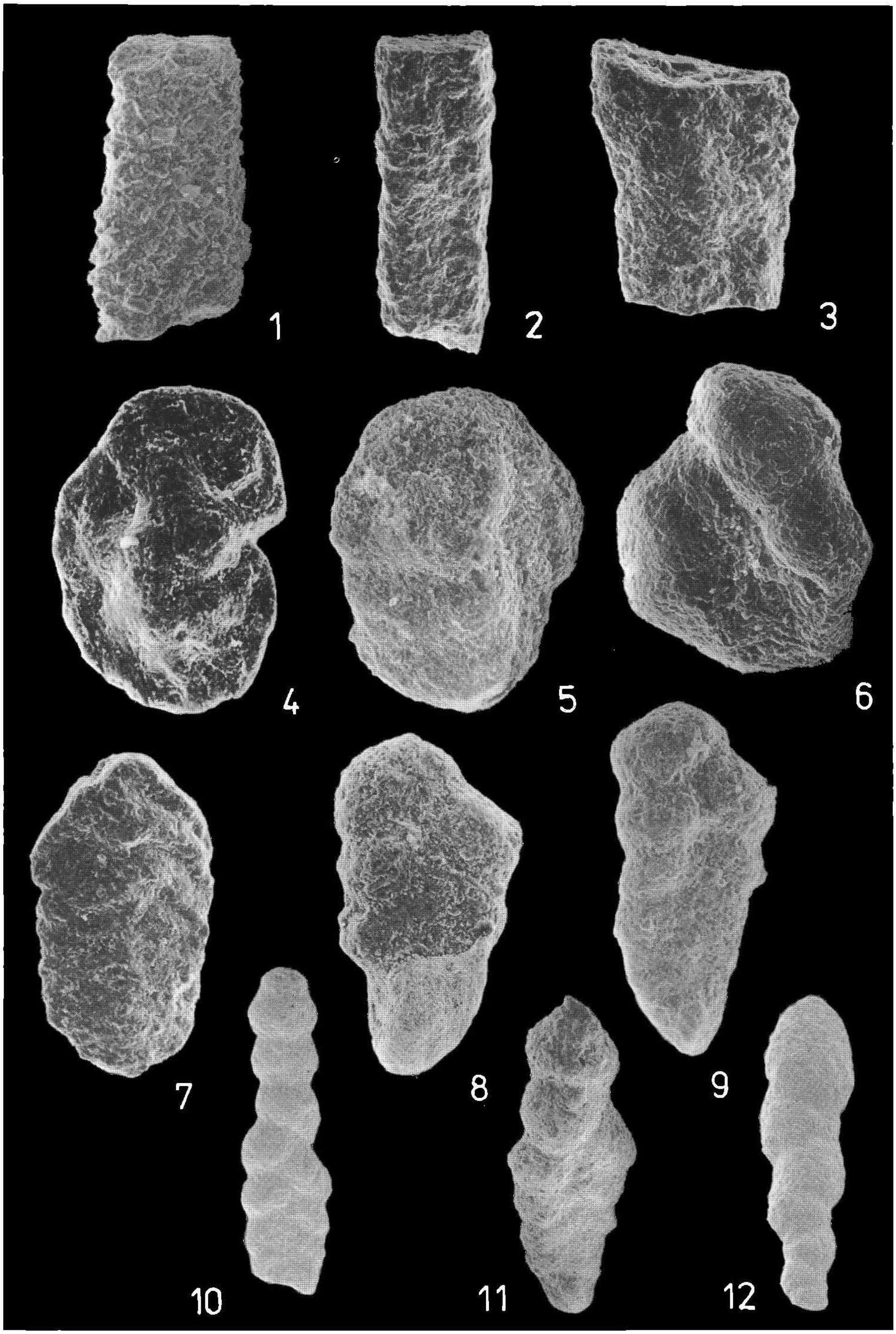
Legend to geological profiles I–III (Fig. 2)

1 – Eggenburgian: basal conglomerates, sandstones and shales;
2 – Turonian: flyschoid sequence of the Kostelec and Manín groups;
3 – Middle and Upper Cenomanian: fine-rhythmical flyschoid sequence (of the Praznov beds);
4 – Middle Cenomanian: coarse rhythmical flyschoid sequence of the Belušské Slatiny beds, sandstones, sandy shales and fine-grained exotic conglomerates;
5 – Upper Albian to Middle Cenomanian: flyschoid sequence of the Kostelec and Manín groups;
6 – Lower Albian: marls;
7 – Middle Albian: ultrabasic rocks;
8 – Barremian to Aptian: dark organogenic limestones, layers of grey Urgonian type limestones, glaukonite limestones and marls;
9 – Barremian to Lower Albian: organogenic and organodetrital orbitoline and hippurite massive limestones (Urgonian facies);
10 – Tithonian to Neocomian: grey banked calpionel limestones;
11 – Upper Oxfordian to Kimmeridgian: light-grey, brownish and pinkish platy limestones;
12 – Callovian to Oxfordian: cherty limestones, nodular limestones, and radiolarites;
13 – Liassic to Lower Dogger: spongolite limestones, sandy light-pinkish and red crinoidal limestones;
14 – Rhaetian: dark-grey sandy limestones and lumachelle limestones;
15 – Upper Carnian to Norian: Hauptdolomit with layers of red Keuper shales;
16 – faults.



Compiled on the basis of archival maps 1:25000 of Beluša (J. Salaj & M. Rakus, 1963) and Pružina (J. Salaj 1963)

Fig. 2. Geological profiles of the middle cretaceous in the strážovské vrchy MTS



Legend see page 60

Plate 1

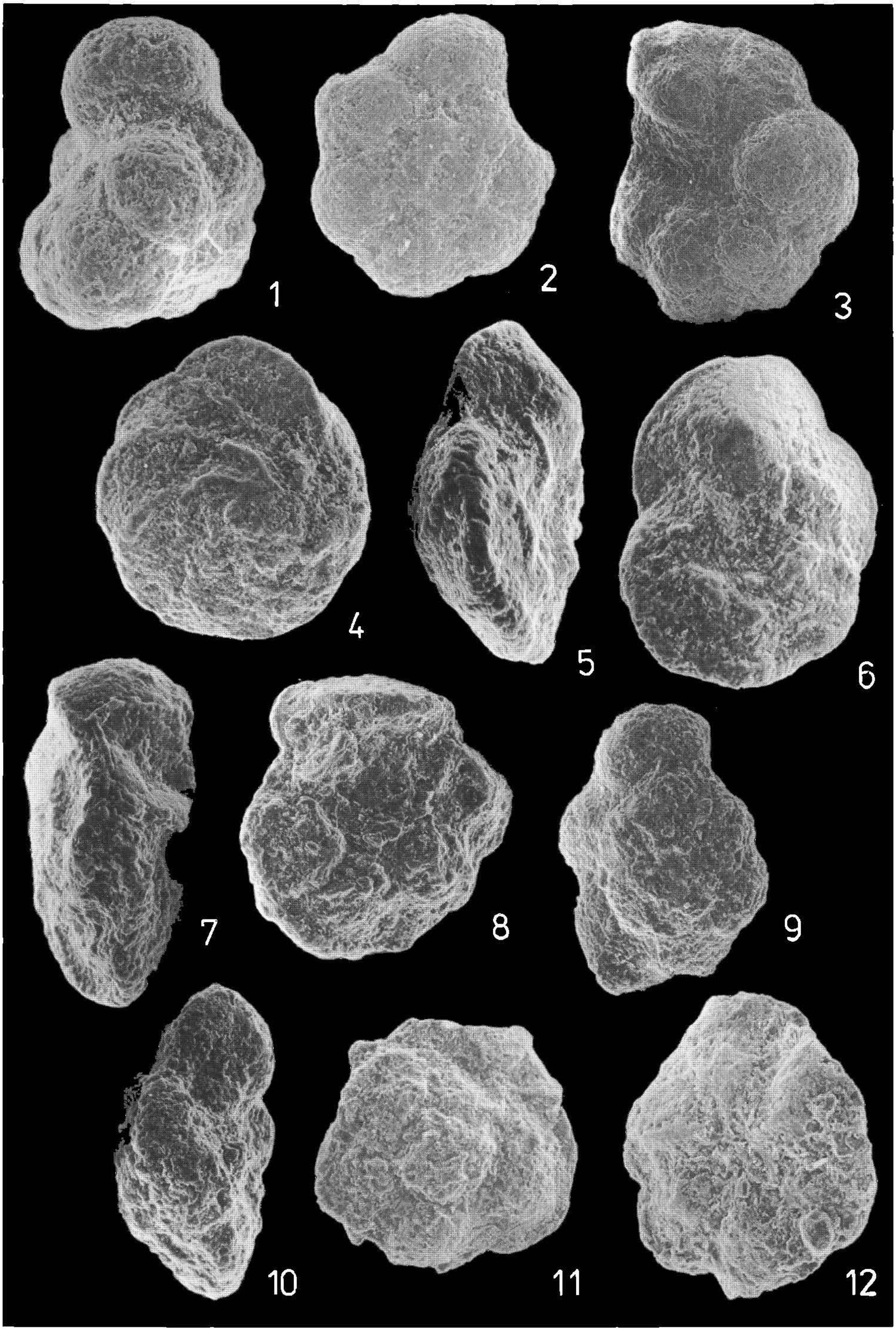
Scanning (JSM_3) micrographs of significant benthinic foraminifera

Fig. 1. *Rhabdammina discreta* BRADY; lateral view 70×.
Loc.: Trstie, sample no. 30. Lower Albian.
Fig. 2. *Dendrophrya latissima* GRZYBOWSKI; lateral view 50×.
Loc.: Trstie, sample no. 22. Lower Cenomanian.
Fig. 3. *Dendrophrya robusta* GRZYBOWSKI; lateral view 65×.
Loc.: Trstie, sample no. 22. Lower Cenomanian.
Fig. 4. *Haplophragmoides walteri* GRZYBOWSKI; umbilical view 70×.
Loc.: Belušské Slatiny, sample no. 1010. Middle Cenomanian.
Fig. 5–6. *Haplophragmoides nonioninoides* (REUSS); 5. lateral view 60×; 6. umbilical view 60×.
Loc.: Trstie, sample no. 30. Lower Albian.
Fig. 7. *Spiroplectammina navarroana* CUSHMAN; lateral view 70×.
Loc.: Dolný Lieskov, sample no. 22. Lower Cenomanian.
Fig. 8. *Spiroplectinata davidi* MOULLADE; lateral view 75×.
Loc.: Trstie, sample no. 29. Lower Albian.
Fig. 9. *Spiroplectinata davidi* MOULLADE; lateral view 50×.
Loc.: Trstie, sample no. 30. Lower Albian.
Fig. 10. *Spiroplectinata annectens* (PARKER & JONES); lateral view 65×.
Loc.: Trstie, sample no. 30. Lower Albian.
Fig. 11. *Spiroplectinata complanata* REUSS; lateral view 40×.
Loc.: Trstie, sample no. 30. Lower Albian.
Fig. 12. *Pleurostomella subnodosa* REUSS; lateral view 35×.
Loc.: Trstie, sample no. 30. Lower Albian.

Plate 2

Scanning (JSM_3) micrographs of significant planktonic foraminifera

Fig. 1–3. *Ticinella roberti* (GANDOLFI); 1. peripheral view 90×; 2. spiral view 90×; 3. umbilical view 100×.
Loc.: Trstie, sample no. 29. Lower Albian.
Fig. 4–6. *Thalmanninella brotzeni* SIGAL; 4. spiral view 70×; 5. peripheral view 90×; 6. umbilical view 80×.
Loc.: Belušské Slatiny, sample no. 1007. Lower Cenomanian.
Fig. 7. *Thalmanninella deeckei* (FRANKE); peripheral view 90×.
Loc.: Dolný Lieskov, sample no. 24. Lower Cenomanian.
Fig. 8. *Thalmanninella reicheli* (MORNOD); oblique umbilical view 60×.
Loc.: Belušské Slatiny, sample no. 573. Upper Cenomanian.
Fig. 9. *Rotalipora montsalvensis* (MORNOD); spiral view 60×.
Loc.: Dolný Lieskov, sample no. 39. Middle to Upper Cenomanian.
Fig. 10–12. *Thalmanninella evoluta* (SIGAL); 10. peripheral view 90×; 11. spiral view 75×; 12. umbilical view 75×.
Loc.: Dolný Lieskov, sample no. 22. Middle Cenomanian.


1
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11
12

Plate 3

Scanning (JSM_3) micrographs of significant nannofossils

Fig. 1. *Chiastozygus* sp., 5000×, proximal view;
Loc.: Trstie, no. 478/77.
Fig. 2. *Chiastozygus cuneatus* (LYULEVA) ČEPEK et HAY, 6000×, distal view;
Loc.: Trstie, no. 480/77.
Fig. 3. *Parhabdolithus* ex gr. *asper* (STRADNER) MANIVIT, 3500×, proximal view;
Loc.: Trstie, no. 480/77.
Fig. 4. *Cretarhabdus* sp. 5000×, proximal view;
Loc.: Trstie, no. 478/77.
Fig. 5. *Cretarhabdus crenulatus* BRAMLETTE et MARTINI, 5000×, proximal view;
Loc.: Trstie, no. 482/77.
Fig. 6. *Watznaueria barnesae* (BLACK) PERCH-NIELSEN, 5000×, proximal view;
Loc.: Trstie, no. 482/77.
Fig. 7. *Praediscosphaera cretacea* (ARKHANGELSKIJ) GARTNER, 5000×, profil;
Loc.: Trstie, no. 481/77.
Fig. 8. *Praediscosphaera cretacea* (ARKHANGELSKIJ) GARTNER, 5000×, distal view;
Loc.: Trstie, no. 480/77.
Fig. 9. *Praediscosphaera cretacea* (ARKHANGELSKIJ) GARTNER, 5000×, distal view;
Loc.: Lieskov, no. 489/77.
Fig. 10. *Zygolithus compactus* (BUKRY) NOËL, 5000×, distal view;
Loc.: Lieskov, no. 486/77.
Fig. 11. *Zygolithus erectus* DEFLANDRE, 4000×, distal view;
Loc.: Trstie, no. 480/77.
Fig. 12. *Zygolithus compactus* (BUKRY) NOËL, 5000×, proximal view;
Loc.: Lieskov, no. 488/77.

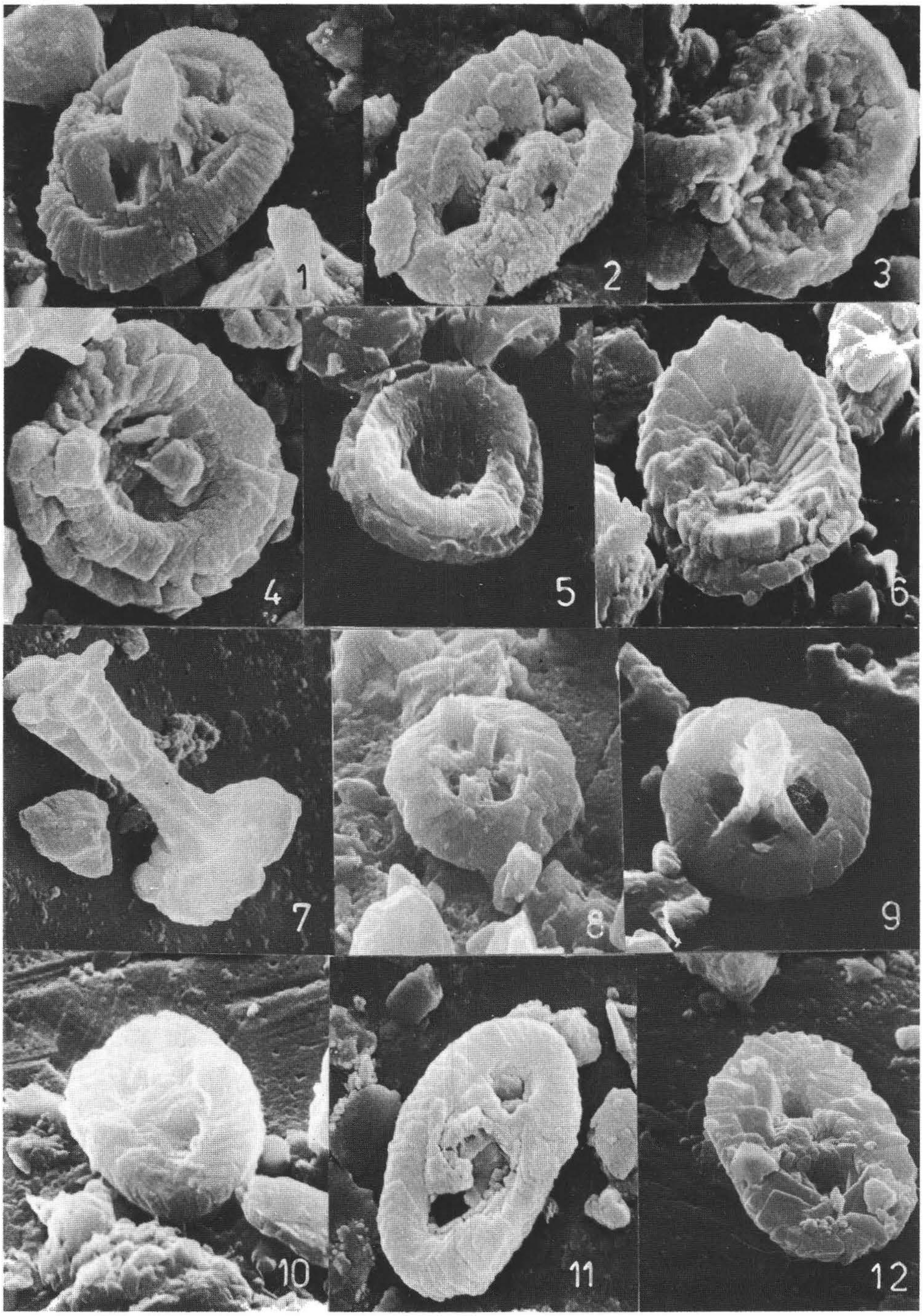
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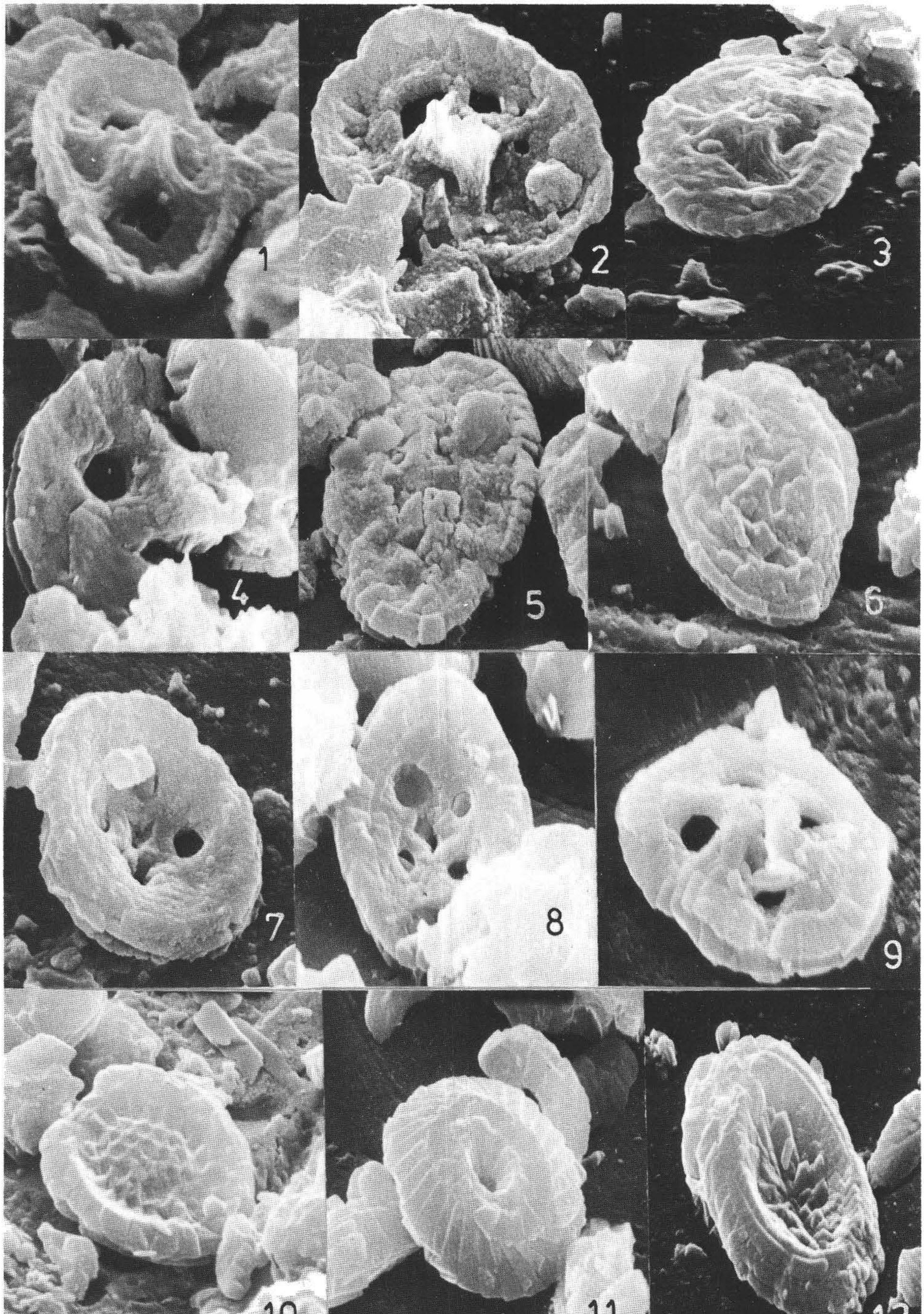
Plate 4

Scanning (JSM_3) micrographs of significant nannofossils

Fig. 1. *Eiffelithus turriseiffeli* (DEFLANDRE) REINHARDT, 5000×, distal view; Loc.: Trstie, no. 483/77.
Fig. 2. *Eiffelithus turriseiffeli* (DEFLANDRE) REINHARDT, 4000×, distal view; Loc.: Lieskov, no. 489/77.
Fig. 3. *Eiffelithus turriseiffeli* (DEFLANDRE) REINHARDT, 5000×, distal view; Loc.: Slopná, no. 436/79.
Fig. 4. *Podorhabdus albianus* BLACK, 4500×, distal view; Loc.: Trstie, no. 483/77.
Fig. 5. *Gartnerago obliquum* (STRADNER) REINHARDT, 4500×, distal view; Loc.: Slopná, no. 434/79.
Fig. 6. *Gartnerago obliquum* (STRADNER) REINHARDT, 5000×, distal view; Loc.: Slopná, no. 440/79.
Fig. 7. *Podorhabdus orbiculofenestrus* (GARTNER) THIERSTEIN, 4500×, proximal view; Loc.: Slopná, no. 436/79.
Fig. 8. *Podorhabdus orbiculofenestrus* (GARTNER) THIERSTEIN, 5000×, proximal view; Loc.: Lieskov, no. 489/77.
Fig. 9. *Podorhabdus orbiculofenestrus* (GARTNER) THIERSTEIN, 5000×, distal view; Loc.: Lieskov, no. 489/77.
Fig. 10. *Cribrosphaera ehrenbergi* ARKHANGELSKIJ, 5000×, proximal view; Loc.: Slopná, no. 440/79.
Fig. 11. *Watznaueria barnesae* (BLACK) PERCH-NIELSEN, 5000×, distal view; Loc.: Slopná, no. 436/79.
Fig. 12. *Broinsonia* sp., 5000×, proximal view; Loc.: Slopná, no. 441/79.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