ANDRZEJ GAŹDZICKI

FORAMINIFERS AND BIOSTRATIGRAPHY OF UPPER TRIASSIC AND LOWER JURASSIC OF THE SLOVAKIAN AND POLISH CARPATHIANS

(plates 27–41)

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Numerous benthonic foraminifer assemblages (comprising 104 species) were found in Upper Triassic-Lower Jurassic strata in the West Carpathians of Slovakia and Poland. A sequence of three foraminifer zones is recognized: *Triasina oberhauseri* Partial-range Zone (Norian), *Glomospirella friedli* and *Triasina hantkeni* Assemblage Zone (Rhaetian), and *Ophthalmidium leischneri* and *Ophthalmidium walfordi* Assemblage-Zone (Hettangian-?Sinemurian) — defining basal part of the Jurassic system in the Carpathians. This subdivision is correlated with standard ammonoid and conodont zonations. The studied foraminifer assemblages were related to lagoon areas and biostromal elevations in shelf zone with predominating carbonate sedimentation. Evolutionary trends in Involutinidae and Ammodiscidae in Late Triassic and Early Jurassic are analysed. In taxonomic composition and stratigraphic distribution the Triassic and Jurassic foraminifer assemblages of the West Carpathians do not differ from contemporaneous assemblages known from other parts of the Tethys Realm. The Lower Jurassic assemblage from West Carpathians displays some similarity to foraminifer assemblage known from epicontinental basin of north-western Europe.

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Project no. 4
„Triassic of the Tethys Realm"

OTWORNICE I BIOSTRATYGRAFIA GÓRNEGO TRIASU I DOLNEJ JURY SŁOWACKICH I POLSKICH KARPAT

Streszczenie. — Opracowano zespoły otwornic bentonicznych z osadów górnego triasu i dolnej jury Karpat Słowackich i Polskich obejmujące 104 gatunki. W zbadanej sekwencji osadów wyróżniono trzy poziomy otwornicowe: poziom ścieśniony *Triasina oberhauseri* (noryk), poziom zespołowy *Glomospirella friedli* i *Triasina hantkeni* (retyk) oraz poziom zespołowy *Ophthalmidium leischneri* i *Ophthalmidium walfordi* (hetang — ?synemur) definiujący podstawę systemu jurajskiego w Karpatach. Poziomy otwornicowe skorelowano ze standardowymi poziomami głowonogowymi i konodontowymi. Wykazano, że zbadane otwornice związane były z szelfowymi lagunami i biostromalnymi elewacjami o dominującej sedymentacji węglanowej. Rozważono charakter ewolucyjnych zmian w obrębie górnotriasowych i dolnojurajskich Involutinidae i Ammodiscidae. Stwierdzono, że zespoły otwornic z Karpat Zachodnich nie różnią się pod względem składu taksonomicznego i rozprzestrzenienia stratygraficznego

od równowiekowych zespołów z innych rejonów Tetydy. Ponadto zespół dolnojurajski z Karpat Zachodnich wykazuje pewne podobieństwo do równowiekowego zespołu z epikontynentalnego basenu północno-zachodniej Europy.

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CONTENTS

INTRODUCTION

Marine Upper Triassic and Lower Jurassic strata exposed in the West Carpathians of Slovakia and Poland contain numerous biostratigraphically significant benthonic foraminifers. The 33 representative sections of the investigated strata in the Tatricum, Fatricum, Hronicum and Silicicum have been measured and sampled in order to establish a vertical dis-

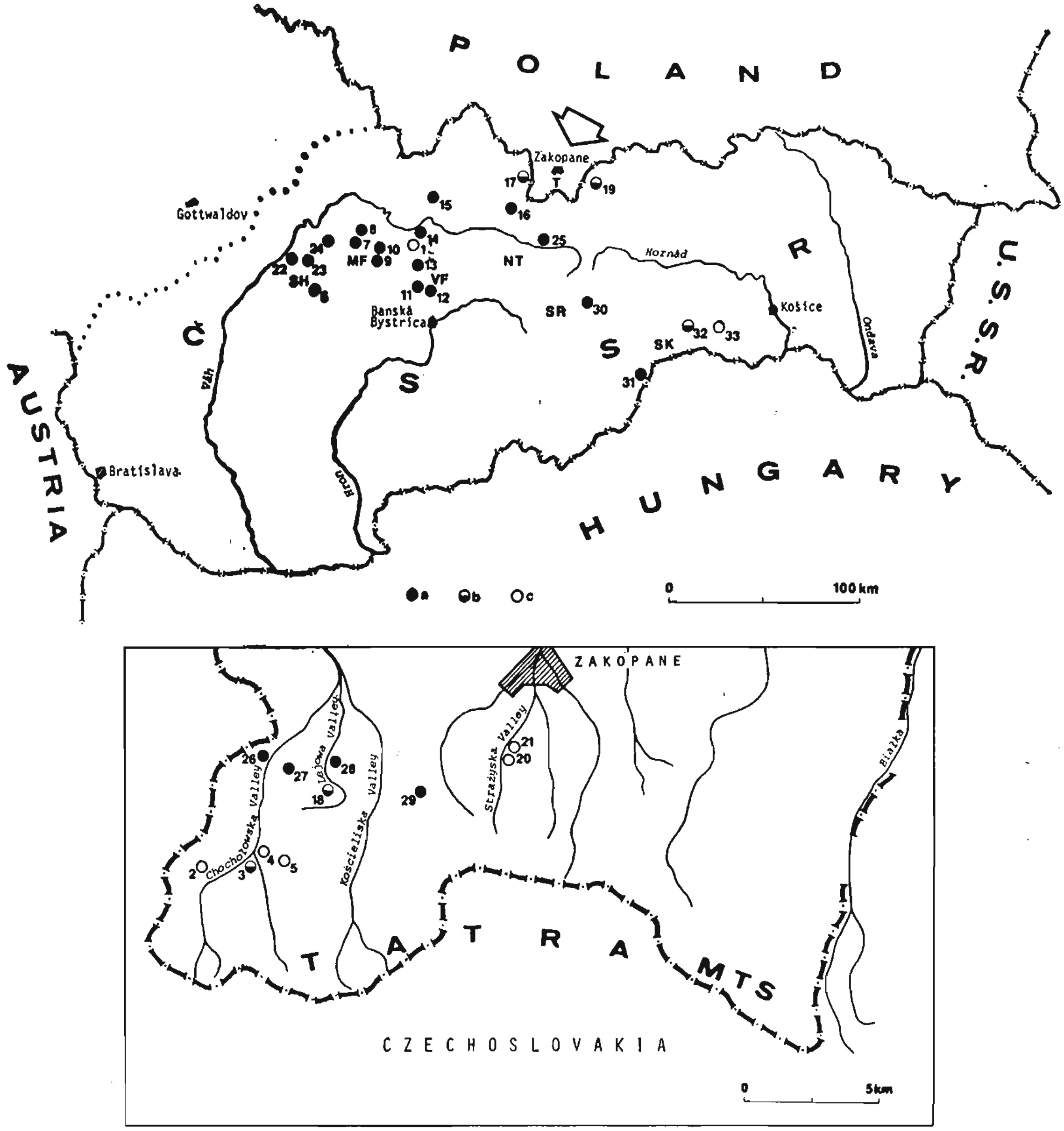

Fig. 1

Locality maps of the Upper Triassic and Lower Jurassic sections in the West Carpathians of Slovakia and Poland sampled for foraminifers (arrow indicates the Tatra Mts. region shown in detail below the main location map). — 1–5 — Tatricum: *1* Rúbaň Skala, *2* Bobrowiec Mt., *3* Kopieniec Staroroboсiański Mt., *4* Dudziniec Mt., *5* Kobyla Głowa Crag; 6–21— Fatricum, *6* Hireška, *7* Lesnianska Valley, *8* Široka Valley, *9* Suchá Valley, *10* Slovianska Valley, *11* Dedošova Valley, *12* Križna Valley, *13* Belianska Valley, *14* Ráztoky, *15* Zázrivská Valley, *16* Bobrovček-Hrádky, *17* Velká Furkaska Mt., *18* Lejowa Valley I, *19* Štefanský žlab, *20* Strążyska Valley I, *21* Strążyska Valley II; 22–29 — Hronicum: *22* Norovica Mt., *23* Rovnianska Valley, *24* Tŕstie, *25* Hybe, *26* Chochołowska Valley, *27* Wielka Sucha Valley, *28* Lejowa Valley II, *29* Przysłop Miętusi; 30–33 — Silicicum: *30* Skalka, *31* Malý Mlynský vrch Mt., *32* Bleskový prameň, *33* Miglinc. SH — Strážovská hornatina Mts., MF — Malá Fatra Mts., VF — Velká Fatra Mts., NT — Nízke Tatry Mts., T — Tatra Mts., SR — Slovenské rudohorie Mts., SK — Slovenský kras

a — profiles enclosing Upper Triassic deposits, *b* — profiles enclosing Upper Triassic and Lower Jurassic deposits, *c* — profiles enclosing Lower Jurassic deposits.

tribution of the foraminifers and associated biota (fig. 1). About 1,100 thin sections have been prepared, over 800 of which contained foraminifers. One hundred and four benthonic foraminifer species have been found in the investigated sequence. Of these, 79 are calcareous forms and 25 are agglutinated. Foraminifers are fairly common in the deposits of the Norovica and Fatra Formations (uppermost Triassic) and lower and upper limestones of Kopieniec Formation (Lower Lias).

The stratigraphic position of the Upper Triassic strata from the West Carpathians was determined by conodont studies (MOCK 1971, 1975; KOZUR and MOCK 1974*a*; GAŹDZICKI 1978*a*, *b*; GAŹDZICKI *et al.* 1978, 1979*a*). This made possible the determination of the age of foraminifer-bearing samples and correlation of stratigraphic ranges of foraminifers in West Carpathians and other regions of the Tethys Realm.

Occurrence of foraminifers in the Upper Triassic and Lower Jurassic strata was reported from the Slovakian Carpathians by MIŠIK (1961, 1964, 1966), SALAJ and JENDREJÁKOVÁ (1967), SALAJ *et al.* (1967), SALAJ (1969*a*, *b*; 1977*a*, *b*; 1978), JENDREJÁKOVÁ (1970, 1972), MIŠIK and BORZA (1976), GAŹDZICKI *et al.* (1978, 1979*a*, *b*), MICHALIK and JENDREJÁKOVÁ (1978), MICHALÍK *et al.* (1979), and from the Polish Tatra Mts by SAXL (*in* GOETEL 1917), GAŹDZICKI (1970, 1974, 1975, 1977), GAŹDZICKI and ZAWIDZKA (1973), and GAŹDZICKI and MICHALÍK (1980).

The investigated foraminifer collections (thin sections) are housed in: Institute of Paleobiology of the Polish Academy of Sciences, Warszawa; Institute of Geology of the Slovak Academy of Sciences, Bratislava; Department of Geology and Paleontology of the Faculty of Natural Sciences J. A. Comenius University, Bratislava; and Institute of Geology of the Warsaw University, Warszawa.

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Abbreviations used:

GUSAV — Institute of Geology, Slovak Academy of Sciences, Bratislava
IGP — Institute of Geology, University of Warsaw, Warsaw
PFUK — Department of Geology and Paleontology, J. A. Comenius University, Bratislava
ZPAL — Institute of Paleobiology, Polish Academy of Sciences, Warsaw

MATERIAL AND METHODS

The studies on benthonic foraminifers of the Upper Triassic and Lower Jurassic of the West Carpathians were carried out on thin sections from samples carefully taken in individual sections (figs 1, 5–12). In the studied rocks, foraminifers are fairly common and relatively well-preserved. A great variability of sections of foraminifer tests made fairly accurate and reliable identifications (figs 5–12) possible. The studies covered about 1,100 thin sections (about 2.5 cm × 3.0 cm in size), over 800 of which yielded foraminifers. The number of foraminifers in a thin section is ranging from a few to over 300, about 50 on the average. About 25,000 of various sections of foraminifer tests were analysed in detail, the majority of which was identifiable (see pls 31–41).

The thin section method is especially useful in studies on foraminifers of the family Involutinidae, fairly common in the Upper Triassic and Lower Jurassic and of high stratigraphic and paleogeographic value. Generic and specific identifications of involutinids are based on internal structure of the test, observable in thin sections. Even in the case of random orientation, two or three sections are sufficient for determination of structural type of a test.

It should be noted that the thin section method appeared highly successful and it becomes increasingly popular in studies on calcareous foraminifers, especially those occurring in hard carbonate rocks.

GEOGRAPHIC AND GEOLOGIC SETTING

Upper Triassic and Lower Jurassic rocks crop out in several place in the West Carpathians of Slovakia and Poland (fig. 1). They are highly variable in facies development, reflecting changes in sedimentary basin of the Carpathians at the turn of the Triassic and Jurassic. The changes are indicated by lateral variability and succession of rocks in individual paleotectonic-facies zones in the West Carpathians (fig. 2).

The present study covers outcrops of the relevant rocks in the Strážovská hornatina Mts., Malá Fatra Mts., Velká Fatra Mts., Nizke Tatry Mts., Tatra Mts., Slovenské rudohorie Mts., and Slovenský kras (see fig. 1). Thirty three sections of the investigated strata were measured and sampled in order to establish succession of facies and distribution of foraminifers and associated biota. A special attention was paid to rocks of the Fatra Formation and Kopieniec Formation in the Fatricum, Norovica Formation and Hybe Beds in the Hronicum, Bleskový prameň Lmst., and Zlambach Beds in the Silicicum and Lias of the Tatricum in the Velká Fatra Mts., on account of the presence of very rich and highly diversified assemblages of benthonic foraminifers.

The studies recently carried out by MICHALÍK *et al.* (1979), GAŹDZICKI *et al.* (1979b), GAŹDZICKI and MICHALÍK (1980) and MICHALÍK (1980) made possible lithostratigraphical subdivision of the Upper Triassic and Lower Jurassic sequences in the Fatricum and Hronicum in the West Carpathians (figs 3–4).

The Fatricum sequence was divided into four formal lithostratigraphic units: Carpathian Keuper Group and Fatra, Kopieniec and Janovky Formations, further subdivided into several informal members (see fig. 3). This sequence is about 200 m thick, ranging in age from Norian to Sinemurian (GAŹDZICKI *et al.* 1979*b*).

The uppermost Triassic deposits of the Hronicum (Norovica Formation) are only fragmentarily preserved, as in several places they have underwent an erosion due to Early Kimmerian tectonic phase (GAŹDZICKI and MICHALÍK 1980, fig. 1). The Norovica Formation overlies the Hauptdolomit and underlies the Lower Lias crinoidal limestones (fig. 4). Three members are

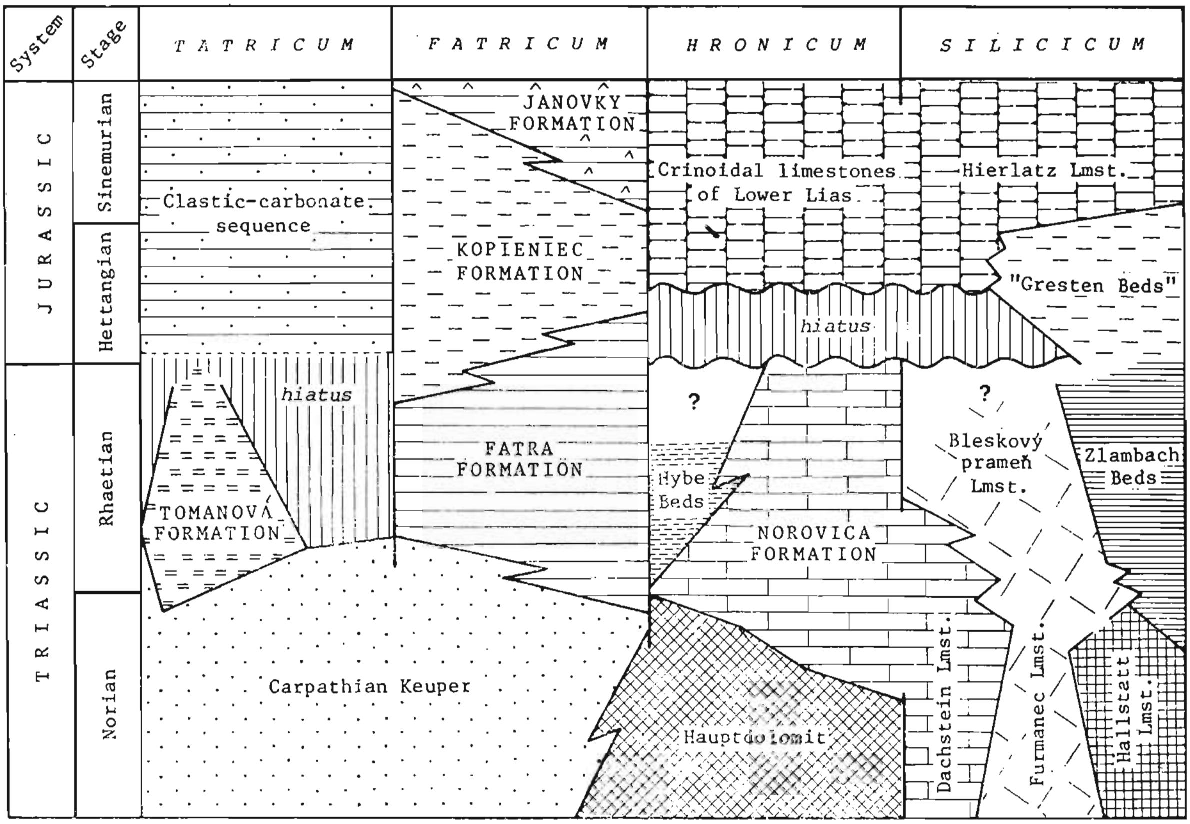

Fig. 2
Scheme of stratigraphic and regional facies distribution in Upper Triassic and Lower Jurassic of the Slovakian and Polish Carpathians. For details see MELLO 1974, MICHALÍK 1977 *a*, GAŹDZICKI *et al.* 1979 *b*, GAŹDZICKI and MICHALÍK 1980, MICHALÍK 1980.

distinguished: Lower Limestone, Siwa Woda Limestone and Mojtin Limestone Members. This Formation is up to 50 m thick and ranges in age from the Upper Norian (Sevatian) to the Upper Rhaetian (GAŹDZICKI and MICHALIK 1980).

DISTRIBUTION OF FORAMINIFERS AND ASSOCIATED BIOTA

A detailed analysis of distribution of foraminifers and associated biota in deposits of the Upper Triassic and Lower Jurassic covers eight sections (figs 5–12) representing different paleotectonic-facies units in the West Carpathians (fig. 2). Sedimentary sequences and frequency distribution of foraminifers in the sections studied are given separately for Upper Triassic and Lower Jurassic.

Upper Triassic sequences

Foraminifers are especially numerous in rocks of the uppermost Triassic in the Fatricum, Hronicum and Silicicum but they are also present in the Tatricum in the Tatra Mts.

Tatricum. — The uppermost Triassic deposits of this unit in the Tatra Mts are developed either as clastic complex with plant remains (Tomanová Formation) or clastic-carbonate rocks with marine fauna (RADWAŃSKI 1968, MICHALÍK *et al.* 1976, MICHALÍK 1980). Foraminifers were found in clastic-carbonate complex in Mt. Kopieniec Staroroboċiański section only (3), where they are represented by single, poorly preserved tests of the genus *Frondicularia*, occurring in sandy biomicrites. Moreover, RADWAŃSKI (1968) reported the presence of *Lenticulina*

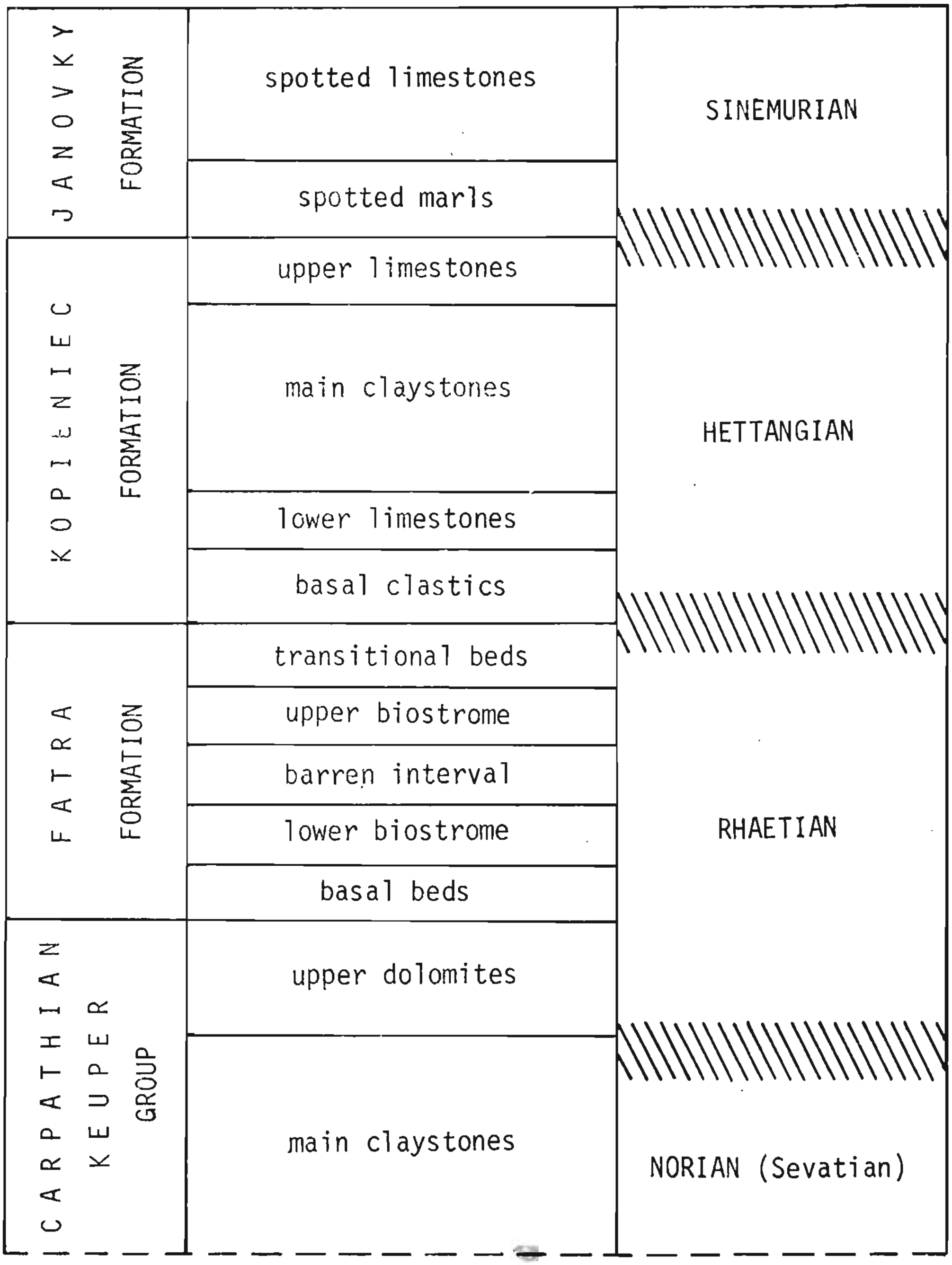

Fig. 3
Lithostratigraphic subdivision of the Upper Triassic and Lower Jurassic sequence of the Fatricum in the West Carpathians.

sphaerica KÜBLER and ZWINGLI, *Frondicularia woodwardi* HOWCHIN and *Cornuspira* sp. from the Za Kiczerem Valley section but the latter are without any greater stratigraphic value.

Fatricum. — In that paleotectonic-facies unit, the Upper Triassic sequence is represented by the Carpathian Keuper Group and Fatra Formation (figs 2–3). Rocks of that age are cropping out in several places in the West Carpathians of Slovakia and Poland (fig. 1, see also GOETEL 1917, MICHALÍK 1973, 1974, 1977, 1978*a*, *b*, GAŹDZICKI 1974, GAŹDZICKI *et al.* 1979*b*). The sequence is here characterized in reference to the Mt. Velká Furkaska section (17) in the Tatra

Crinoidal limestones of Lower Lias		HETTANGIAN
NOROVICA FORMATION	Mojtin Limestone Member	RHAETIAN
	Siwa Woda Limestone Member	
	Lower Limestone Member	?NORIAN (Sevatian)
Hauptdolomit		NORIAN CARNIAN

Fig. 4
Lithostratigraphic subdivision of the uppermost Triassic sequence of the Hronicum in the West Carpathians.

Mts and Križna Valley section (12) in the Velká Fatra Mts (figs. 5–6). Foraminifers are exceptionally rare in rocks of the Carpathian Keuper Group, except for upper dolomites in the Mt. Velká Furkaska section (17). In that locality, numerous representatives of *Agathammina austroalpina* Kristan-Tollmann and Tollmann (pl. 37: 1–5), were found to occur along with single ostracodes in dolomicrite matrix. Foraminifers were also found in the Lejowa Valley I section (18) in identical stratigraphic position. The findings are worth noting as these are first records of foraminifers in the Carpathian Keuper Group.

The overlying Fatra Formation comprises dark-gray compact organodetrital limestones with intercalations of loferitic dolomites, marls, and shales rich in faunal remains (figs 5–6, see also Goetel 1917, Gaździcki 1974, Michalík and Jendrejáková 1978, Michalík 1978*a*, *b*). The Formation was subdivided into some informal lithostratigraphic units: basal beds, lower biostrome, barren interval, upper biostrome, and transitional beds (figs. 3, 5–6; see also Michalik *et al.* 1979, Gaździcki *et al.* 1979*b*).

Rich foraminifer assemblages comprising representatives of the families Ammodiscidae and Involutinidae mainly occur in lower and upper biostromes (see figs 5–6). In subordinate amount, there also occur Tetrataxidae, Miliolidae and Nodosariidae, whereas associations comprising the highest numbers of individuals are formed by *Glomospirella friedli* Kristan-Tollmann (pl. 27: 1), *Triasina hantkeni* Majzon (pl. 27: 2, pl. 30: 3, 5) as well as *Aulotortus tumidus* (Kristan-Tollmann) (pl. 30: 1) and *Tolypammina gregaria* Wendt (pl. 27: 1). The foraminifers were found in organodetrital limestones, mainly brachiopod-crinoid-coral biomicrites and biosparites (pl. 27: 1–2). Some predominance of the genera *Glomospira* and *Glomospirella* is noted in rocks containing admixture of detrital quartz.

In rocks of the Fatra Formation, foraminifers are most often accompanied by algae: *Thaummatoporella parvovesiculifera* (Raineri) and *Aciculella* sp., corals: *Retiophyllia clathrata* (Emmrich), *Astraeomorpha crassisepta* Reuss and *Phacelostylophyllum robustum* Roniewicz, brachiopods mainly belonging to *Rhaetina gregaria* (Suess) and *Zugmayerella uncinata* (Schaf-

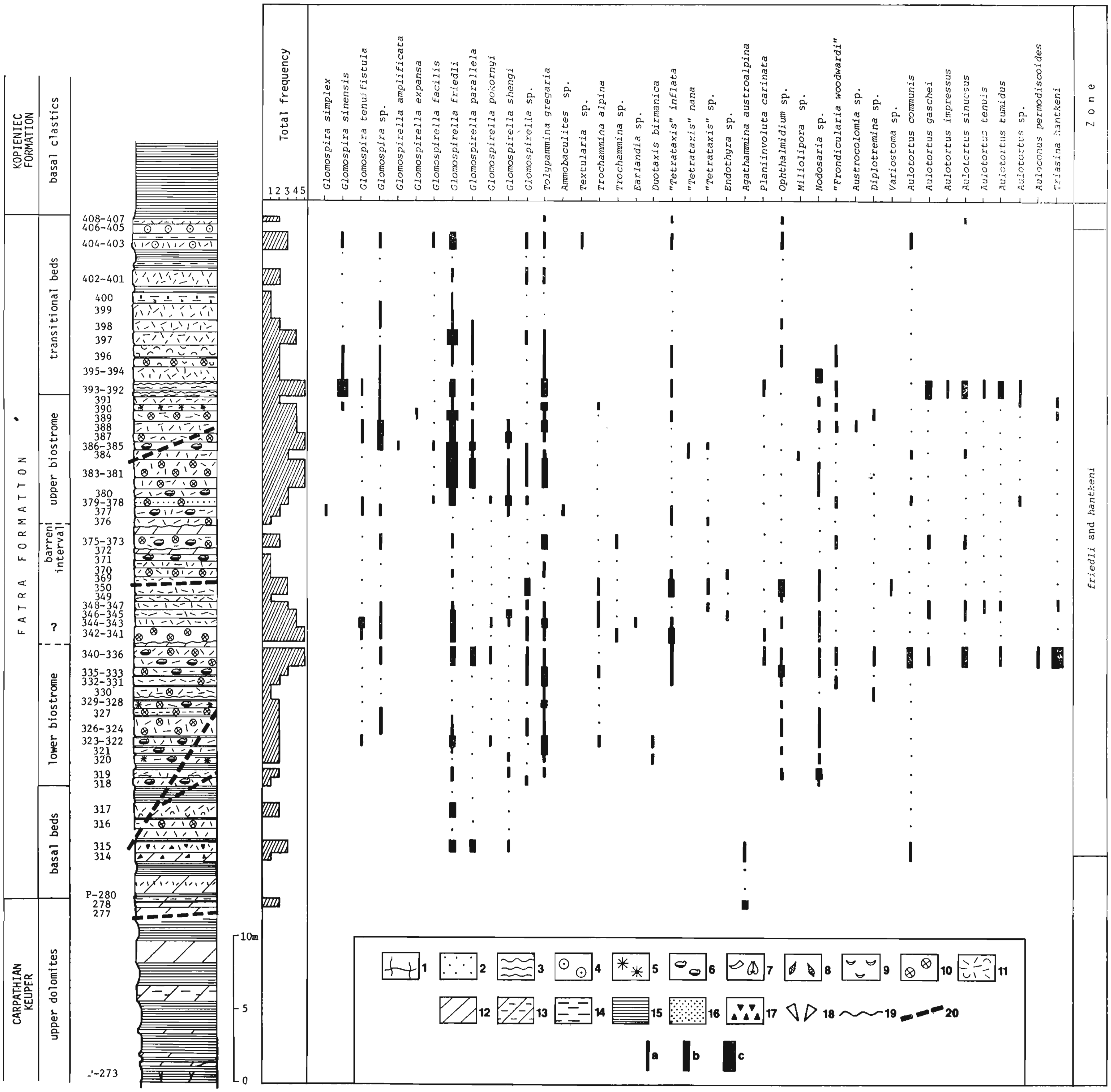

Fig. 5

Detailed section of the Carpathian Keuper and the Fatra Formation (Upper Triassic) at the Velká Furkaska Mt., West Tatra Mts.; the section (17 in fig. 1) comprises lithology as well as frequency and distribution of foraminifers

Lithology: *1* limestone, *2* sandy limestone, *3* nodular limestone, *4* oolitic limestone, *5* coral limestone, *6* brachiopod limestone, *7* *Megalodon* limestone, *8* gastropod limestone, *9* lumachelles, *10* crinoid limestone, *11* organodetrital limestone, *12* dolomite, *13* loferitic dolomite, *14* marl, *15* marly shale, *16* sandstone, *17* breccia, *18* belemnites, *19* erosion surfaces, *20* dislocations

Total frequency of foraminifers: 1:1–10 specimens, 2:11–30 specimens, 3:31–50 specimens, 4:51–70 specimens, 5: more than 70 specimens in thin section from a given layer.

Distribution of foraminifers presenting number of specimens of a definite species or genus in thin section from a given layer: *a* — rare (1–5 specimens), *b* — frequent (6–25 specimens), *c* — abundant (more than 25 specimens).

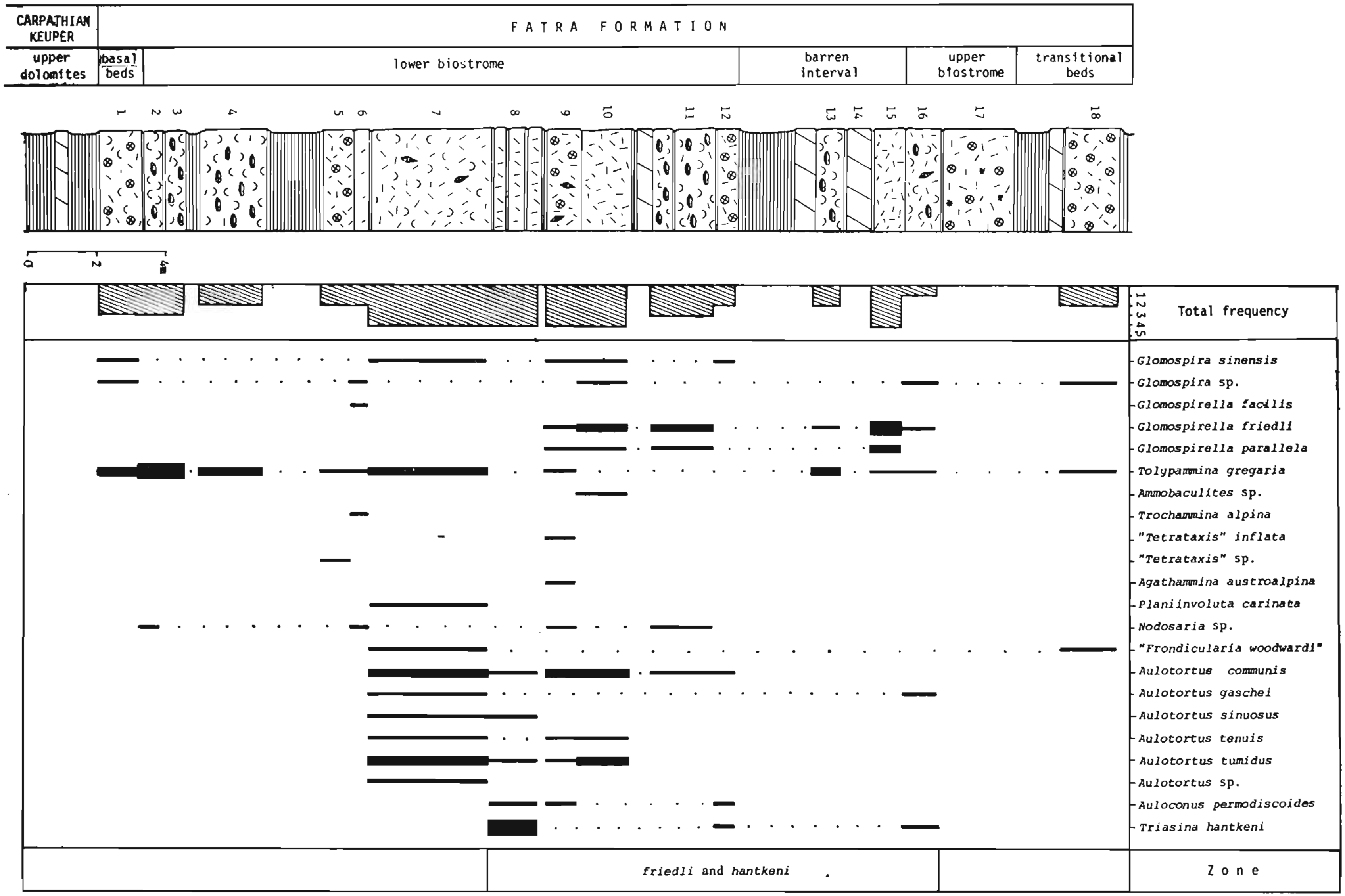

Fig. 6

Detailed section of the Fatra Formation (uppermost Triassic) in the Križna Valley, Velká Fatra Mts. (12 in fig. 1); explanations as for fig. 5.

HÄUTL) and pelecypods: *Chlamys winkleri* STOPPANI, *Lopha haidingeriana* (EMMRICH) and *Placunopsis alpina* WINKLER (comp. MICHALÍK and JENDREJÁKOVÁ 1978, GAŹDZICKI *et al.* 1979*b*, MICHALIK *et al.* 1979).

Hronicum. — The uppermost Triassic deposits in the Hronicum of the West Carpathians are fragmentarily preserved (figs. 1–2). These are mostly light-grey, compact, organodetrital limestones resembling Dachstein Limestones. The sequence is assigned to the Norovica Formation (GAŹDZICKI and MICHALÍK 1980). Only in Hybe section (Hybe Beds), the uppermost Tria-

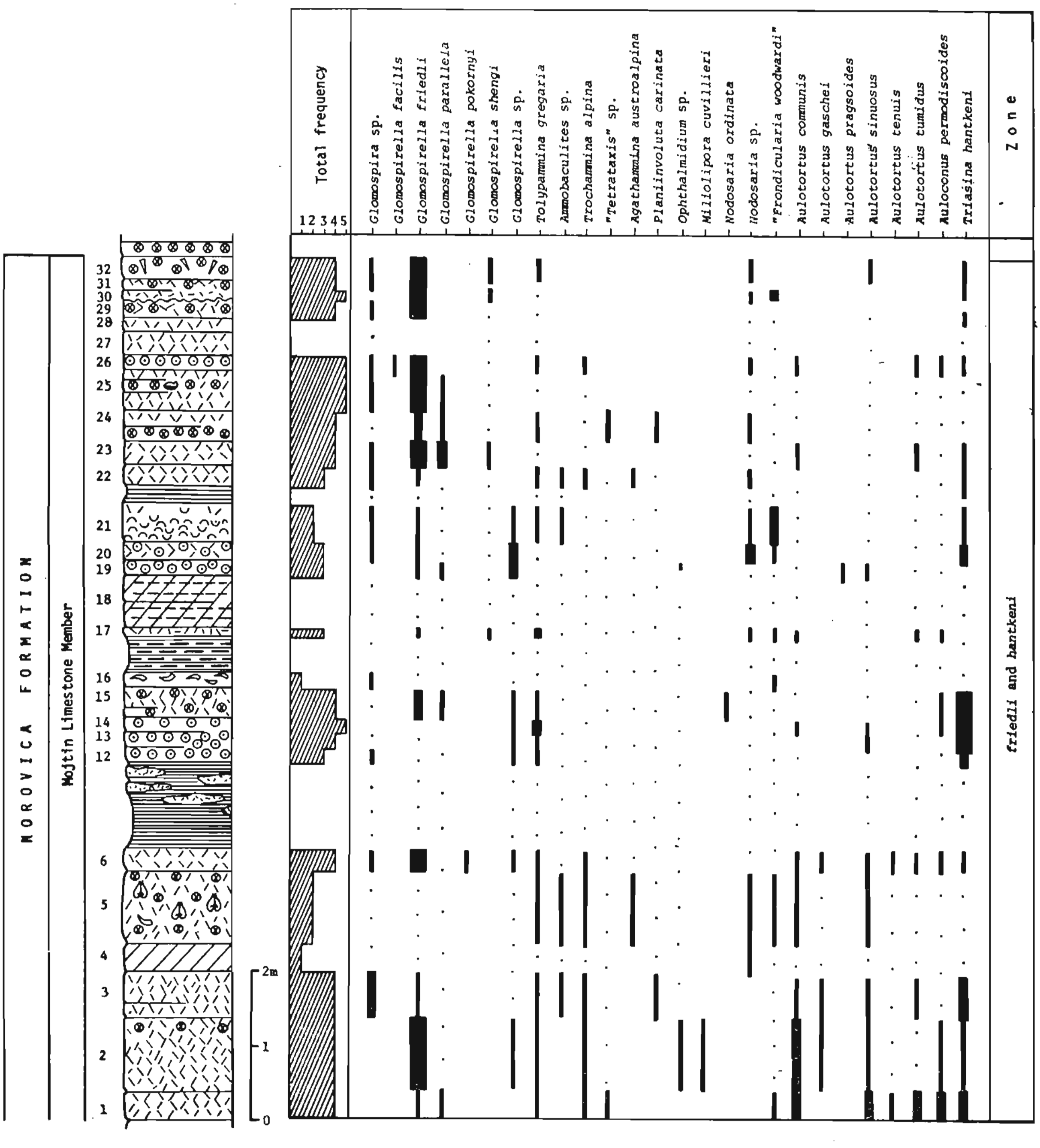

Fig. 7
Detailed stratotype section of the Norovica Formation (uppermost Triassic) at the Norovica Mt., Strážovská hornatina Mts. (22 in fig. 1); explanations as for fig. 5.

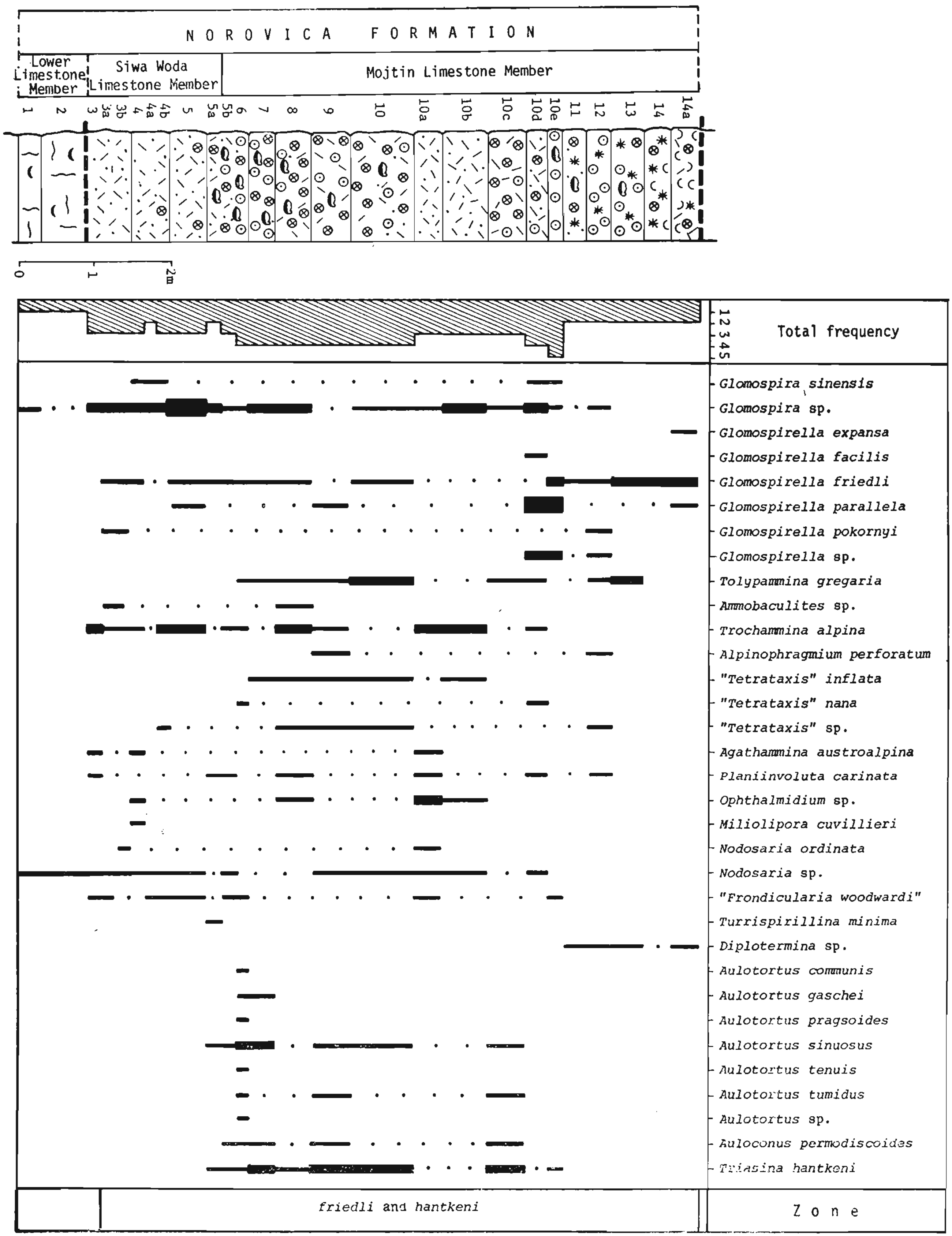

Fig. 8

Detailed hypostratotype section of the Norovica Formation (uppermost Triassic) in the Chochołowska Valley, West Tatra Mts. (26 in fig. 1); explanations as for fig. 5.

ssic strata are represented by dark limestones intercalated by marls and marly shales (STACHE 1868, MICHALIK 1973, GAŹDZICKI *et al.* 1979*a*).

Sedimentary sequence and frequency distribution of foraminifers in Norovica Formation is presented in reference to Mt. Norovica section (22) in the Strážovská hornatina Mts (fig. 7) and Chochołowska Valley section (26) in the Tatra Mts (fig. 8). Foraminifers were found in both Siwa Woda Limestone and Mojtin Limestone Members (figs. 7–8).

In the Chochołowska Valley section (26), sandy biopelsparites of the Siwa Woda Limestone Member yield innumerous foraminifers identified as *Glomospira* sp., *Trochammina alpina* KRISTAN-TOLLMANN, *Agathammina austroalpina* KRISTAN-TOLLMANN and TOLLMANN, *Nodosaria* sp., and very rare *Glomospirella friedli* KRISTAN-TOLLMANN (fig. 8). *Triasina hantkeni* MAJZON appears at the top of this member. It is worth to note that *Triasina hantkeni* co-occurs in the uppermost part of this member with stratigraphically important conodonts *Misikella posthernsteini* KOZUR and MOCK (see GAŹDZICKI 1978*a*, *b*; GAŹDZICKI and MICHALIK 1980). This is the first locality where these fossils so important for stratigraphy of the uppermost Triassic made their appearance.

Very rich foraminifer assemblages comprising representatives of the families Involutinidae and Ammodiscidae were encountered in crinoid-brachiopod oosparites of the Mojtin Limestone Member (figs. 7–8). Here the abundant associations of *Triasina hantkeni* MAJZON (pl. 28: 2, pl. 30: 4) and *Glomospirella friedli* KRISTAN-TOLLMANN (pl. 28: 1) were also found. It should be noted that the frequence of involutinids in those rocks is incomparably higher than in the remaining uppermost Triassic sequences in the West Carpathians.

Besides the above mentioned conodonts *Misikella posthernsteini* KOZUR and MOCK, the fossils accompanying foraminifers (see figs. 7–8) most often include algae *Aciculella* sp., corals *Phacelostylophyllum robustum* RONIEWICZ, and *Cyathocoenia schafhautli* (WINKLER), brachiopods *Rhaetina gregaria* (SUESS) and *Zugmayerella uncinata* (SCHAFHÄUTL), and pelecypods *Atreta intusstriata* (EMMRICH), *Rhaetavicula contorta* (PORTLOCK) and *Placunopsis alpina* WINKLER (see GAŹDZICKI and MICHALÍK 1980).

HYBE (25) is the best known locality of so called "Kössen Beds" in the Slovak Carpathians, a classical locality on account of its rich fauna (GOETEL 1917, KOUTEK 1927, MICHALÍK 1973, 1975, 1976, 1977b). The Upper Triassic sequence is represented here (fig. 9) by Hauptdolomit of Carnian and Norian age, bedded light-grey Dachstein Limestone (Norian), and the Hybe Beds — consists of black limestones and marls with rich Rhaetian fauna.

In this sequence the following foraminifers were found (for location of samples see fig. 9).

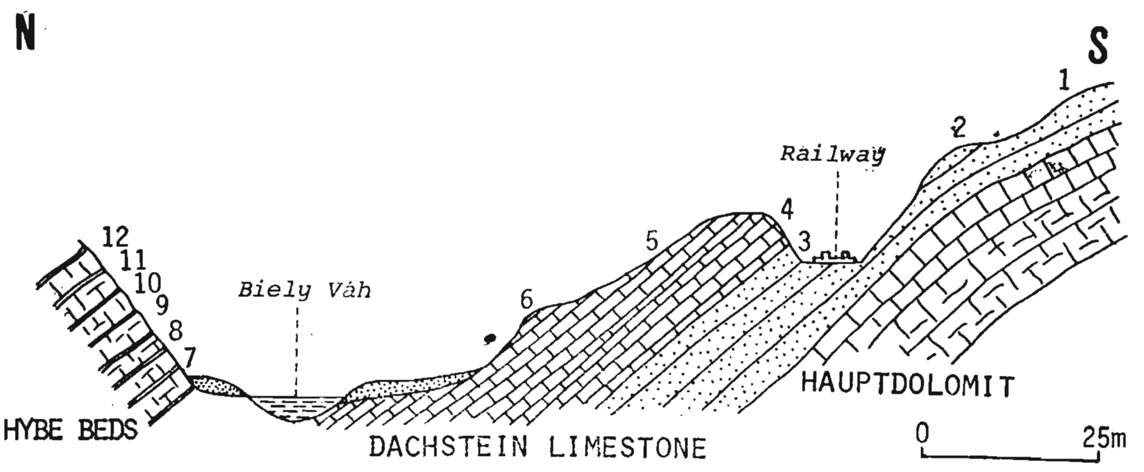

Fig. 9
Section of the Upper Triassic deposits near Hybe, Nizke Tatry Mts. (25 in fig. 1); numbers denote the sampling sites. Section adopted from KOUTEK 1927.

Samples 1–3 (biopelmicrites) yielded:

Aulotortus sp.
Aulotortus gaschei (KOEHN-ZANINETTI and BRÖNNIMANN)

Samples 4–8 (mainly biooosparites) yielded:

Trochammina alpina KRISTAN-TOLLMANN
Alpinophragmium perforatum FLÜGEL
Agathammina austroalpina KRISTAN-TOLLMANN and TOLLMANN
Miliolipora cuvillieri BRÖNNIMANN and ZANINETTI
Nodosaria ordinata TRIFONOVA
Aulotortus communis (KRISTAN)
Aulotortus gaschei (KOEHN-ZANINETTI and BRÖNNIMANN)
Aulotortus tenuis (KRISTAN)
Triasina oberhauseri (KOEHN-ZANINETTI and BRÖNNIMANN (fig. 21a, b)
Auloconus permodiscoides (OBERHAUSER)

Such association of foraminifers suggests the Norian (?Sevatian) (*Triasina oberhauseri* Zone) age of rocks bearing them.
Samples 9–12 (brachiopod-crinoid biosparite) yielded:

Glomospirella friedli KRISTAN-TOLLMANN
Glomospirella pokornyi (SALAJ)
Glomospirella parallela KRISTAN-TOLLMANN
Trochammina alpina KRISTAN-TOLLMANN
Tetrataxis inflata KRISTAN
Agathammina austroalpina KRISTAN-TOLLMANN and TOLLMANN
Miliolipora cuvillieri BRÖNNIMANN and ZANINETTI
Planiinvoluta carinata LEISCHNER
Nodosaria ordinata TRIFONOVA
Lingulina aff. *placklensis* KRISTAN-TOLLMANN
Aulotortus communis (KRISTAN)
Aulotortus gaschei (KOEHN-ZANINETTI and BRÖNNIMANN)
Aulotortus tumidus (KRISTAN-TOLLMANN)
Aulotortus sinuosus WEYNSCHENK
Triasina oberhauseri KOEHN-ZANINETTI and BRÖNNIMANN
Auloconus permodiscoides (OBERHAUSER)

The foraminifer association is indicative of the Rhaetian age — *Glomospirella friedli* and *Triasina hantkeni* Zone as defined here. However, it should be noted that one of the index fossils, *Triasina hantkeni* MAJZON, is still unknown from the Hybe section (see GAŹDZICKI 1978*b*, GAŹDZICKI *et al.* 1979*a*).

Hybe Beds yield rich assemblages of brachiopods, pelecypods, corals and echinoderms (GOETEL 1917, MICHALÍK 1973, 1975, 1976, 1977*b*). Moreover, ammonites *Arcestes* (*Rhaetites*) cf. *rhaeticus* CLARK and conodonts *Misikella posthernsteini* KOZUR and MOCK, were found in this sequence (ANDRUSOV 1934, MAJERSKÁ 1973).

Silicicum. — In this region, the uppermost Triassic is represented by Bleskový prameň Limestone and Zlambach Beds (fig. 2).

The Bleskový prameň Limestone forms lenses of grey crinoidal limestones above top part of the Furmanec Limestone near Drnava in Slovenský kras (fig. 10). These crinoid-coquinal limestones contain rich macrofaunal assemblages composed mainly of brachiopods, pelecypods and cephalopods (KOLLÁROVÁ-ANDRUSOVOVÁ and KOCHANOVÁ 1973, MELLO 1974).

The following foraminifers were found (sampling as shown in fig. 10).

Glomospirella sp.
Ammobaculites sp. (pl. 36:14)
Tolypammina gregaria WENDT

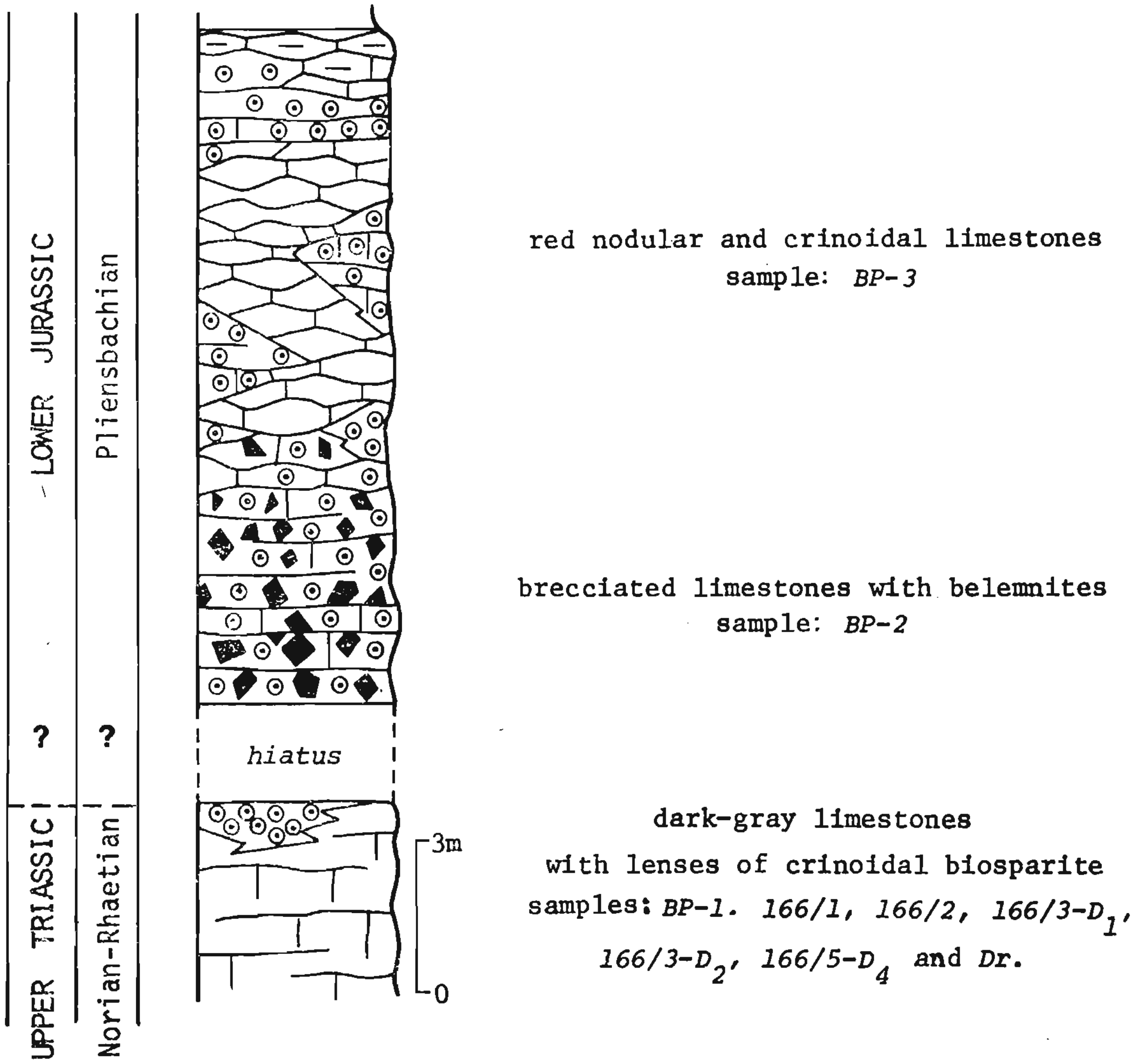

Fig. 10
Section of the Upper Triassic and Lower Jurassic deposits at Bleskový prameň, Slovenský kras (32 in fig. 1). Section adopted from MELLO and BYSTRICKÝ, 1973.

Trochammina alpina KRISTAN-TOLLMANN
Agathammina austroalpina KRISTAN-TOLLMANN and TOLLMANN
Planiinvoluta carinata LEISCHNER
Ophthalmidium "carinatum" (LEISCHER)
Ophthalmidium cf. *carpathicum* (GAŹDZICKI) (pl. 37:11)
Ophthalmidium martanum (FARINACCI) (pl. 37:12)
Galeanella cf. *tollmanni* (KRISTAN) (pl. 37:15).
Miliolipora cuvillieri BRÖNNIMANN and ZANINETTI
Diplotremina sp.
Aulotortus communis (KRISTAN)
Aulotortus gaschei (KOEHN-ZANINETTI and BRÖNNIMANN)
Aulotortus tenuis (KRISTAN)
Involutina turgida KRISTAN
Triasina hantkeni MAJZON
Auloconus permodiscoides OBERHAUSER

The presence of the species *Galeanella* cf. *tollmanni*, *Involutina turgida* and *Triasina hantkeni* indicates the Rhaetian age of Bleskový prameň Limestone (*sensu* GAŹDZICKI *et al.* 1979*a*).

The Malý Mlynský vrch is the best locality of Zlambach Beds in the Slovenský kras (figs. 1–2, see also MOCK 1973). These deposits comprise grey marly pelmicrites and marly and sandy shales. Conodonts and holothurian sclerites are listed in MOCK (1973) and KOZUR and MOCK (1974*a*, *b*). Cephalopods are represented here by the genus *Choristoceras*. The rocks range in age from the Norian (Sevatian) to Rhaetian (see GAŹDZICKI *et al.* 1979*a*).

The following foraminifers were found

Glomospirella cf. *pokornyi* (SALAJ)
Tolypammina gregaria WENDT
Trochammina alpina KRISTAN-TOLLMANN (pl. 36:7)
Ammobaculites sp.
Planiinvoluta carinata LEISCHNER
Agathammina austroalpina KRISTAN-TOLLMANN and TOLLMANN
Agathammina? *iranica* ZANINETTI, BRÖNNIMANN, BOZORGNIA and HUBER
Ophthalmidium "*carinatum*" (LEISCHNER)
Ophthalmidium carpathicum (GAŹDZICKI) (pl. 37:9–10)
Ophthalmidium martanum (FARINACCI)
Ophthalmidium triadicum (KRISTAN)
Nodosaria sp.
Austrocolomia cf. *rhaetica* OBERHAUSER
Turrispirillina cf. *minima* PANTIĆ

In this sequence, involutinids are missing. This may be explained by differences in facies development.

Lower Jurassic sequence

Foraminifers are fairly numerous in Lias rocks of the Fatricum and Silicicum. They were also found in Lias sequences of the Tatricum in the Velká Fatra Mts and Tatra Mts.

Tatricum. — Lias rocks of that unit were studies in the Rúbaň Skala section (1), the Velká Fatra Mts (fig. 1, see also SÝKORA 1975; POLAK 1978). Here mainly crinoid biomicrites with foraminifer assemblages comprising *Involutina liassica* (JONES), *Trocholina umbo* FRENTZEN, numerous nodosariids (*Nodosaria*, *Frondicularia*, *Astacolus*, and *Lenticulina*), *Ophthalmidium leischneri* (KRISTAN-TOLLMANN), and *Ophthalmidium* sp. (pl. 29:1) occur. Attention should be paid to the presence of *Ophthalmidium leischneri* — the index fossil of *leischneri* and *walfordi* Zone (Hettangian — ?Sinemurian). This was the first locality in which that species made their appearance in the Tatricum region.

Foraminifers are accompanied by rich fauna of pelecypods including *Eopecten rollei* (STOLICZKA), *Plagiostoma punctata* SOWERBY, and *Entolium lunare* (ROEMER), and brachiopods — *Lobothyris punctata* (SOWERBY), *Spiriferina alpina* OPPEL, and *Spiriferina pinguis* (OPPEL), confirming the Hettangian — Sinemurian age of the rocks bearing them (see SÝKORA 1975).

In the Tatra Mts. Lias rocks are known, among others from following outcrops: Mt. Bobrowiec (2), Mt. Kopieniec Staroroboclański (3), Mt. Dudziniec (4), and Kobyla Głowa crag (5) (fig. 1, see also RADWAŃSKI, 1959; WÓJCIK 1979, 1981). They are represented by sandy biopelsparites and crinoid biosparites. Foraminifers are very rare here, being represented by *Glomospira* sp. (pl. 39:14), *Textularia* sp. and nodosariids (*Nodosaria*, *Frondicularia*, and *Lenticulina*), which do not have a stratigraphic value.

Fatricum. — In this unit, the Lower Lias is represented by detrital rocks: marly shales and quartz sandstones with marly and limestone intercalations (GOETEL 1917; MIŠIK 1964; GAŹDZICKI 1975), assigned to the Kopieniec and Janovky Formations (fig. 3, see also GAŹDZICKI *et al.* 1979*b*). The Kopieniec Fm. rests in sedimentary continuity on the Fatra Fm. It is subdivided into the following informal lithostratigraphic units: basal clastics, lower limestones, main claystones, and upper limestones (figs. 3, 11–12; see also GAŹDZICKI *et al.* 1979*b*).

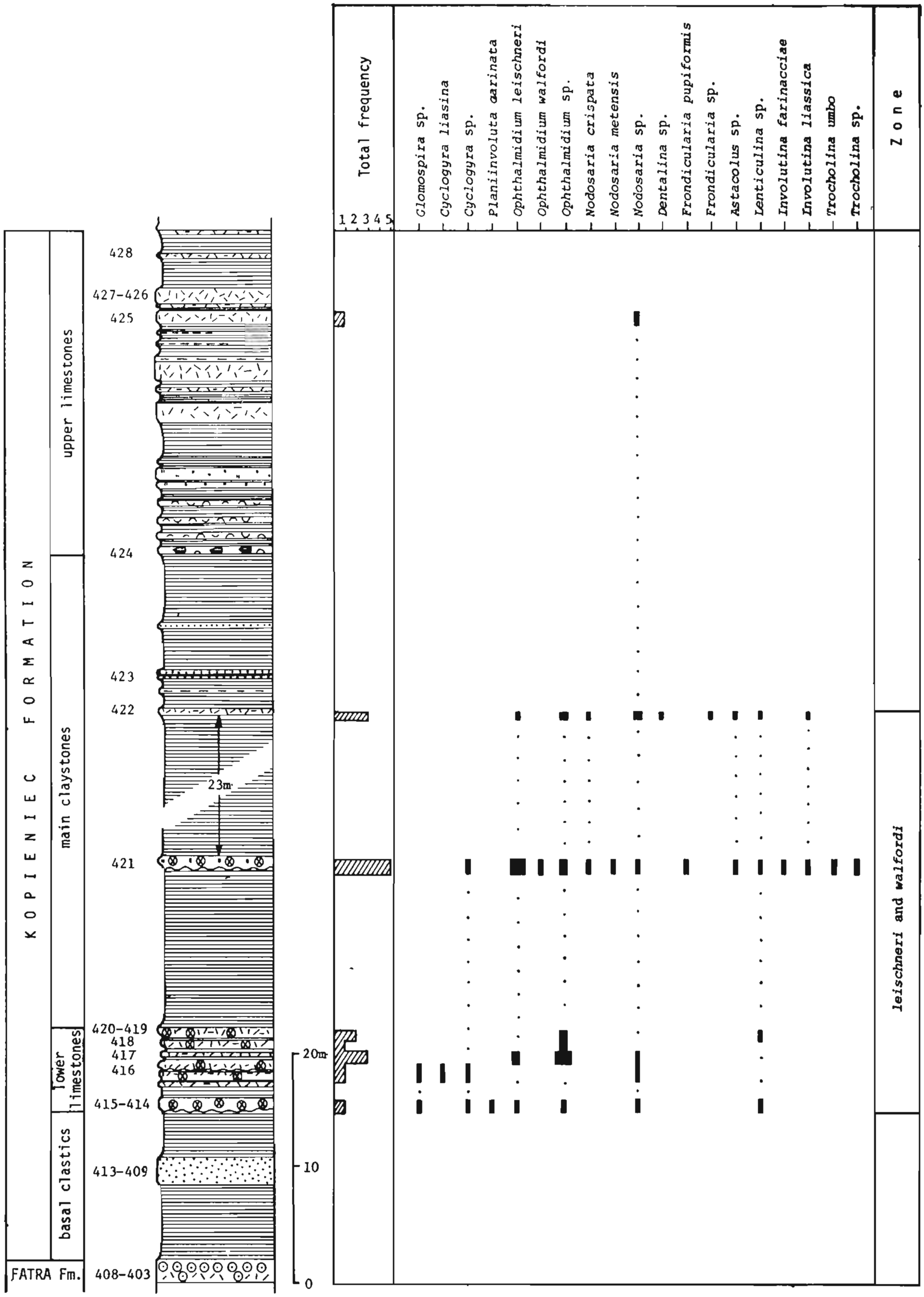

Fig. 11
Detailed section of the Kopieniec Formation (Lower Liassic) at the Velká Furkaska Mt., West Tatra Mts. (17 in fig. 1); explanations as for fig. 5.

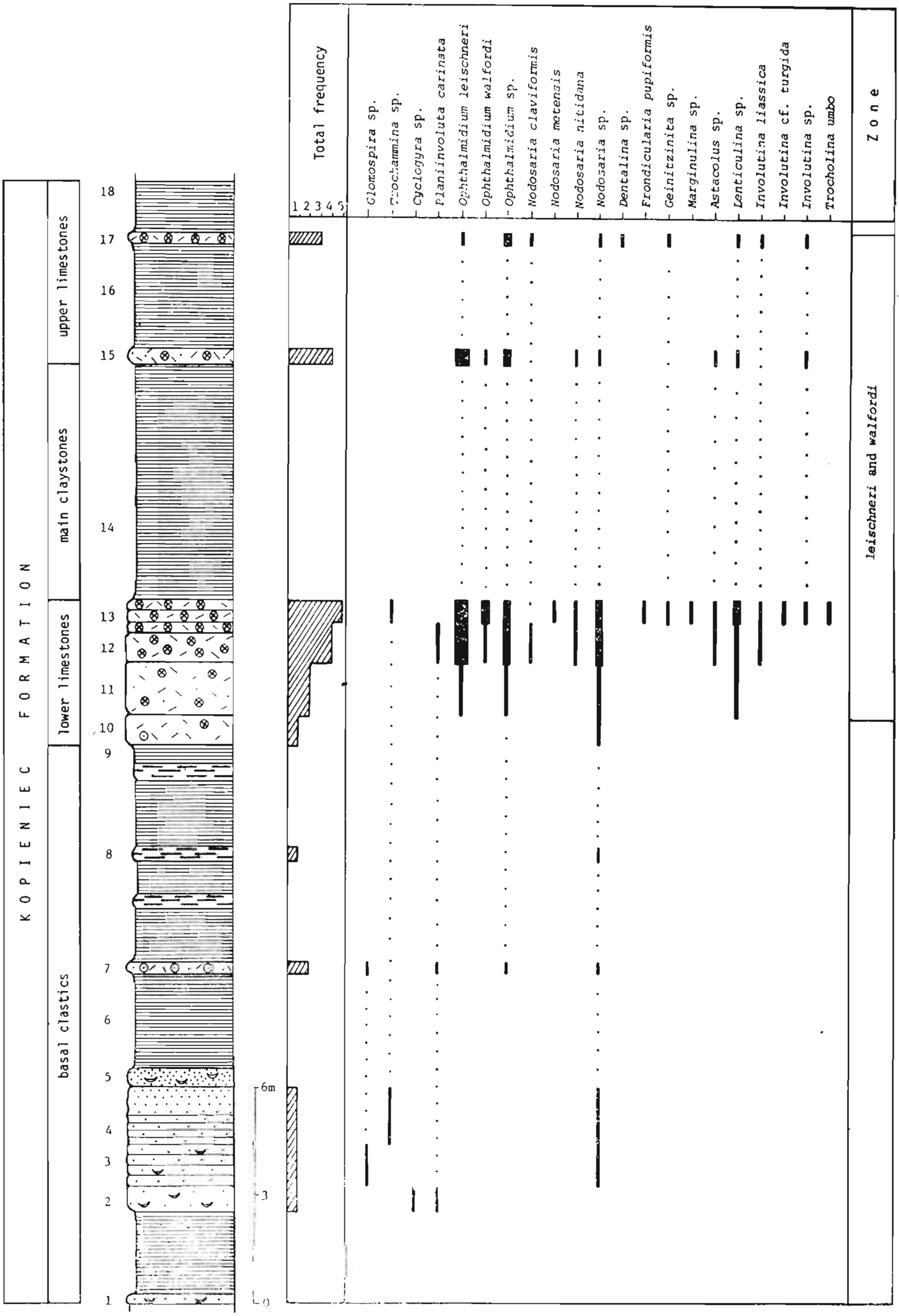

Fig. 12

Detailed section of the Kopieniec Formation (Lower Liassic) in the Strążyska Valley II, Tatra Mts. (21 in fig. 1); explanations as for fig. 5.

The sedimentary sequence was characterized in reference to the Mt. Velká Furkaska (17) and Strążyska Valley II (21) sections in the Tatra Mts (figs. 11–12). Foraminifers are most common in lower and upper limestones of the Kopieniec Formation especially in crinoid-biopelmicrites (pl. 29:2), being represented by the families Miliolidae, Nodosariidae and Involutinidae. Here predominate *Ophthalmidium leischneri* (KRISTAN-TOLLMANN), *Ophthalmidium walfordi* HÄUSLER, *Involutina liassica* (JONES), *Involutina farinacciae* BRÖNNIMANN and KOEHN-ZANINETTI, *Trocholina umbo* FRENTZEN and nodosariids are fairly common (figs 11–12). The co-occurring fauna includes *Gryphea arcuata* LAMARCK and *Pentacrinus* cf. *tuberculatus* MILLER (see GAŹDZICKI 1975) as well as numerous ostracodes.

Silicicum. — In that unit, Lias rocks are known to occur in the Bleskový prameň and Miglinc localities (fig. 1). In lower parts, they are represented by brecciated limestones with belemnites, passing upwards into red nodular and crinoidal limestones (fig. 10). Foraminifers mainly found in crinoidal biomicrites (pl. 29:3), include nodosariids (*Nodosaria*, *Lenticulina*, and *Geinitzinita*) and single *Semiinvoluta* sp. (pl. 39:1) and *Trocholina turris* FRENTZEN (pl. 39:7).

TAXONOMIC COMPOSITION OF FORAMINIFER FAUNA

One hundred and four foraminifer species have been found in the investigated Upper Triassic — Lower Jurassic sequences of the Tatricum, Fatricum, Hronicum and Silicicum in the West Carpathians of Slovakia and Poland. Of these, 25 are agglutinated forms and 79 are calcareous.

The majority of the recorded species are well known from other areas of the Tethys Realm (see ZANINETTI 1976) and also from epicontinental basin of the north-western Europe (see FRANKE 1936, BROUWER 1969 and SCHLOZ 1972), and therefore they are not systematically characterized herein. The systematic part includes besides species recorded for the first time in the West Carpathians also taxa of disputable systematic position and those of correlative importance.

The majority of the investigated foraminifers are, however, figured here (pls 27–41) to show their variability and to facilitate further discussion.

The taxonomy of the recorded foraminifers follows diagnoses and remarks given by the following authors: HO 1959, KRISTAN-TOLLMANN 1961, 1963, 1964*a*, *b*, 1970; OBERHAUSER 1964, LOEBLICH and TAPPAN 1964, 1974; SELLIER de CIVRIEUX and DESSAUVAGIE 1965, KOEHN-ZANINETTI 1969, ZANINETTI 1976, SALAJ 1969*b*, 1976; SALAJ *et al.* 1967, PAZDRO 1972, GUŠIĆ 1975, HOHENEGGER and PILLER 1975, 1977, TAPPAN 1976, and PILLER 1978.

Upper Triassic

In the studied Norian-Rhaetian rocks, 65 species were identified and assigned to 16 families and 29 genera. Calcareous forms predominate here (43 species), being accompanied by the agglutinated ones (22 species).

The Upper Triassic (Norian-Rhaetian) foraminifer assemblage comprises following taxa:

Family **Ammodiscidae** REUSS, 1862

Ammodiscus multivolutus REITLINGER, 1949 — pl. 31:3.
Ammodiscus sp.
Glomospira simplex HARLTON, 1928
Glomospira sinensis HO, 1959 — pl. 31:14–15.
Glomospira tenuifistula HO, 1959
Glomospira sp. — pl. 31:10.

Glomospirella amplificata KRISTAN-TOLLMANN, 1970
Glomospirella expansa KRISTAN-TOLLMANN, 1964 — pl. 31:7–8.
Glomospirella facilis HO, 1959 — pl. 31:11–13.
Glomospirella friedli KRISTAN-TOLLMANN, 1962; emend. BRÖNNIMANN and ZANINETTI, 1970 — pl. 27:1; pl. 28: 1; pl. 32:1–6.
Glomospirella parallela KRISTAN-TOLLMANN, 1964
Glomospirella pokornyi (SALAJ, 1967) — pl. 31:1–2, 4–5.
Glomospirella shengi HO, 1959 — pl. 31:16.
Glomospirella sp. — pl. 31:6; pl. 32:7–8.
Tolypammina gregaria WENDT, 1969 — pl. 27:3; pl. 33:15; pl. 35:9; pl. 36:2–6.

Family **Lituolidae** de BLAINVILLE, 1825

Ammobaculites rhaeticus KRISTAN-TOLLMANN, 1964 — pl. 36:17.
Ammobaculites cf. *rhaeticus* KRISTAN-TOLLMANN, 1964 — pl. 37:15.
Ammobaculites sp. — pl. 36:14, 16.

Family **Textulariidae** EHRENBERG, 1838

Textularia sp.

Family **Trochamminidae** SCHWAGER, 1877

Trochammina alpina KRISTAN-TOLLMANN, 1964 — pl. 36:7.
Trochammina sp. — pl. 36:8.
?*Trochammina* sp. — pl. 36:9.

Family **Caligellidae** REITLINGER, 1959

Alpinophragmium perforatum FLÜGEL, 1967

Family **Moravamminidae** POKORNÝ, 1951

Earlandia sp.

Family **?Tetrataxidae** GALLOWAY, 1933

Duotaxis birmanica ZANINETTI and BRÖNNIMANN, 1975
"*Tetrataxis*" *inflata* KRISTAN, 1957 — pl. 36:11–12.
"*Tetrataxis*" *nana* KRISTAN-TOLLMANN, 1964
"*Tetrataxis*" sp. — pl. 36:10, 13.

Family **Endothyridae** BRADY, 1884

Endothyra sp.

Family **Fischerinidae** MILLET, 1898

Agathammina austroalpina KRISTAN-TOLLMANN and TOLLMANN, 1964 — pl. 37:1–5.
Agathammina? *iranica* ZANINETTI, BRÖNNIMANN, BOZORGNIA and HUBER, 1972
Planiinvoluta carinata LEISCHNER, 1961 — pl. 36:1.

Family **Miliolidae** EHRENBERG, 1839

(*Ophthalmidium* KÜBLER and ZWINGLI was hitherto assigned to the family Nubeculariidae JONES 1875. However, studies on wall microstructure, the mode of coling, length of chambers in relation to whorl, and geometry of chamber interior and peristome (PAZDRO 1971), permit to classify that genus along with *Palaeomiliolina* LOEBLICH and TAPPAN to the family Miliolidae EHRENBERG).

Ophthalmidium "carinatum" (LEISCHNER, 1961)
Ophthalmidium carpathicum (GAŹDZICKI, 1979) — pl. 37: 9–10.
Ophthalmidium cf. *carpathicum* (GAŹDZICKI, 1979) — pl. 37:11.
Ophthalmidium martanum (FARINACCI, 1959) — pl. 37:12.
Ophthalmidium triadicum (KRISTAN, 1957)
Ophthalmidium sp. — pl. 11:13–14.

Family **Milioliporidae** BRÖNNIMANN and ZANINETTI, 1971

Galeanella cf. *tollmanni* (KRISTAN, 1957) — pl. 37:15.
Miliolipora cuvillieri BRÖNNIMANN and ZANINETTI, 1971
Miliolipora sp.

Family **Nodosariidae** EHRENBERG, 1838

Nodosaria ordinata TRIFONOVA, 1965
Nodosaria sp. — pl. 37:8.

"Frondicularia woodwardi" HOWCHIN, 1895 — pl. 37:6–7.
Austrocolomia cf. *rhaetica* OBERHAUSER, 1967
Austrocolomia sp.
Lingulina aff. *placklesensis* KRISTAN-TOLLMANN, 1970

Family **Variostomatidae** KRISTAN-TOLLMANN, 1963

Diplotremina sp. — pl. 37:16.
Variostoma sp.

Family **Involutinidae** BÜTSCHLI, 1880

Aulotortus communis (KRISTAN, 1957) — pl. 33:1.
Aulotortus gaschei (KOEHN-ZANINETTI and BRÖNNIMANN, 1968) — pl. 32:9–16.
Aulotortus impressus (KRISTAN-TOLLMANN, 1964) — pl. 34:4.
Aulotortus pragsoides (OBERHAUSER, 1964)
Aulotortus cf. *pragsoides* (OBERHAUSER, 1964) — pl. 34:1.
Aulotortus sinuosus WEYNSCHENK, 1956 — pl. 28:2; pl. 34:2–3, 5, 7–12.
Aulotortus tenuis (KRISTAN, 1957) — pl. 33:9–11.
Aulotortus tumidus (KRISTAN-TOLLMANN, 1964) — pl. 30:1, pl. 33:3–8.
Aulotortus sp. — pl. 33:2, 13–16; pl. 34:6.
Auloconus permodiscoides (OBERHAUSER, 1964) — pl. 30:2, pl. 35:1–6.
Trocholina acuta OBERHAUSER, 1964
Trocholina crassa KRISTAN, 1957
Triasina hantkeni MAJZON, 1954 — pl. 27:2; pl. 28:2; pl. 30:2–6; pl. 35:7–15.
Triasina oberhauseri KOEHN-ZANINETTI and BRÖNNIMANN, 1968 — fig. 21a, b

Family **Planispirillinidae** PILLER, 1978

?Semiinvoluta sp. — pl. 33:12.

Family indet.

Turrispirillina minima PANTIĆ, 1967

The families Ammodiscidae and Involutinidae predominate in number of both species and individuals in the above foraminifer assemblage, being represented by 15 and 14 species, respectively. A special attention should be paid to numerous associations of foraminifers: *Glomospirella friedli* KRISTAN-TOLLMANN (pl. 27:1, pl. 28:1), *Glomospirella pokornyi* (SALAJ) (pl. 31:1), *Tolypammina gregaria* WENDT (pl. 27:3), *Aulotortus tumidus* (KRISTAN-TOLLMANN) (pl. 30:1), and *Triasina hantkeni* MAJZON (pl. 27:2, pl. 30:2–6), locally of rock-forming importance. There are six species of the family Miliolidae represented by single individuals only. The family Fischerinidae is represented by three species of which *Agathammina austroalpina* KRISTAN-TOLLMANN and TOLLMANN is locally (in upper dolomites of the Carpathian Keuper Group) fairly common (pl. 37:1). The remaining families occur in subordinate numbers. It should be noted that the studied material does not comprise *Semiinvoluta clari* KRISTAN which was previously reported from the West Carpathians (Hybe and Červená Skala sections) by SALAJ (1976, pl. 1:5; 1977, pl. 5:8), SALAJ *et al.* (1967, pl. 6:1, 3) and GAŹDZICKI *et al.* (1979*a*). A thorough analysis of thin sections from Hybe has not confirmed these reports. The misidentified forms represent subaxial sections of *Aulotortus tumidus* (KRISTAN-TOLLMANN).

Lower Jurassic

In the studied Lias rocks, there were identified 39 taxa of the specific or generic rank. They are assigned to eight families and 16 genera. Calcareous forms predominate here (36 species), being accompanied by only three agglutinated taxa.

The Lower Jurassic (Hettangian — Pliensbachian) foraminifer assemblage comprises the following taxa:

Family **Ammodiscidae** REUSS, 1862

Glomospira sp. — pl. 39 : 14.

Family **Textulariidae** EHRENBERG, 1838

Textularia sp. — pl. 39 : 17.

Family **Trochamminidae** SCHWAGER, 1877

Trochammina sp. — pl. 39 : 15.

Family **Fischerinidae** MILLET, 1898

Cyclogyra liasina (TERQUEM, 1866)
Cyclogyra sp. — pl. 39 : 16.
Planiinvoluta carinata LEISCHNER, 1961 — pl. 39 : 8.
Planiinvoluta sp. — pl. 39 : 9.

Family **Miliolidae** EHRENBERG, 1839

Ophthalmidium leischneri (KRISTAN-TOLLMANN, 1962) — pl. 40:1–12.
Ophthalmidium cf. *leischneri* (KRISTAN-TOLLMANN, 1962) — pl. 39:12.
Ophthalmidium martanum (FARINACCI, 1959) — pl. 39:11.
Ophthalmidium walfordi HÄUSLER, 1887 — pl. 40:13–16.
Ophthalmidium sp. — pl. 39:10, 13.

Family **Nodosariidae** EHRENBERG, 1838

Nodosaria claviformis TERQUEM, 1866
Nodosaria cf. *claviformis* TERQUEM, 1866
Nodosaria crispata TERQUEM, 1866
Nodosaria metensis TERQUEM, 1863
Nodosaria cf. *metensis* TERQUEM, 1863 — pl. 41:1–2.
Nodosaria nitidana BRAND, 1937
Nodosaria cf. *nitidana* BRAND, 1937 — pl. 41:4.
Nodosaria sp. — pl. 41:8.
?*Nodosaria* sp. — pl. 41:9.
Dentalina sp.
Frondicularia pupiformis HÄUSLER, 1881
Frondicularia sp. — pl. 41:6.
Geinitzinita sp. — pl. 41:5.
?*Geinitzinita* sp. — pl. 41:7.
Marginulina sp.
Astacolus sp. — pl. 41:10–12.
Lenticulina sp. — pl. 41:13–16.

Family **Involutinidae** BÜTSCHLI, 1880

Involutina farinacciae BRÖNNIMANN and KOEHN-ZANINETTI, 1969 — pl. 28:13.
Involutina liassica (JONES, 1853) — pl. 29:1; pl. 38:1–12, 15.
Involutina turgida KRISTAN, 1957 — pl. 38:14.
Involutina sp. — pl. 38:16.
?*Involutina* sp. — pl. 39:2.
Trocholina umbo FRENTZEN, 1941 — pl. 39:3–4.
Trocholina cf. *umbo* FRENTZEN, 1941 — pl. 39:6.
Trocholina turris FRENTZEN, 1941 — pl. 39:7.
Trocholina sp. — pl. 39:5.

Family **Planispirillinidae** PILLER, 1978

Semiinvoluta sp. — pl. 39:1.

In this assemblage the families Nodosariidae and Involutinidae predominate in number of both species and individuals, being represented by 17 and nine species, respectively. Nodosariids are markedly diversified. Best represented in number of individuals are the genera *Nodosaria* and *Lenticulina*. Among involutinids the most important and numerous are *Involutina liassica* (JONES) and *Trocholina umbo* FRENTZEN.

The family Miliolidae is represented by the genus *Opthalmidium*. *O. leischneri* (KRISTAN-TOLLMANN) forms monotypic associations composed of large numbers of individuals and is locally of marked rock-forming value in the studied Lower Lias sequence. *Ophthalmidium* *walfordi* Häusler, was so far known only from the epicontinental basin of the north-western Europe.

The families Fischerinidae (with four genera) and Ammodiscidae, Textulariidae, Trochamminidae and Planispirillinidae (with one genus each) occur in subordinate numbers.

EVOLUTIONARY TRENDS

The character of evolutionary trends of Triassic and Early Jurassic families Involutinidae and Ammodiscidae is analysed in reference to variability in size and microstructure of test, number and arrangement of whorls and chambers as well as stratigraphic distribution in the studied sequences of the West Carpathians. Attention is also paid to evolutionary changes traceable in most important representatives of the genus *Ophthalmidium* Kübler and Zwingli.

Involutinidae. — The family comprises two-chambered forms consisting of spherical proloculus and tubular deuteroloculus, the coiling of which may be streptospiral, planispiral, oscillating or trochospiral. Segmentation of deuteroloculus first appears in the genus *Triasina* Majzon and development of umbilical masses composed of numerous pillars — in the genera *Involutina* Terquem and *Trocholina* Paalzow. Wall structure is built of numerous aragonite crystal needles, another important feature (see Hohenegger and Piller 1977*a*, Piller 1978).

Involutinids, on account of similarities in wall structure and test morphology, should be regarded as derivatives of Paleozoic family Archaediscidae Cushman 1928. The genus *Permodiscus* Dutkevich in Czernysheva 1948 (fig. 13, see also Oberhauser 1964) may represent a direct ancestor of the earliest involutinids.

Figure 13 inferred evolutionary trends of Triassic and Early Jurassic Involutinidae Bütschli from the West Carpathians. Broken lines show probable evolutionary connections.

The first link in evolutionary lineages of involutinids is *Mesodiscus eomesozoicus* (Oberhauser) which appeared in the Scythian and persisted at least till the end of the Carnian (see Gaździcki *et al.* 1975, Piller 1978). That species is characterized by planispiral coiling which may help tracing its origin back to the genus *Permodiscus*.

More advanced forms, representing the genus *Aulotortus* Weynschenk, first appeared in the Middle Triassic (Anisian). They include *A. pragsoides*, *A. sinuosus*, and *A. praegaschei*. The latter is characterized by the most primitive type of test, including streptospiral pattern of test structure, and *Aulotortus sinuosus* and *A. pragsoides* — by planispiral coiling of deuteroloculus. It should be added here that *A. sinuosus* still displays marked oscillations within the last whorls (pl. 34:7–9). It seems that the above species have evolved from the genus *Mesodiscus* in the latest Scythian.

A marked acceleration in evolution and radiation of involutinids may be noted in the Upper Triassic (Norian-Rhaetian). This is reflected by appearance of numerous new species of the genus *Aulotortus* (see fig. 13), including *A. impressus*, *A. communis*, *A. tenuis*, and *A. tumidus*. The species are characterized by planispiral pattern of test structure but they differ markedly from one another in test shape and number and arrangement of whorls. In the Norian, there also appears the genus *Triasina*. That genus is represented by highly characteristic and, at the same time, very short evolutionary line *T. oberhauseri* → *T. hantkeni*. The appearance of segmentation of deuteroloculus represents a new element in evolutionary lineage of involutinids and further evidence for progress in their radiation (see fig. 13). The above mentioned forms presumably evolved from the genus *Aulotortus* (most probably from *A. pragsoides*) in the Late Carnian.

In the Norian, trochospiral *Auloconus permodiscoides* (Oberhauser) appears. These forms

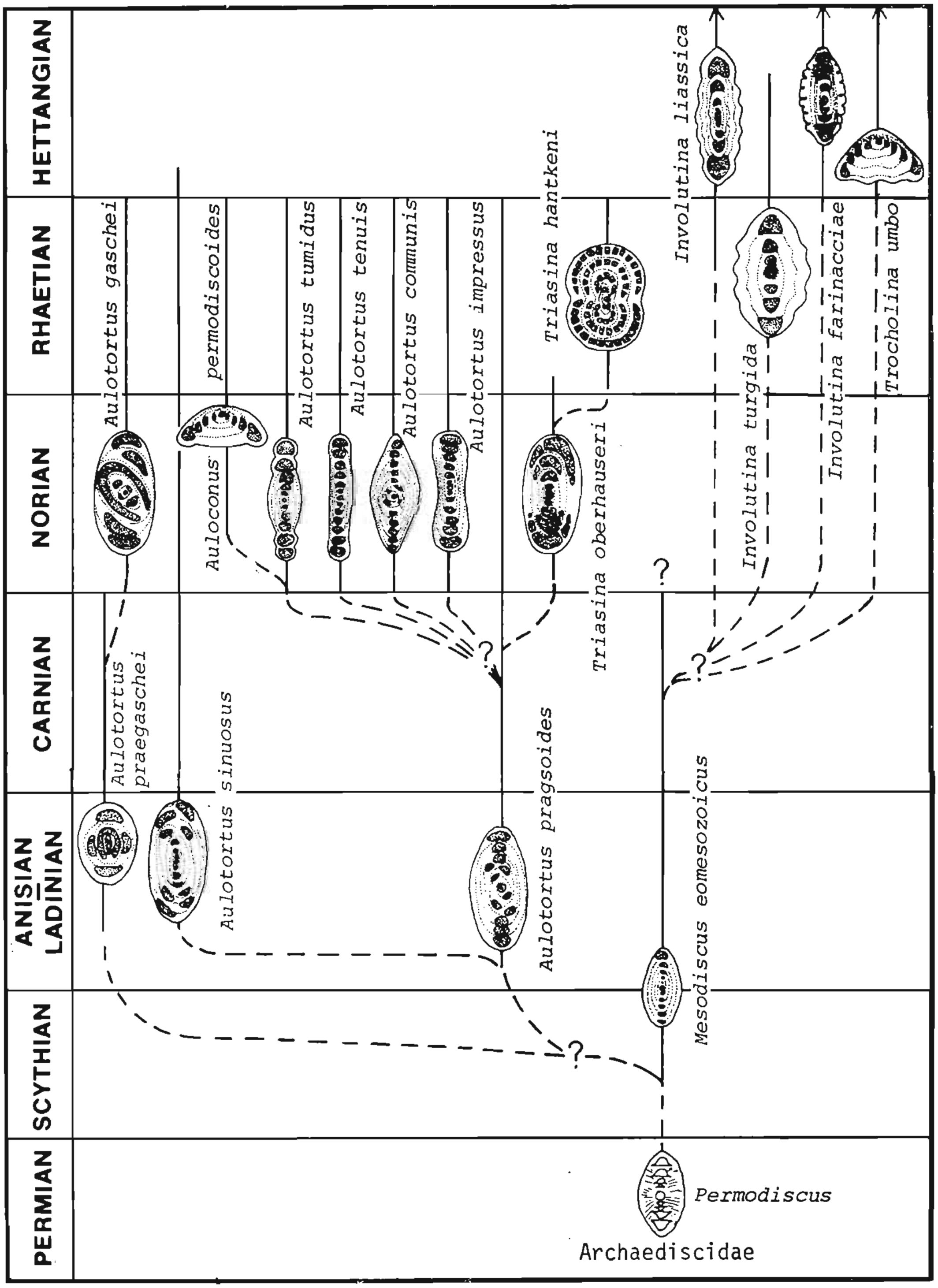

Fig. 13
Stratigraphic distribution and suggested evolutionary trends within the family Involutinidae BÜTSCHLI, 1880 in Triassic and Lower Jurassic of the West Carpathians.

may be also regarded as derivatives of the genus *Aulotortus* (most probably from the species *A. tumidus*).

The accelerated radiation of involutinids in the Norian-Rhaetian times has been followed by sudden extinction of all of them at the turn of the Rhaetian and Hettangian (= Triassic/Jurassic boundary), except for *A. sinuosus*. The crisis was also survived by a few other species of *Involutina* and *Trocholina*, which did not appear before the Late Rhaetian: e.g. *Involutina liassica*, *I. turgida*, *I. farinacciae*, and *Trocholina umbo*, known also from the Lias. The latter species are characterized by planispiral or trochospiral pattern of coiling and umbilical masses composed of numerous pillars. The appearance of pillars most probably is a new element in evolutionary line of involutinids. Both *Involutina* and *Trocholina* seem to represent derivatives of the genus *Mesodiscus*, from which they may have evolved at the turn of the Carnian and Norian.

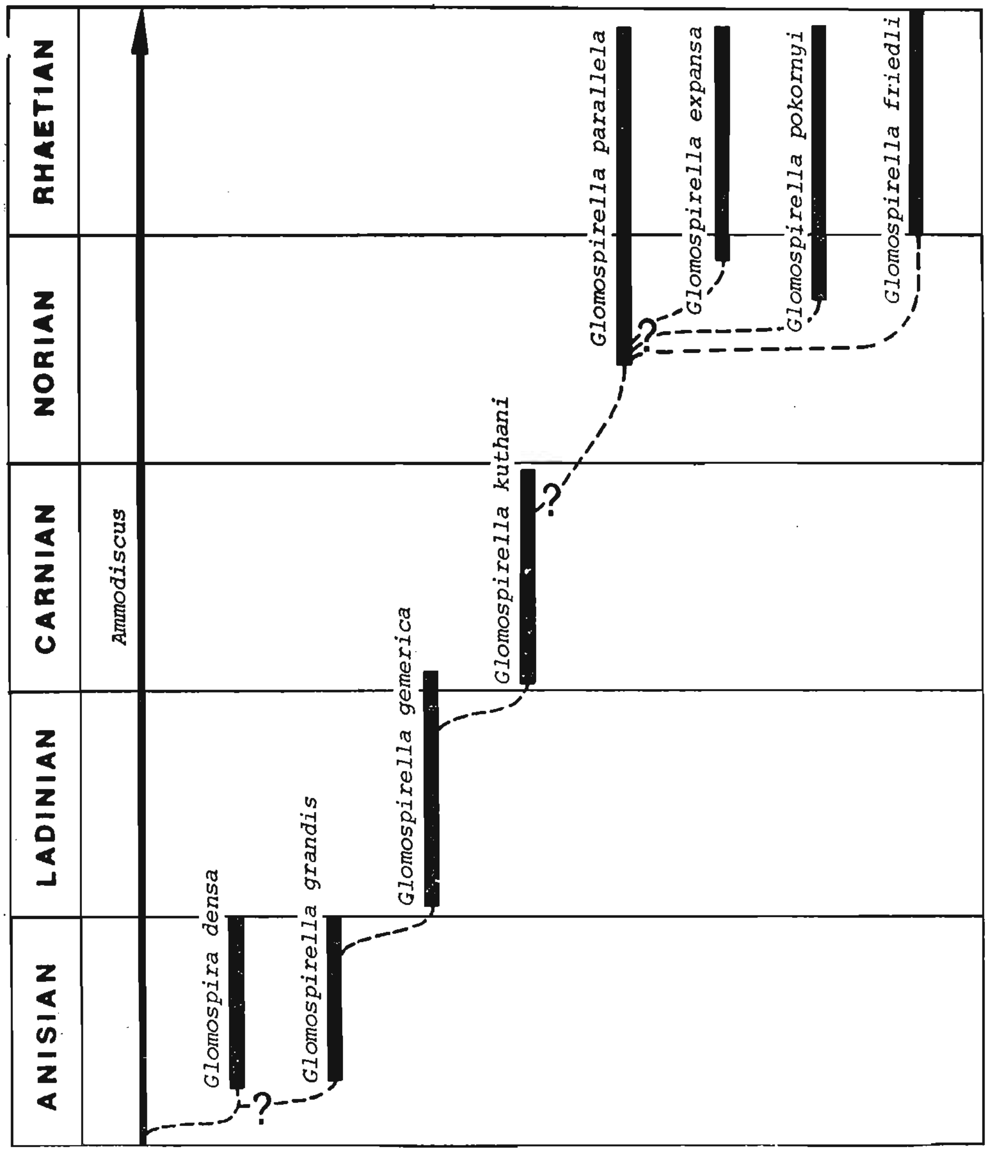

Fig. 14
Stratigraphic distribution and suggested evolutionary trends of most important Triassic representatives of the family Ammodiscidae Reuss, 1862 in the West Carpathians.

Ammodiscidae. — In analysis of that family, attention was mainly paid to the genera *Glomospira* RZEHAK and *Glomospirella* PLUMMER. They are characterized by irregular and planispiral pattern of test structure and test consisting of proloculus and undivided planispirally enrolled tubular chamber. Walls are very finelly agglutinated. The family is especially common in the Middle and Upper Triassic of the West Carpathians.

Stratigraphically significant Anisian foraminifers include *Glomospira densa* and *Glomospirella grandis* (see SALAJ *et al.* 1967, BORZA 1970, BEŁKA and GAŹDZICKI 1976), which are presumably derivatives of the genus *Ammodiscus* REUSS.

In the Ladinian-Carnian strata, Ammodiscidae are rather innumerous and of limited value, except for the representatives of *Glomospirella gemerica* and *G. kuthani* (fig. 14, see also SALAJ 1976).

Similarly as in the case of Involutinidae, the evolution of Ammodiscidae became markedly accelerated at the turn of the Norian and Rhaetian. At that time, a marked radiation took place (fig. 14) and several new species appeared: *Glomospirella parallela*, *G. expansa*, *G. pokornyi*, and finally *G. friedli* (figs. 5–9, see also MICHALÍK *et al.* 1979).

The above mentioned crisis at the turn of the Triassic and Jurassic affected also Ammodiscidae. All their species known from the Norian-Rhaetian sequences in the West Carpathians became extinct at the end of the Triassic and only innumerous *Glomospira* sp. are present in the Lower Lias (pl. 39:14).

Ophthalmidiinae. — The analysis of phylogenetic relations within this subfamily is markedly impeded by insufficient knowledge, especially in the case of Triassic forms. In the studied sections, this subfamily is primarily represented by individuals of the genus *Ophthalmidium* (fig. 15). The oldest representative of that genus in the West Carpathians is *Ophthalmidium chialingchiangensis* (HO 1959), first recorded in the Upper Scythian and known to be especially numerous in the Anisian (see GAŹDZICKI and ZAWIDZKA 1973, SALAJ 1977, 1980). That taxon presumably evolved from representatives of the Paleozoic genus *Hemigordius* SCHUBERT 1908 (see ZANINETTI and BRÖNNIMANN 1969). *Ophthalmidium tricki* (LANGER 1968) and *O. exiguum* KOEHN-ZANINETTI 1968 are known from the Anisian-Ladinian, and the latter — also from the Lower Carnian (GAŹDZICKI *et al.* 1978, SALAJ 1980).

Ophthalmidium is fairly rare in the Upper Carnian-Lower Norian strata of the West Carpathians, becoming more common and therefore of higher stratigraphic value from the Middle Norian upwards. This is connected with appearance of new species: *O. carpathicum*, *O. triadicum*, *O.* "*carinatum*" and *O. martanum*, the last two known also from the Lower Lias (fig. 15).

In the studied foraminifer assemblages from the West Carpathians, *Ophthalmidium* begin to predominate from the lowermost Lias (Hettangian-Sinemurian) upwards. The association of *O. leischneri*, often accompanied by *O. walfordi*, are especially numerous. Upper parts of the Jurassic section display maximum development of the genus *Ophthalmidium* (see PAZDROWA 1958, PAZDRO 1972).

The recognized evolutionary lineages of foraminifers are especially important for evaluating stratigraphic value of these microfossils and for better understanding of their taxonomy.

SEDIMENTARY ENVIRONMENT WITH REMARKS ON FORAMINIFERAL PALEOECOLOGY AND TAPHONOMY

In the West Carpathians, the richest associations of Upper Triassic-Lower Jurassic benthonic foraminifers were found in rocks of the Fatra and Norovica Formations, Hybe Beds, Skalka Limestone, Bleskový prameň Limestone and Kopieniec Formation. The rocks originated in relatively shallow marine environments. Such nature of the environments is evidenced by

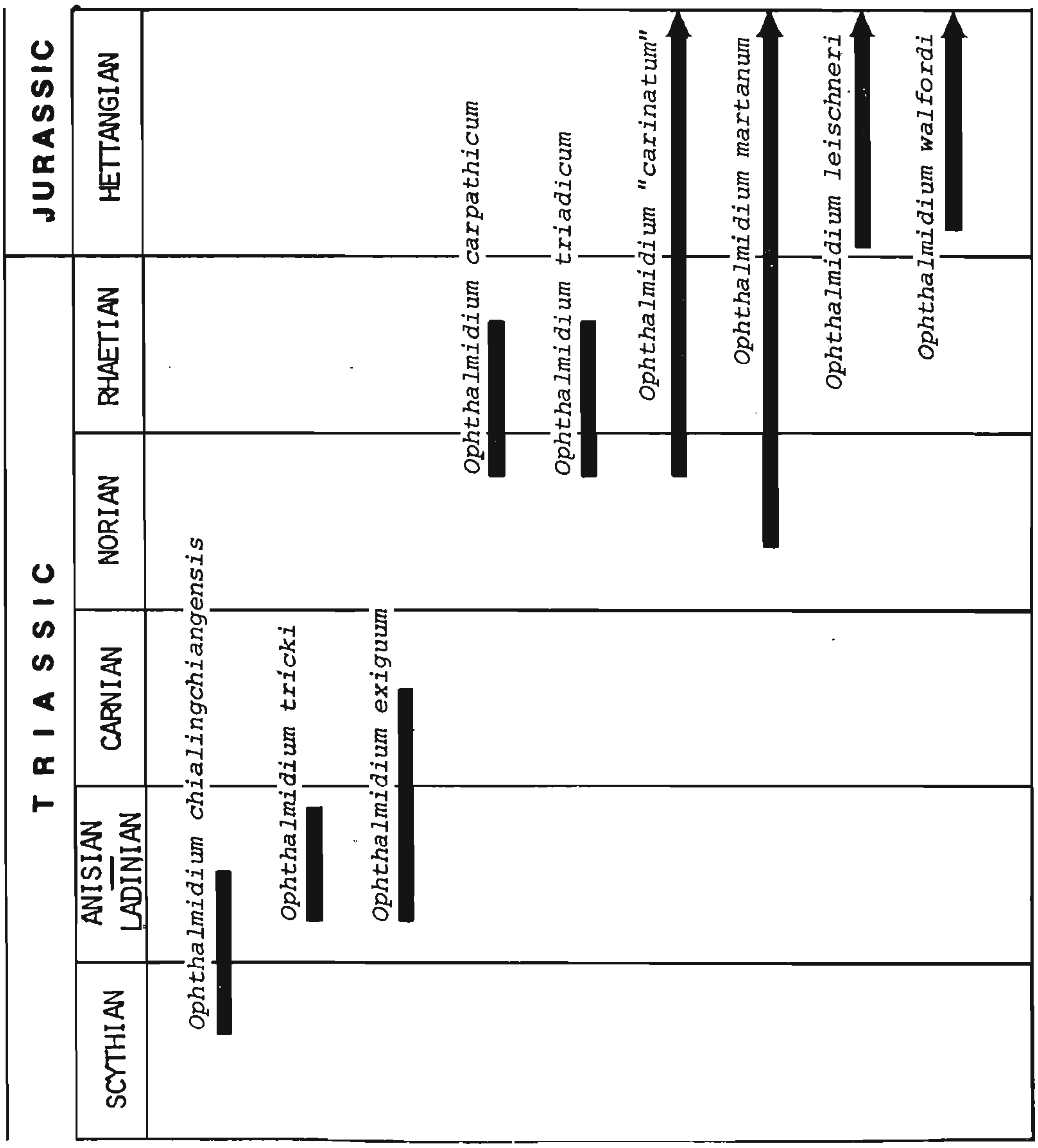

Fig. 15
Stratigraphic distribution of most important representatives of the genus *Ophthalmidium* KÜBLER and ZWINGLI, 1870 in Triassic and Lower Jurrassic of the West Carpathians.

the wealth of ooids and oncoids as well as various skeletal fragments. Among the later, there are present both fragments of sessile (sponges, corals, brachiopods, pelecypods, and crinoids) and vagile benthonic forms (gastropods, ophiuroids, echinoids and starfishes (see ČEPEK 1970, GAŹDZICKI 1974, 1975, MICHALÍK 1978*b*, MICHALÍK and JENDREJÁKOVÁ 1978, GAŹDZICKI and MICHALÍK 1980). Locally, foraminifers are the major microfaunal components of the communities (see pls. 27: 1–2, 28; 2, 29:1–2, 30:1–6). Algal coatings around bioclasts or foraminifers tests are common (pls. 27:3, 29:1–2, 38:13–15), giving further support to deposition in photic zone under shallow-marine conditions (see SELLWOOD 1978). The abundance of calcarenites is typical of shallow subtidal zone with high agitation of waters (HECKEL 1972). The general lithological character of the rocks reflects some significant facies changes, related to uplifting movements from the turn of the Triassic and Jurassic (Early Kimmerian phase). The movements resulted in marked decrease of depth of the sedimentary basin in relation to that from the Late Triassic, some sea regression at the turn of the Rhaetian and Hettangian (not leading, however, to emergence of land), and predominance of clastic deposits in basal part of Lias sequence (figs. 11–12). A new marine transgression has begun at the beginning of the Jurassic (Hettangian-Sinemurian). It is reflected by numerous intercalations of carbonate rocks rich in marine fossils in Lower Lias clastic sequence (figs. 11–12, see also ČEPEK 1970, GAŹDZICKI *et al.* 1979*b*).

Ecological distribution of benthonic foraminifers was analysed on the basis of the best known succession of the Fatra Formation (see MICHALÍK and JENDREJÁKOVÁ 1978, MICHALÍK 1978*a*, *b*; GAŹDZICKI *et al.* 1979*b*). Foraminifers are here primarily limited to biostromal elevations and lagoons in shelf zone, characterized by marked predominance of shallow-water carbonate deposits (fig. 16). The foraminifers display a specific pattern of distribution and, therefore, they appear to be good facies indicators (see fig. 16).

The foraminifers are most common in areas of biostromal elevations (fig. 16), built by algae, sponges, corals, and brachiopods. The elevations are inhabited mainly by Involutinidae and Ammodiscidae. The representatives of the sessile genus *Tolypammina*, often encrustating coral colonies, are especially numerous in central parts of such elevations. They are sometimes accompanied by *Alpinophragmium*. The family Involutinidae is here mainly represented by the genera *Aulotortus*, *Auloconus*, and *Triasina*, most common in inner parts of the elevations and forming associations especially rich in individuals (pls. 27:2, 30:3, 5). It is worth to note that involutinids inhabitating that zone are characterized by massive structure, and large (about 1 mm in size) and relatively thick walled tests. Such features of tests may be explained by high water turbulence (see MURRAY 1973, BOLTOVSKOY and WRIGHT 1976). In the area of biostromal elevations, the representatives of the genera *Glomospira* and *Glomospirella* appear somewhat less frequent than involutinids.

Involutinids and ammodiscids also predominate in lagoon zones, characterized by marly and marly limestone facies. Here predominate representatives of the genera *Aulotortus*, *Glomospira* and *Glomospirella*. The last two genera are mainly found in lagoon zones affected by supply of terrigenic material of psammite size from neighbouring land areas (see BEŁKA and GAŹDZICKI 1976). Relatively smaller associations are formed by *Triasina*, *Auloconus*, *Trochammina*, "*Tetrataxis*" and nodosariids. Involutinids occurring in the lagoon zone are characterized by smaller and finer tests than those from the biostromal elevations (see pl. 30:1), which may be explained by less turbulent waters as well as lower availability of $CaCO_3$ (see GREINER 1974, DOUGLAS 1979).

Foraminifers are also locally recorded in rocks formed in hypersaline environments of the restricted shelf zone. In that zone, they are represented by associations of *Agathammina* (pl. 37:1) and *Glomospira* and *Glomospirella* (pl. 31:9), the only taxons capable to accomodate to the changed sedimentary conditions. Involutinids are completely missing in that environment (see SALAJ 1980).

It should be noted that common fluctuations in bathymetry and salinity, typical for sedimentary environment of the Fatra Formation (see MICHALIK 1980), were unfavourable for development of foraminifers. They are here somewhat impoverished in number of taxa and individuals in relation to foraminifers from rocks of the Norovica Formation (see GAŹDZICKI and MICHALÍK 1980).

An interesting association of foraminifers is formed by *Involutina liassica*, *I. turgida*, *I. farinacciae* and *Trocholina umbo* in deposits of the Kopieniec Formation. The foraminifers are characterized by development of umbilical masses composed of pillars (see pl. 38:1–16). As stated above, the appearance of pillars is treated as a new element in evolutionary development of "post-Triassic" Involutinidae (BRÖNNIMANN and KOEHN-ZANINETTI 1969). It is highly probable that the appearance of pillars was similarly related to adaptation to new environmental conditions connected with a change in the sedimentary basin in the Early Lias (see GAŹDZICKI

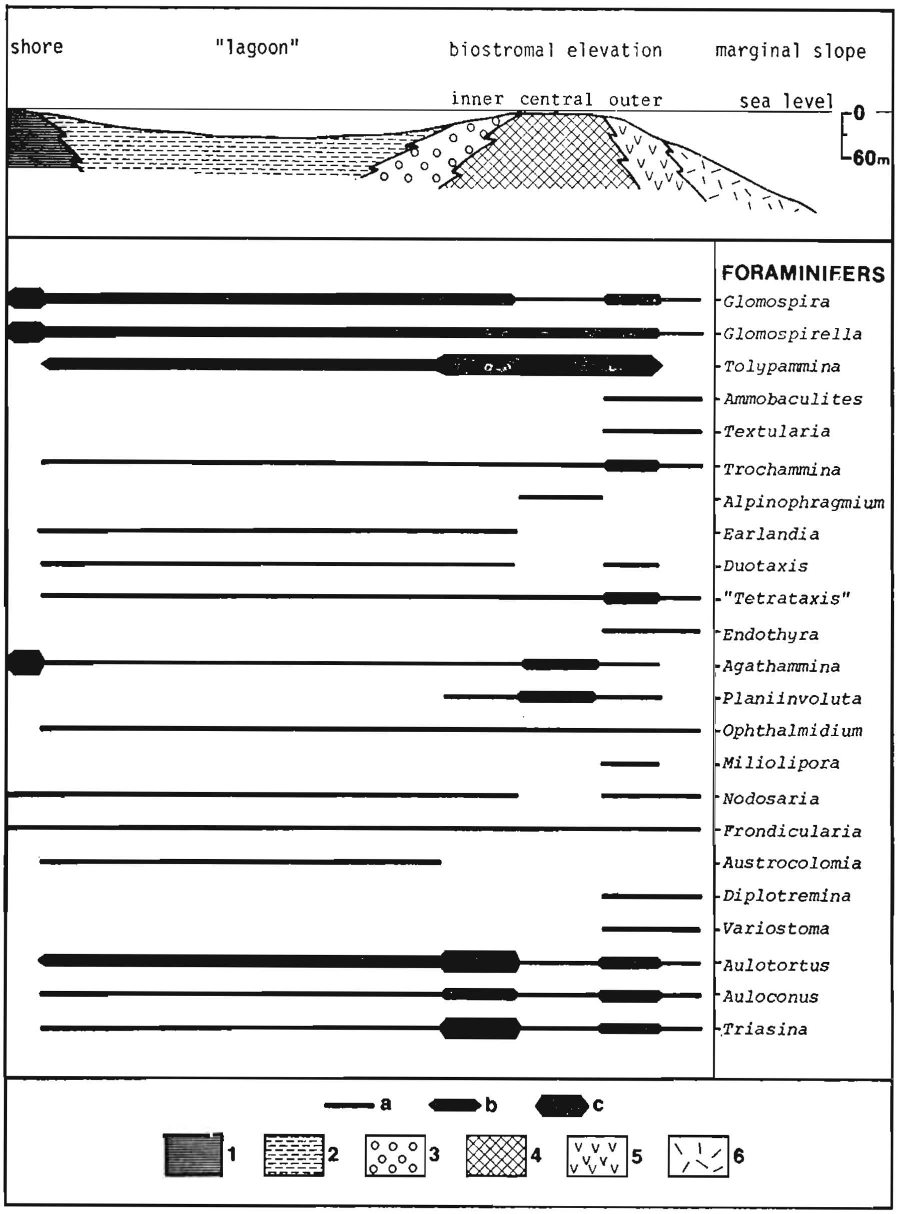

Fig. 16

Ecologic distribution and frequency of the foraminifers in the lithofacies of the Fatra Formation (uppermost Triassic of the Križna unit). *1* dolomite and marly dolomite; *2* marl and marly limestone with pelecypods and gastropods, sometimes sandy limestone; *3* skeletal limestone (calcarenite) with megalodonts and algae; *4* coral and sponge limestone; *5* brachiopod (*Rhaetina*) lumachelles; *6* crinoid limestone.
Frequency of foraminifers: *a* rare, *b* frequent, *c* abundant

et al. 1979*b*). Be this the case, the appearance of pillars should be treated as phenotypic variability in involutinids (see Zaninetti 1976, Piller 1978).

Regeneration of tests is fairly rare in the studied foraminifer assemblages. The phenomenon appears most common in Lower Lias species *Ophthalmidium leischneri*. Individuals of that species, especially microspheric forms could easily loose outer whorl due to mechanical breakage on account of fine structure of their tests. Regeneration of tests damaged in that way is connected with reconstruction of one or two last chambers which, however, follow a different structure pattern than the preceding ones (see pl. 40:12).

Tests of many foraminifers (mainly involutinids) occurring in the studied rocks, especially in the Mojtin Limestone Member of the Norovica Formation, are often broken (pl. 28:2). The destruction took place during their post mortem transportation by local bottom currents. The co-occurring brachiopods and crinoids are also crushed (see pl. 28:2).

Foraminifer tests are often covered with onkolitic crusts (pls. 27:2, 30:5, 38:14), visible in thin sections as thin uniform envelopes (pl. 38:13) or thick irregular coatings (pl. 38:15). The origin of onkolitic crusts, envelopes and coatings is connected with the activity of blue-green algae (see BATHURST 1971). Algal crusts enveloping foraminifer tests from all sides, give evidence for movement of the tests on sea floor.

Foraminifer tests with oolitic coatings (pl. 30:4) have also been found. In that case,the tests acted as nuclei and the final shape of an ooid reflects that of the test (pls. 31:3, 38:16). Coatings of *Girvanella* NICHOLSON and ETHERIDGE are less common. The algae either form overgrowths (pl. 33:16) or continuous coatings of foraminifer tests (pl. 35:7).

Some tests of large foraminifers of the genera *Aulotortus and Triasina* were found to provide a substratum for attachment of sessile foraminifers *Tolypammina gregaria* WENDT. Tolypamminas were not only inhabitating the surface of the large tests but they were also entering their interior, living in some chambers (see pls. 33:15, 35:9).

Diagenetic alternations often resulted in the deformation as well as recrystallization of foraminifer tests. Deformations of tests of *Triasina hantkeni* MAJZON due to compaction were mainly recorded in marly limestones of the Norovica Formation (pls. 30:6, 35:8). Tests of foraminifers, mainly those of the family Involutinidae, more often display sparitization (pls. 27:2, 28:2, 30:1–3). Sparitization was usually progressing from the test center, inaccessible for micritic mud (see pls. 30:1–2, 35:12, 15). In some cases, the whole interior of the test is filled with sparite crystals (pls. 30:1–2, 35:6, 15). Advancing recrystallization may lead to obliteration of internal structure of foraminifer tests (see pls. 30:2–3, 35:15).

FORAMINIFER BIOSTRATIGRAPHY

The zonation of Upper Triassic and Lower Jurassic strata was carried out in reference to the results of studies on foraminifer successions in 33 sections in different tectonic units of the West Carpathians (fig. 1). The recognized evolutionary lineages and the rates of evolutionary changes in test morphology of representatives of the families Involutinidae and Ammodiscidae and the subfamily Ophthalmidiinae permit to separate a few stratigraphically important species and to use them in establishing relatively precise zonation. A sequence of three foraminifer zones — *Triasina oberhauseri* (Norian), *Glomospirella friedli* and *Triasina hantkeni* (Rhaetian), *Ophthalmidium leischneri* and *Ophthalmidium walfordi* (Hettangian — ?Sinemurian) Zones — is recognized as the first appearance and extinction of individual species in the sections studies is taken into account (figs. 5–12). Lower boundaries of the above zones are defined by first appearance of their index species. The above subdivision represents at the same time a revision of those previously proposed by SALAJ (1969*a*, 1977) and GAŹDZICKI (1974, 1977).

Triasina oberhauseri Zone

Partial-range Zone; Norian (*sensu* KOZUR 1972, 1980)

Definition. — Interval with zonal marker, from its first occurrence to the first occurrence of *Triasina hantkeni* or *Glomospirella friedli*.

Type locality. — Hybe (section 25, layers 4–8), Nizke Tatry Mts (Czechoslovakia). — see fig. 9.

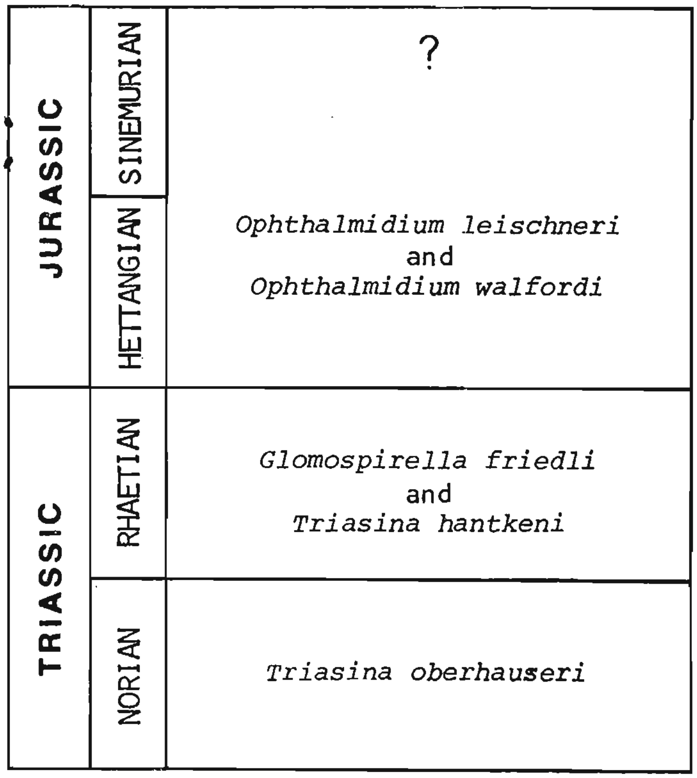

Fig. 17
Foraminifer biostratigraphy of the uppermost Triassic and lowermost Jurassic in the West Carpathians.

Remarks. — SALAJ (1977) differentiated the *Semiinvoluta clari* and *Triasina oberhauseri* Assemblage-Zone in Middle Norian (Alaunian) strata. However, the forms assigned to *Semiinvoluta clari* by SALAJ (1976, pl. 1:5, 1977, pl. 5:8) and GAŹDZICKI *et al.* (1979*a*) appeared to be misidentified and the majority of them represent the species *Aulotortus tumidus*. There is no evidence for the presence of *Semiinvoluta clari* in the Norian of the West Carpathians and, consequently, it cannot be used as index fossil.

It was also found that the stratigraphic range of *Triasina oberhauseri*, the other zonal marker, comprises the Lower Norian (Lacian) — lowermost Rhaetian interval and this species is a direct ancestor of *Triasina hantkeni*. This gives support to differentiation of *Triasina oberhauseri* Partial-range Zone in the Norian. It should be noted that *Triasina oberhauseri* was also found in samples from Norian Dachstein Limestone of Bakony Forest in Hungary, kindly supplied by Prof. E. VÉGH-NEUBRANDT.

Geographic distribution. — Czechoslovakia (SALAJ 1976, GAŹDZICKI *et al.* 1979*a*), Hungary (GAŹDZICKI, this paper), Austria (KOEHN-ZANINETTI and BRÖNNIMANN 1968), USSR (EFIMOVA 1974), Turkey (ZANINETTI 1976), China (HE YAN 1980).

Glomospirella friedli and *Triasina hantkeni* Zone

Assemblage Zone; Rhaetian (*sensu* KOZUR 1973, see also GAŹDZICKI *et al.* 1979*a*)

Definition. — The range of this zone is defined by stratigraphic ranges of the species *Glomospirella friedli* and *Triasina hantkeni*. This zone is also characterized by the association of index fossils with *Glomospirella pokornyi* (only on lower part of the zone).

Type locality. — Mt. Velká Furkaska (section 17, layers 317–404), Tatra Mts (Czechoslovakia). — see fig. 5.

Remarks. — On the basis of foraminifer microfauna, the Rhaetian was divided into the Lower — the *pokornyi* and *friedli* Zone, and the Upper — the *hantkeni* Zone (SALAJ 1969*a*, 1977; GAŹDZICKI 1974, 1977). However, further detailed analysis of stratigraphic distribution of foraminifers in sections of the uppermost Triassic in the West Carpathians has shown that the index fossil, *Glomospirella friedli*, is present in both lower and upper parts of the Rhaetian (figs 5–8), whereas the index fossil of the Upper Rhaetian, *Triasina hantkeni*, already appears in the lowermost Rhaetian. These findings preclude the use of the above mentioned subdivision of the Rhaetian and, therefore, the previously proposed *pokornyi* and *friedli* Zone and *hantkeni* Zone are here treated as a single, *Glomospirella friedli* and *Triasina hantkeni* Assemblage Zone, comprising the whole Rhaetian Stage in the West Carpathians.

Geographic distribution. — Czechoslovakia (SALAJ *et al.* 1967, SALAJ 1969*a*, 1977) Poland (GAŹDZICKI 1970, 1974, 1977), Hungary (MAJZON 1954, ORAVECZ-SCHEFFER 1973), Romania (GAŹDZICKI, this paper), Austria (KRISTAN-TOLLMANN 1962, OBERHAUSER 1964, PAPP and TURNOVSKY 1970), France (ZANINETTI 1977*a*, *b*), Switzerland (WEIDMANN and ZANINETTI 1974), Italy (ANONYMOUS 1959, BOSELLINI and BROGLIO LORIGA 1965, FUGANTI and MOSNA 1966), Yugoslavia (RADOIČIĆ 1966, PANTIĆ 1967, PANTIĆ-PRODANOVIĆ 1975, GUŠIĆ 1975), Greece (CHRISTODOULOU and TSAILA-MONOPOLIS 1972, ZANINETTI and THIEBAULT 1975), Morocco (RAOULT 1962), Tunisia (SALAJ and STRANIK 1970), Turkey (BRÖNNIMANN *et al.* 1970, ZANINETTI 1976), Iran (BRÖNNIMANN *et al.* 1972, ZANINETTI *et al.* 1972), Afghanistan (LYS and MARIN 1973), China (HO YEN and HU LAN-YING 1977, HE YAN 1980), Philippines (FONTAINE *et al.* 1979) and Papua New Guinea (GAŹDZICKI 1978).

Ophthalmidium leischneri and ***Ophthalmidium walfordi*** Zone

Assemblage Zone; Hettangian — ?Sinemurian

Definition. — The range of this zone is defined by stratigraphic ranges of the species *Ophthalmidium leischneri* and *Ophthalmidium walfordi*. The zone is also characterized by an association of the index fossils and *Involutina liassica*, *Involutina farinacciae* and *Trocholina umbo*.

Type locality. — Mt. Velká Furkaska (section 17, layers 414–442), Tatra Mts. Czechoslovakia) — see fig. 11.

Remarks. — In the West Carpathians, the basal part of the Hettangian and, therefore, the base of the Lias are defined by the first appearance of *Involutina liassica* (see SALAJ 1969*a*). That species is, however, inconvenient as index fossil as its range straddles the Rhaetian/Hettangian boundary, extending from upper part of the Rhaetian through the Jurassic up to the Lower Cretaceous (KRISTAN 1957, RADOIČIĆ 1962, PILLER 1978). That is why the author (GAŹDZICKI 1974, 1977) has proposed to single out "*Vidalina*" *leischneri* Range Zone in Lower Lias of the Tatra Mts. According to newly obtained data on Lower Lias sections of the West Carpathians (figs. 11–12), *Ophthalmidium leischneri* occurs together with *Ophthalmidium walfordi*, hitherto known from coeval rocks of epicontinental basin in north-western Europe only (FRANKE 1936, WOOD and BARNARD 1946). Be this the case, the distinction of the *Ophthalmidium leischneri* and *Ophthalmidium walfordi* Assemblage Zone should make it possible to correlate Lias sections of the Tethys Realm and those of epicontinental basin in the north-western Europe. This also indicates that the lower boundary of this zone delineates the boundary between the Triassic and Jurassic in the West Carpathians. It should be added that upper boundary of that zone is still poorly defined as a detailed analysis of higher stratigraphic members is till missing in the region studied.

Geographic distribution. — Czechoslovakia (GAŹDZICKI, this paper), Poland (GAŹDZICKI, 1974, 1975), Austria (LEISCHNER 1961, KRISTAN-TOLLMANN 1962, PAPP and TURNOVSKY 1970), Federal Republic of Germany (ISSLER 1908, FRANKE 1936), Great Britain (WOOD and BARNARD 1946), France (ZANINETTI 1977*a*), Italy (CITA 1965), Yugoslavia (RAMOVŠ and REBEK 1970, GUŠIĆ 1975), Turkey (BRÖNNIMANN *et al.* 1970).

STRATIGRAPHIC CORRELATION

Foraminifer zonation of the uppermost Triassic in the West Carpathians has been correlated with orthostratigraphic ammonoid zonation of the Norian and Rhaetian *sensu* KOZUR (1973, 1980), concordant with the GÜMBEL'S (1861) subdivision (fig. 18, see also GAŹDZICKI *et al.* 1979*a*). *Triasina oberhauseri* Zone, as interpreted above, extends from *Mojsisovicsites kerri* Zone to *Cochloceras suessi* Zone (Norian). *Glomospirella friedli* and *Triasina hantkeni* Zone may be correlated with ammonoid *Choristoceras haueri* and *Choristoceras marshi* Zones (Rhaetian) and its extent corresponds to that of the conodont *Misikella posthernsteini* Zone (GAŹDZICKI 1978*a,b*; GAŹDZICKI *et al.* 1979*a*). In turn, the extent of Lower Lias *Ophthalmidium leischneri* and *Ophthalmidium walfordi* Zone corresponds to that of the ammonoid *Psiloceras planorbis Schlotheimia angulata* and presumably *Arietites bucklandi* Zones (Hettangian — ?Sinemurian); (GAŹDZICKI *et al.* 1979*b*, see also KRISTAN-TOLLMANN 1962).

STAGE	RHAETIAN		HETTANGIAN	
Substage	Lower	Upper	Lower	Upper
Ammonoid zones	*Choristoceras haueri*	*Choristoceras marshi*	*Psiloceras planorbis*	*Schlotheimia angulata*
Conodont zones	*Misikella posthernsteini*		—	
Foraminifer zones	*Glomospirella friedli* and *Triasina hantkeni*		*Ophthalmidium leischneri* and *Ophthalmidium walfordi*	

Fig. 18
Stratigraphic correlation of the ammonoid, conodont and foraminifer zones in the Rhaetian and Hettangian of the Alpine-Carpathian region. For stratigraphic comments see GAŹDZICKI *et al.* 1979 *a*.

REMARKS ON CHRONOSTRATIGRAPHIC BOUNDARIES

The foraminifer zonation given above makes it possible to single out the following stages: Norian (*Triasina oberhauseri* Zone), Rhaetian (*Glomospirella friedli* and *Triasina hantkeni* Zone), and Hettangian — ?Sinemurian (*Ophthalmidium leischneri* and *Ophthalmidium walfordi* Zone). At the same time, it makes possible reanalysis of the question of stratigraphic boundaries between Carnian and Norian, Norian and Rhaetian and Rhaetian and Hettangian (= Triassic/Jurassic boundary) in the West Carpathians.

Carnian/Norian boundary. — The boundary is passing in the interval delineated from below by the last occurrence of *Glomospirella kuthani* (SALAJ), index fossil of the *kuthani* Zone *sensu* SALAJ (1969*a*, 1977), and from above — by first appeararce of *Triasina oberhauseri* KOEHN-ZANINETTI and BRÖNNIMANN, index fossil of the *oberhauseri* Zone *sensu* GAŹDZICKI (this paper).

Strata of the Carnian age are out of scope of this paper so it should be noted that in the West Carpathians they are dated by several foraminifers including *Glomospirella kuthani* (SALAJ, *Mesodiscus eomesozoicus* (OBERHAUSER), *Aulotortus praegaschei* (KOEHN-ZANINETTI), *Lamelliconus biconvexus* (OBERHAUSER), *L. procerus* (LIEBUS), *Pachyphloides klebelsbergi* (OBERHAUSER), and *P. oberhauseri* SELLIER de CIVRIEUX and DESSAUVAGIE (see SALAJ 1969*a*, 1977; SALAJ and JENDREJÁKOVÁ 1967; SALAJ *et al.* 1967; JENDREJÁKOVÁ 1973, GAŹDZICKI *et al.* 1978).

Norian/Rbaetian boundary. — Lower boundary of the Rhaetian Stage is defined by the first appearance of *Glomospirella friedli* or *Triasina hantkeni* (see figs. 5–10). The underlying strata are of the Norian (Sevatian) age. The boundary is passing within the Carpathian Keuper or Fatra Formation in the Fatricum and within the Norovica Formation in the Hronicum (fig. 2).

Rhaetian/Hettangian boundary. — In the sections studied (figs. 5, 11–12), the uppermost layer yielding index fossils of the Rhaetian, *Glomospirella friedli* or *Triasina hantkeni*, and the lowermost layer with index fossils of the Hettangian — ?Sinemurian, *Ophthalmidium leischneri* or *O. walfordi*, are separated by a series of clastic deposits without any foraminifers, 10 to 15 m thick. The Rhaetian/Hettangian boundary (= Triassic/Jurassic boundary) in the West Carpathians is drawn within this series, interpreted as the correlation error interval.

DIACHRONISM OF THE LITHOSTRATIGRAPHIC UNITS

A detailed biostratigraphic zonation of the Upper Triassic and Lower Jurassic of the West Carpathians, established on the basis of foraminifers, shows that boundaries of the Carpathian Keuper, and Fatra and Kopieniec Formations in the Fatricum and Norovica Formation in the Hronicum are diachronous and they cannot be used as time lines (figs 2, 5–10). Upper part of the Carpathian Keuper Group in the sections Mt. Velká Furkaska (section 17) and Lejowa Valley I (section 18), widely assumed to be of the Carnian-Norian age (SOKOŁOWSKI 1959, KOTAŃSKI 1963, 1979), was found to be of the Rhaetian age (GAŹDZICKI *et al.* 1979b). Sedimentation of rocks of the Fatra and Norovica Formations was recently shown to begin as early as the Late Norian (GAŹDZICKI and IWANOW 1976, GAŹDZICKI and MICHALIK 1980) whereas the Kopieniec Formation began to originate not before the Rhaetian (*friedli* and *hantkeni* Zone) on the Štefanský žlab section (19) and even not before the Hettangian — ?Sinemurian (*leischneri* and *walfordi* Zone) in the Mt. Velká Furkaska section (18). This disappearance of carbonate facies of the Fatra Formation and development of clastic facies of the Kopieniec Formation in the Carpathian sedimentary basin in Late Triassic and Early Jurassic times prove an increasing regression related to uplifting movements of the Early Kimmerian phase. In the West Carpathians, the movements began in the Rhaetian (*friedli* and *hantkeni* Zone) and their maximum activity was marked in the Early Lias (*leischneri* and *walfordi* Zone).

PALEOGEOGRAPHIC DISTRIBUTION

In the Late Triassic and Early Jurassic, geographic distribution of benthonic foraminifer faunas, mainly comprising representatives of the families Involutinidae, Ammodiscidae, and Miliolidae, was controlled by facies pattern.

In the analysis of the distribution, attention should be paid to Involutinidae. Representatives of that family form associations comprising large numbers of individuals in Triassic rocks. The occurrence of such associations appears clearly related to areaş of lagoons and biostromal elevations in shelf zones, where a carbonate sedimentation was prevailing.

The analysis of distribution of Upper Triassic facies in Europe and North Africa (fig. 19) has shown that shallow-water carbonate facies, characterized by the wealth of sponge, corals, brachiopods, pelecypods, and echinoderms, fairly well coincides with areas of occurrence of involutinids (fig. 20). According to paleogeographic distributions (SMITH and BRIDEN 1977, figs. 12, 25, 51, see also MICHALÍK 1978*a*, fig. 1), such shallow-water carbonate facies of the Upper Triassic were related to shelf areas, mainly those of the northern coast of the Tethyan Ocean. Therefore, the distribution of involutinids in the uppermost Triassic of the Tethys is found to coincide with that of the shallow-water facies (fig. 20). It follows that for the late Triassic, involutinids are a sensitive paleogeographic indicator for the Tethys Realm.

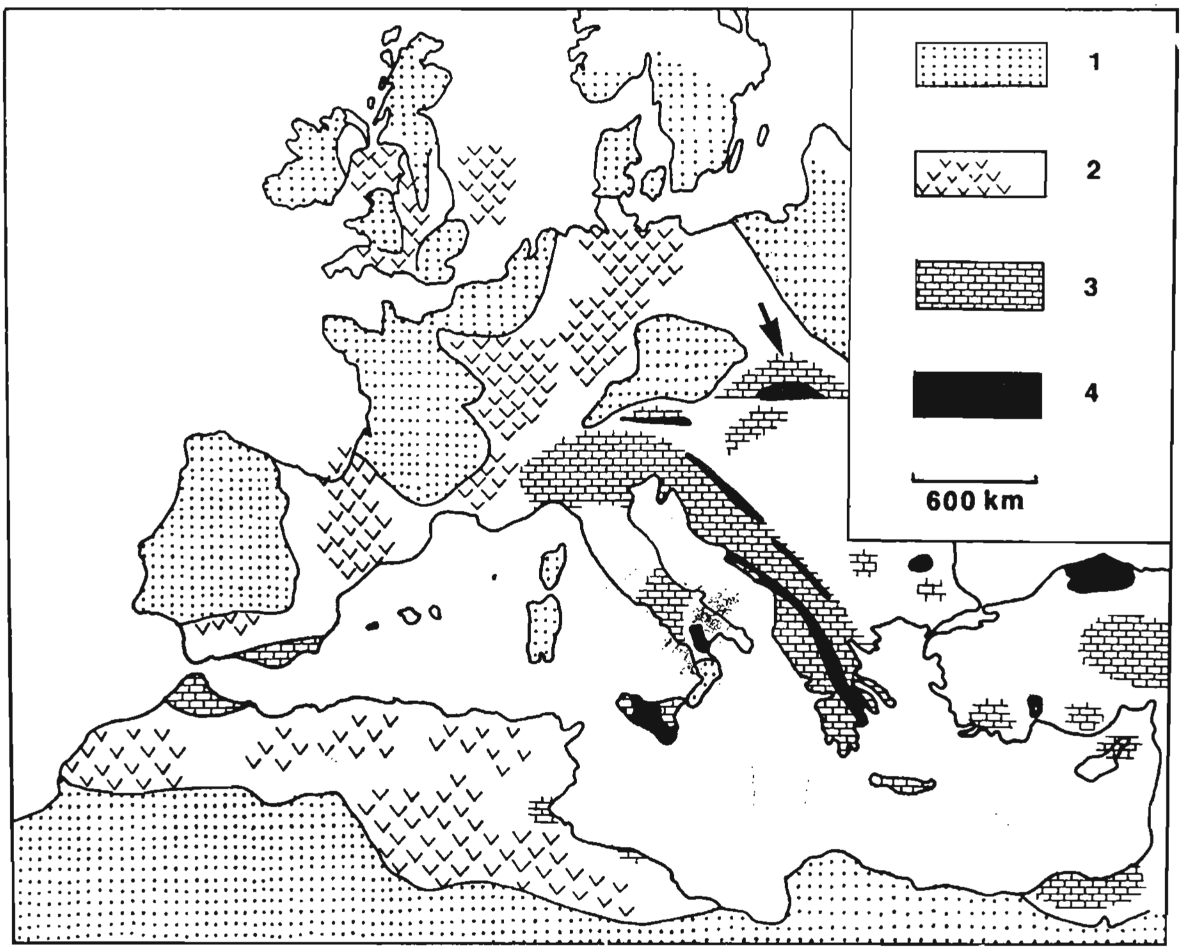

Fig. 19

Present distribution of the Late Triassic facies in Europe and North Africa (arrow indicates the area investigated in the present paper): *1* continental facies (red beds); *2* evaporite facies with main halite deposits (vvv); *3* shallow-water carbonate facies (platform carbonates with more or less subsidence); *4* deeper water facies (Hallstatt Limestone and related facies). (Adopted from BOSELLINI and HSÜ, 1973, figs 1–3).

The studied Norian-Rhaetian foraminifer assemblages of the West Carpathians (in the Fatra and Norovica Formations, Hybe Beds, Skalka Limestone and Bleskový prameň Limestone) are very similar to contemporaneous assemblages in other parts of the Tethys Realm in both taxonomic composition and stratigraphic succession of individual associations. The similarities are not confined to assemblages from neighbouring areas in the Alpine Europe (GAŹDZICKI 1974, ZANINETTI 1976, SALAJ 1980), being equally high in other parts of the Tethys Realm: from Rif Mts. in Morocco to Calamian Islands of Philippines as well as Papua New

Guinea (fig. 20, see also ZANINETTI 1976, GAŹDZICKI and SMIT 1977, FONTAINE *et al.* 1979, HE YAN 1980 and GAŹDZICKI and GUPTA 1981)[1].

The investigated Lower Lias foraminifer assemblages from the West Carpathians (mainly those from the Kopieniec Formation and from the Tatricum in the Velká Fatra Mts.) also do not differ from contemporaneous assemblages of the Tethys Realm in specific composition or stratigraphic distribution. Lower Lias foraminifers characterized by vast geographic distribution, especially in the Tethys Realm. They are known from Hungary (FÜLÖP 1976), Lower Austria (KRISTAN-TOLLMANN 1962, FUCHS 1970, PAPP and TURNOVSKY 1970), Northern Limestone Alps (LEISCHNER 1961, FABRICIUS 1966, TOLLMANN 1976), Haute-Savoie (ZANINETTI 1977*a*) Southern Alps (CITA 1965, COUSIN and NEUMANN 1971, TSAMANTOURIDIS 1971), Apen-

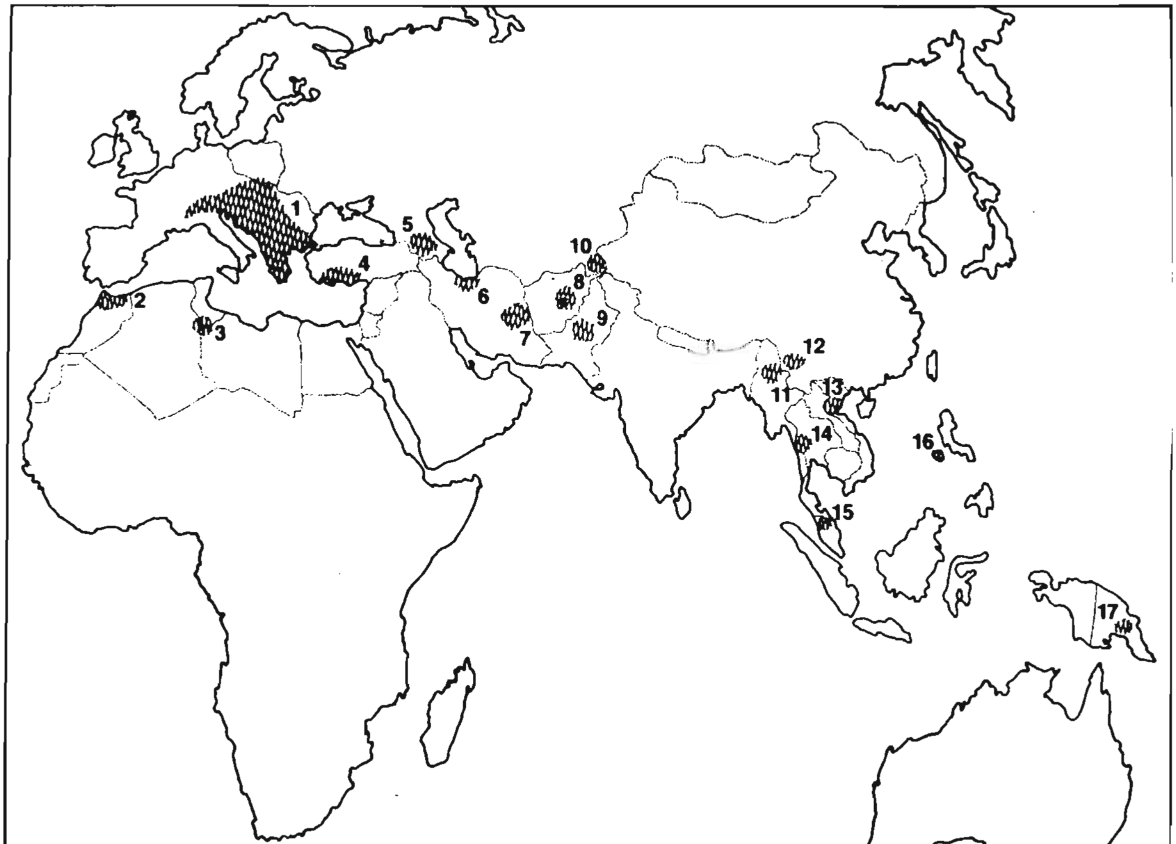

Fig. 20

Geographic distribution of Involutinidae in the uppermost Triassic deposits of the Tethys Realm

1 Alpine Europe (GAŹDZICKI 1974, ZANINETTI 1976); *2* Rif Mts., Morocco (RAOULT 1962); *3* Djebel Fkirine, Tunisia (SALAJ and STRANIK 1970); *4* Taurus Mts., Turkey (BRÖNNIMANN *et al.* 1970); *5* Caucasus Mts., Soviet Union (EFIMOVA 1974); *6* Alborz Mts., Iran (ZANINETTI *et al.* 1972); *7* Kuh-e-Nayband Mts., Iran (BRÖNNIMANN *et al.* 1972); *8* Wardak Mts., Afghanistan (LYS and MARIN 1973); *9* Samana Suk, Pakistan (ZANINETTI and BRÖNNIMANN 1975); *10* Pamir Mts. Soviet Union (DRONOV *et al.* 1982); *11* Kyaukme-Longtawkno area, Burma (BRÖNNIMANN *et al.* 1975); *12* Yunnan, China (HO YEN and HU LAN-YING, 1977); *13* Hoang Mai, Vietnam (LIEM 1966); *14* Si Sawat, Thailand (KEMPER *et al.* 1976); *15* Kodiang, Malaysia (GAŹDZICKI and SMIT 1977); *16* Busuanga, Calamian Islands, Philippines (FONTAINE *et al.* 1979); *17* Gurumugl, Papua New Guinea (GAŹDZICKI in preparation)

[1] Recently the assemblage of Norian involutinids *Aulotortus gaschei, A. sinuosus* and *Triasina oberhauseri* was found (GAŹDZICKI and REID *in press*) to be also present in the North America (Lime Peak, Yukon, Canada).

nines (FARINACCI 1967, PASSERI 1971), Sicily (BARBIERI 1964), Karavanken Mts. (RAMOVŠ and REBEK 1970), Croatia (GUŠIĆ 1975), Dinaric Alps (RADOIČIĆ 1966), Taurus Mts (BRÖNNIMANN *et al.* 1970) and Western Highlands of Papua New Guinea (HAIG 1979).

The foraminifer assemblage from the Kopieniec Formation (Hettangian — ?Sinemurian) of the West Carpathians also somewhat resemble those of the "Oolithenbank" in the Baden-Wuerttembergian Hettangium, representing typical epicontinental deposits (SCHLOZ 1972). The above similarities may be also traced within Lower Lias sequences in other parts of the north-western Europe (see FRANKE 1936, WOOD and BARNARD 1946, DREXLER 1958 and BROUWER 1969).

The record of the species *Ophthalmidium walfordi* HÄUSLER, hitherto known from the Lower Lias of the epicontinental basin of the north-western Europe only (ISSLER 1908, FRANKE 1936, WOOD and BARNARD 1946), in the Tatra Mts. is of interest. From the Lower Lias of the two sedimentary basins are also known some other species including *Involutina liassica*, *Trocholina umbo* and numerous representatives of family Nodosariidae (see BROUWER 1969).

Taking into account the present state of knowledge of Lower Lias foraminifers, it may be stated that they occur both in geosynclinal and epicontinental basins at those times.

At the same time the presented data indicate that the environmental conditions prevailing in the Carpathian geosyncline and epicontinental basin of the north-western Europe were quite similar during the Early Lias, which was undoubtedly determined by the existence of effective marine connections between those basins. This point of view is further supported by earlier observations of GOETEL (1917), who emphasized a marked resemblance of the sandstone with *Cardinia* from the Tatra Mts and Lower Lias sandstones of Swabia in petrological characteristic and composition of faunal assemblages.

FINAL REMARKS

The benthonic foraminifers of Upper Triassic and Lower Jurassic seem to be good environmental indices for shelf areas of the Tethyan Ocean. Their wide geographic distribution, mass occurrence and relatively high rate of evolution, give them significant stratigraphic value.

The Involutinidae, Ammodiscidae and Miliolidae are most common in the sequences studied. Their distribution was related to extensive shelf areas with predominating carbonate sedimentation. Ammodiscidae, most common in onshore zones characterized by supply of psammitic terrigenous material were the exception.

A special stratigraphic value is attributed to the Involutinidae and Ammodiscidae as their evolution during Late Triassic underwent marked acceleration. Fast species alternation permits to use them for relatively precise zonation.

A major part of involutinids became extinct at the Rhaetian/Hettangian (= Triassic/Jurassic) boundary and only some of them are present in Lias and younger strata. From the base of the Lias (Hettangian-Sinemurian) upwards, the analysed foraminifer assemblages begin to display predominance of Ophthalmidiinae, the peak in development of which took place already in the Jurassic.

The mass occurrence of the foraminifers, particularly in the Upper Triassic, results in their high stratigraphic value comparable with that of cephalopods and conodonts, i.e. the groups giving the basis for biostratigraphy of that epoch.

The intercorrelation of the proposed foraminifer zones with standard cephalopod and conodont zones makes possible the use of foraminifers in local, regional, and intercontinental stratigraphic correlations, especially in those parts of the Tethys Realm where the cephalopods and conodonts are scarce or absent.

SYSTEMATIC PALEONTOLOGY

Suborder **Textulariina** DELAGE and HÉROUARD, 1896
Superfamily **Ammodiscacea** REUSS, 1862
Family **Ammodiscidae** REUSS, 1862
Subfamily **Ammodiscinae** REUSS, 1862
Genus *Glomospirella* PLUMMER, 1945
Glomospirella friedli KRISTAN-TOLLMANN, 1962
emend. BRÖNNIMANN and ZANINETTI, 1970
(pl. 27:1; pl. 28:1; pl. 31:1–6)

1962. *Glomospirella friedli* KRISTAN-TOLLMANN: 229, pl. 1:1–9, 12–17.
1970. *Glomospirella friedli* KRISTAN-TOLLMANN; BRÖNNIMANN and ZANINETTI: 10, pl. 1:4–8, fig. 4 (*in* BRÖNNIMANN *et al.* 1970).
1976. *Glomospirella friedli* KRISTAN-TOLLMANN; ZANINETTI: 96, pl. 8:1–5 (with synonymy).
1978. *Aulotortus friedli* (KRISTAN-TOLLMANN); PILLER: 5, pl. 1:1.

Material. — Over 1,000 fairly well preserved specimens in thin sections.

Association. — Usually with *Glomospira sinensis*, *Glomospira* sp., *Glomospirella parallela*, *G. pokornyi*, *G. shengi*, *Tolypammina gregaria*, *Trochammina alpina*, "*Tetrataxis*" *inflata*, *Agathammina austroalpina*, "*Frondicularia woodwardi*", *Nodosaria* sp., sometimes with involutinids (*Aulotortus communis*, *A. gaschei*, *Auloconus permodiscoides*, and *Triasina hantkeni*).

Description. — as given by KRISTAN-TOLLMANN (1962), BRÖNNIMANN and ZANINETTI (*in* BRÖNNIMANN *et al.* 1970) and ZANINETTI (1976).

Dimensions of the test (in μm)

	pl. 32:2	pl. 32:3	pl. 32:4
diameter	440	400	580
thickness	360	320	340
diameter of the proloculus	—	50	50

Remarks. — The specimens of *Glomospirella friedli*, very numerous and particularly well-preserved in the uppermost Triassic of the West Carpathians, make some important conclusions possible. The studied forms (pl. 6:1–6) are characterized by test outline ovate in axial and oblique sections and circular in the equatorial. A special attention should be paid to the mode of coiling of test. Central part of test is streptospirally coiled and it comprises 6 to 8 whorls (pl. 32:2–4). It is followed by elements of sigmoidal coiling, passing into planispiral, comprising four whorls at the average (pl. 32; 1–3). Wall microstructure of tests which escaped recrystallization is very finely agglutinated and, sometimes, incrusted with single crystals of pyrite. The above features clearly evidence that the forms belong to the genus *Glomospirella* PLUMMER. It should be noted, however, that HOHENEGGER and PILLER (1975) and PILLER (1978) interpreted *Glomospirella friedli* as a synonym of *Aulotortus gaschei* (KOEHN-ZANINETTI and BRÖNNIMANN), taking into account identify of the mode of coiling and wall microstructure of recrystallized tests. The mode of coiling is similar but, nevertheless, some differences remain. Planispiral part is well-developed in *Glomospirella friedli* and rarely visible in sections of *Aulotortus gaschei*, comprising about four and usually less than two whorls, respectively. Umbilical masses, typical of involutinids, are well developed in *Aulotortus gaschei* and missing in *Glomospirella friedli*. Walls of tests of the former often display perforation (see pl. 32:9–10), whereas those of *Glomospirella friedli* are imperforate.

It should be admitted, however, that the tests of the two species are difficult to separate when recrystallized, which may explain the above viewpoint of HOHENEGGER and PILLER. When the material is well preserved as in the present case, it may be easily shown that the species are separate and assignable to two different families, Ammodiscidae and Involutinidae.

The marked similarity in size, shape, and mode of coiling of these species is an excellent example of advanced homeomorphy.

Occurrence. — West Carpathians (Strážovská hornatina Mts, sections: 6 — Hireška, 22 — Norovica Mt., 23 — Rovnianska Valley, 24 — Tŕstie; Malá Fatra Mts. sections: 7 — Lesnianska Valley, 8 — Široka Valley, 9 — Suchá Valley, 10 — Slovianska Valley, 15 — Zázrivská Valley; Velká Fatra Mts., sections: 11 — Dedošova Valley, 12 — Križna Valley, 13 — Belianska Valley, 14 — Ráztoky; Nizke Tatry Mts., section: 25 — Hybe; Tatra Mts., sections: 16 — Bobrovček-Hrádky, 17 — Velká Furkaska Mt., 18 — Lejowa Valley I, 19 — Štefanský žlab, 26 — Chochołowska Valley, 38 — Lejowa Valley II, 29 — Przysłop Miętusi; Slovenské rudohorie Mts. section: 30 — Skalka: Rhaetian (*friedli* and *hantkeni* Zone; the conodont *posthernsteini* Zone).

It is also know from uppermost Triassic (mostly Rhaetian) of Bakony Forest (ORAVECZ-SCHEFFER 1973), Apuseni Mts., Tarcaita Dolomite of the Dieva nappe (GAŹDZICKI, unpublished) and Western Alps (KRISTAN-TOLLMANN 1962, KOEHN-ZANINETTI 1969, BRÖNNIMANN *et al.* 1969, HOHENEGGER and LOBITZER 1971, WEIDMANN and ZANINETTI 1974, HOHENEGGER and PILLER 1975, ZANINETTI 1976, 1977; PILLER 1978, GAŹDZICKI *et al.* 1979*a*), Dolomites (CROS and NEUMANN 1964, BOSELLINI and BROGLIO LORIGA 1965), Apennines (BOCCALETTI *et al.* 1969), Dinaric Alps (PANTIĆ-PRODANOVIĆ 1975), Prokletije Mts. (PANTIĆ 1974), Macedonia (UROŠEVIĆ and DUMURDANOV 1976), Stara Planina Mts. (UROŠEVIĆ and ANDELKOVIĆ 1970), Taygète Mts. of Greece (ZANINETTI and THIEBAULT 1975), Caucasus Mts. (EFIMOVA 1975), Eastern Atlas Mts. of Tunisia (SALAJ and STRANIK 1970), Taurus Mts. of Turkey (BRÖNNIMANN *et al.* 1970), Kuh-e-Nayband Mts. and Alborz Mts. of Iran (BRÖNNIMANN *et al.* 1971, ZANINETTI *et al.* 1972), Wardak Mts. of Afghanistan (LYS and MARIN 1973), Yunnan province of China (HO YEN and HU LAN-YING 1977) and Kuta Formation of Papua New Guinea (GAŹDZICKI 1978).

Glomospirella pokornyi (SALAJ, 1967)
(pl. 31:1–2, 4–5)

1967. *Angulodiscus pokornyi* SALAJ: 128, pl. 6 :4*a*, *b* (*in* SALAJ *et al.*).
1977. *Glomospirella pokornyi* (SALAJ); GAŹDZICKI: 93 pl. 1:6–13 (with synonymy).
non 1978. *Aulotortus pokornyi* (SALAJ); PILLER: 61, pl. 11:1–7.

Material. — About 200 specimens in thin sections.

Association. — Most often with *Glomospira* sp., *Glomospirella friedli*, *G. parallela*, *Glomospirella* sp., *Trochammina alpina*, *Agathammina austroalpina*, "*Tetrataxis inflata*", *Nodosaria* sp., "*Frondicularia woodwardi*", *Diplotremina* sp.; occasionally with *Aulotortus communis*, *A. sinuosus*, *A. tumidus*, *Auloconus permodiscoides*, and *Triasina hantkeni*.

Description. — as given by SALAJ (*in* SALAJ *et al.* 1967).
Dimensions of the test (in μm):

	pl. 31:2	pl. 31:4	pl. 31:5
diameter	410	440	450
thickness	80	80	—

Remarks. — The species described was originally assigned by SALAJ (*in* SALAJ *et al.* 1967) to *Angulodiscus* (KRISTAN 1957, which is treated by PILLER (1978) as a junior synonym of *Aulotortus* WEYNSCHENK 1956.

The analysis of representatives of this species from the uppermost Triassic of the West Carpathians has shown that their test walls are very finely agglutinated. This, along with the arrangement of whorls in both axial and equatorial sections (pl. 31:1–2, 4–5) is typical of the genus *Glomospirella* PLUMMER 1945.

It should be also noted that the specimens from the Norian-Rhaetian of the Northern Limestone Alps, assigned to *Aulotortus pokornyi* (SALAJ by PILLER (1978, pl. 11:1–7), do not match the diagnosis of that species, differing mainly in having a calcareous wall. These forms would be best assigned to *Aulotortus communis* (KRISTAN 1957).

Occurrence. — West Carpathians (Strážovská hornatina Mts., sections: 6 — Hireška, 24 — Tŕstie; Malá Fatra Mts., sections: 7 — Lesnianska Valley, 8 — Široka Valley, 10 — Slovianska Valley, 15 — Zázrivská Valley; Velká Fatra Mts., sections: 1 — Dedosova Valley, 14 — Ráztoky, Nizke Tatry Mts., section: 25 — Hybe; Tatra Mts., sections: 16 — Bobrovček-Hrádky, 17 — Velká Furkaska Mt., 18 — Lejowa Valley I, 19 — Štefanský žlab, 26 — Chochołowska Valley, 29 — Przysłop Miętusi; Slovenský kras, section: 31 — Malý Mlynský vrch Mt.): Rhaetian (*friedli* and *hantkeni* Zone; conodont *posthernsteini* Zone).

This species was also reported from the Rhaetian of the Eastern Atlas Mts. in Tunisia (SALAJ and STRANIK 1970).

Suborder **Miliolina** DELAGE and HÉROUARD, 1896
Superfamily **Miliolacea** EHRENBERG, 1839
Family **Miliolidae** EHRENBERG, 1839
Subfamily **Ophthalmidiinae** WIESNER, 1920
Genus *Ophthalmidium* KÜBLER and ZWINGLI, 1870
Ophthalmidium carpathicum (GAŹDZICKI, 1979)
(pl. 37:9–10)

1979. "*Vidalina*" *carpathica* GAŹDZICKI: 98, pl. 4:3–5 (*in* GAŹDZICKI *et al.* 1979*a*).

Material. — Fifteen specimens in thin sections.

Association. — With *Glomospira* sp., *Glomospirella* sp., *Trochammina alpina*, *Agathammina austroalpina*, *Ophthalmidium* "*carinatum*", *Nodosaria ordinata*, *Austrocolomia* sp. and *Diplotremina* sp.

Description. — as given by GAŹDZICKI (*in* GAŹDZICKI *et al.* 1979*a*).
Dimensions of the test (in μm):

	pl. 37:9	pl. 37:10
diameter	350	360
thickness	60	70
diameter of the proloculus	40	—

Remarks. — *Ophthalmidium carpathicum* differs from the remaining Upper Triassic — Lower Jurassic species of *Ophthalmidium* KÜBLER and ZWINGLI in constriction between central part and the ultimate whorl, especially well visible in axial section (pl. 37:9–10). The constriction may be responsible for breaking-off of the ultimate whorls as the representatives of that species are often found incomplete, i.e. represented by proloculus and two inner whorls only (see pl. 37:11). It should be noted that the forms devoid of the ultimate whorl are very close to megalospheric forms of the species *Ophthalmidium* "*carinatum*" (LEISCHNER 1961) = *Involutina carinata* LEISCHNER 1961 (see LEISCHNER 1961, pl. 2:15a–c) known from the uppermost Triassic and Lower Lias of Northern Limestone Alps.

In accordance with the suggestions of WERNLI (1972) and DECROUEZ *et al.* (1978), the species is here assigned to *Ophthalmidium* KÜBLER and ZWINGLI 1870 on acount of its multilocular test structure, and not to *Vidalina* SCHLUMBERGER 1900, characterized by bilocular structure and not known from rocks older than the Late Cretaceous.

Occurrence. — West Carpathians Slovenský kras, section: 31 — Malý Mlynsky vrch Mt.: Upper Norian (Sevatian); 32 — Bleskový prameň: Rhaetian (*friedli* and *hantkeni* Zone).

Ophthalmidium leischneri Kristan-Tollmann, 1962

(pl. 40:1–12)

1962. *Neoangulodiscus leischneri* (Kristan-Tollmann: 230, pl. 2:25–34.
1976. *Ophthalmidium leischneri* (Kristan-Tollmann); Zaninetti: 144, pl. 7:14–16 (with synonymy).
1977. "*Vidalina*" *leischneri* (Kristan-Tollmann); Gaździcki: 94, pl. 3:9–12, 16 (with synonymy).

Material. — Over 500 well-preserved specimens in thin sections.

Association. — Most often together with *Ophthalmidium walfordi*, *Involutina liassica*, *I. turgida*, *I. farinacciae*, *Trocholina umbo*, and nodosariids (*Astacolus*, *Nodosaria*, *Frondicularia* and *Lenticulina*), occasionally with *Trochammina* sp. and *Planiinvoluta carinata*.

Description. — as given by Kristan-Tollmann (1962).

Dimensions of the test (in μm):

	pl. 40:1	pl. 40:5	pl. 40:8
diameter	200	210	270
thickness	80	80	—
diameter of the proloculus	50	—	30

Remarks. — Large populations of *Ophthalmidium leischneri*, found in analysed Lower Lias rocks, permit to recognize megalo- and microspheric forms. The former, biconvex in axial section (pl. 40:1–2), with 3–5 chambers and proloculus about 50 microns in size on the average, are less common here than the latter, with depressed umbilical masses (pl. 40:5–6), 7–8 chambers, and proloculus about 30 microns in size.

Single equatorial sections (pl. 40:8, 10), clearly showing internal structure of test, fully confirm assignment of that species to *Ophthalmidium* Kübler and Zwingli.

Occurrence. — West Carpathians (Velká Fatra Mts., section: 1 — Rúbaň Skala; Tatra Mts., sections: 17 — Velká Furkaska Mt., 18 — Lejowa Valley I, 20–21 — Strążyska Valley I and II); Hettangian — ?Sinemurian (*leischneri* and *walfordi* Zone).

This species was reported from the Lower Lias of Northern Limestone Alps (Leischner 1961), substratum of the Vienna Basin (Kristan-Tollmann 1962), Haute-Savoie (Zaninetti 1977), Southern Alps (Cita 1965, Tsamantouridis 1971), Karavanken Mts. (Ramovš and Rebek 1970), Croatia (Gušić 1975) and from Taurus Mts. (Brönnimann *et al.* 1970).

Ophthalmidium walfordi Häusler, 1887

(pl. 40:13–16)

1887. *Ophthalmidium walfordi* Häusler: 192, pl. 6:7–11.
1936. *Ophthalmidium walfordi* Häusler; Franke: 122, pl. 12:16.
1946. *Ophthalmidium walfordi* Häusler; Wood and Barnard: 91, fig. 6.

Material. — Forty specimens in thin sections.

Association. — Mainly with *Ophthalmidium leischneri*, *Involutina liassica*, *I. turgida*, *I. farinacciae*, *Trocholina umbo*, *Nodosaria* sp., and *Lenticulina* sp.

Description. — as given by Häusler (1887).

Dimensions of the test (in μm):

	pl. 40:13	pl. 40:14	pl. 40:16
diameter	360	440	360
thickness	40	50	—
diameter of the proloculus	25	—	—

Remarks. — *Ophthalmidium walfordi* differs from the remaining representatives of the genus *Ophthalmidium* Kübler and Zwingli in specific development of the last chamber. The chamber is straight and markedly diverges from the planispiral part of the test (pl. 40:16), and its length is most equal to diameter of the planispiral part (pl. 40:13–15). The recorded number of chambers ranges from seven to eight.

A characteristic final chamber, initiating the development of the linear series of chambers, suggests attachment of that species to foreign bodies during its life.

Occurrence. — West Carpathians (Tatra Mts., sections: 17 — Velká Furkaska Mt., 18 — Lejowa Valley I, 20–21 — Strążyska Valley I and II): Hettangian — ?Sinemurian (*leischneri* and *walfordi* Zone).

Hitherto known from the Lias of the epicontinental basin of north-western Europe (ISSLER 1908, FRANKE 1936, WOOD and BARNARD 1946). This is the first record of that species not only from the Carpathians but from the whole Tethys Realm.

Ophthalmidium sp.

(pl. 37:13–14)

Material. — Seven specimens in thin sections.

Association. — *Glomospira* sp., *Trochammina alpina*, *"Tetrataxis" inflata* and *Triasina hantkeni*.

Description. — Test lenticular in outline in axial sections (pl. 37:13–14), somewhat elongate, with well-marked neck. Chambers, 5–7 in number, spirally coiled; the last two chambers comprise a major part of the test, forming the outer whorl. Proloculus circular, located in the center of the test. Aperture terminal, with distinct prominent lip. Variability in size of individuals is fairly high.

Dimensions of the test (in μm):

	pl. 37:13	pl. 37:14
diameter	200	490
thickness	70	180
diameter of the proloculus	30	—

Remarks. — Test outline and internal structure match well the diagnosis of the genus *Ophthalmidium*. However, the specimens are poorly preserved, sections innumerous, and variability in size is fairly high which makes specific identification hazardous.

Occurrence. — West Carpathians (Tatra Mts., sections: 17 — Velká Furkaska Mt., 26 — Chochołowska Valley): Rhaetian (*friedli* and *hantkeni* Zone, the conodont *posthernsteini* Zone).

Suborder **Involutinina** HOHENEGGER and PILLER, 1977
Superfamily **Involutinacea** BÜTSCHLI, 1880
Family **Involutinidae** BÜTSCHLI, 1880
Genus *Aulotortus* WEYNSCHENK, 1956
Aulotortus gaschei (KOEHN-ZANINETTI and BRÖNNIMANN, 1968)
(pl. 32:9–16)

1968. *Angulodiscus? gaschei* KOEHN-ZANINETTI and BRÖNNIMANN: 74, pl. 1:A–F, pl. 2:A–F, fig. 3.
1976. *Involutina gaschei* (KOEHN-ZANINETTI and BRÖNNIMANN); ZANINETTI: 159, pl. 9:13–15 (with synonymy).
1978. *Aulotortus friedli* (KRISTAN-TOLLMANN); PILLER: 55, pl. 8:3–8, pl. 9:1–16.

Material. — About 200 specimens in thin sections.

Association. — Most often with involutinids (*Aulotortus sinuosus*, *A. tenuis*, *A. tumidus*, *A. communis*, *Auloconus permodiscoides*, *Triasina hantkeni*, *T. oberhauseri*); and sometimes with *Glomospira sinensis*, *Glomospirella friedli*, *G. parallela*, *Tolypammina gregaria*, *Trochammina alpina*, "*Tetrataxis*" *inflata*, *Agathammina austroalpina* and "*Frondicularia woodwardi*".

Description. — as given by KOEHN-ZANINETTI and BRÖNNIMANN (1968) and ZANINETTI (1976).

Dimensions of the test (in μm):

	pl. 32:9	pl. 32:13	pl. 32:16
diameter	440	760	720
thickness	260	—	480

Remarks. — *A. gaschei* appears to be a homeomorph of *Glomospirella friedli* (comp. p. 145) differing from the latter by streptospiral coiling of the first 6–8 whorls (pl. 32:9–16) which are obscured by the outer, planispirally coiled whorls. It differs clearly from *G. friedli* in the presence of umbilical masses and somewhat in test size (about 700 μm and 500 μm on the average, respectively). Moreover, the representatives of *A. gaschei* studied are characterized by calcareous wall sometimes displaying perforation (pl. 32:9–10). *Aulotortus gaschei* differs from its direct ancestor, *A. praegaschei* KOEHN-ZANINETTI, known from the Ladinian-Carnian, in planispirally coiled outer whorls.

Occurrence. — West Carpathians (Nizke Tatry Mts., section: 25 — Hybe): Norian (*oberhauseri* Zone); Strážovská hornatina Mts., sections: 6 — Hireška, 22 — Norovica Mt., 24 — Tŕstie; Malá Fatra Mts., sections: 8 — Široka Valley, 9 — Suchá Valley, 10 — Slovianska Valley; Velká Fatra Mts., sections: 12 — Križna Valley, 14 — Ráztoky; Nizke Tatry Mts., section: 25 — Hybe; Tatra Mts., section: 16 — Bobrovček -Hrádky, 17 — Velká Furkaska Mt., 18 — Lejowa Valley I, 26 — Chochołowska Valley, 28 — Lejowa Valley II; Slovenské rudohorie Mts., section: 30 — Skalka; Slovenský kras, section: 32 — Bleskový prameň): Rhaetian (*friedli* and *hantkeni* Zone; the conodont *posthernsteini* Zone).

This species was also fairly often reported from the Norian-Rhaetian sequences of Northern Limestone Alps (KOEHN-ZANINETTI and BRÖNNIMANN 1968, HOHENEGGER and LOBITZER 1971, PILLER 1978, SCHÄFER 1979), Dolomites (CROS and NEUMANN 1964), Croatia (GUŠIĆ 1975), Dinaric Alps (PANTIĆ-PRODANOVIĆ 1975), Prokletije Mts. (PANTIĆ 1974), Stara Planina Mts. (UROŠEVIĆ and ANDELKOVIĆ 1970), Taygète Mts in Greece (ZANINETTI and THIEBAULT 1975), Caucasus Mts. (EFIMOVA 1974), Taurus Mts. (BRÖNNIMANN *et al.* 1970), Wardak Mts. of Afganistan (LYS and MARIN 1973), Kyaukme-Longtawkno area in Burma (BRÖNNIMANN *et al.* 1975) and Kodiang Limestone Formation in Malaysia (GAŹDZICKI and SMIT 1977).

Genus *Involutina* TERQUEM, 1862

Involutina liassica (JONES, 1853)

(pl. 29:1; pl. 38:1–12, 15)

1853. *Nummulites*? *liassicus* JONES: 275.
1961. *Involutina liassica* (JONES); MIŠIK: 179, pl. 29:1–2.
1969. *Involutina liassica* (JONES); KOEHN-ZANINETTI: 82, figs 22–24 (with synonymy).
1978. *Involutina liassica* (JONES); PILLER: 65, pl. 13:1–9.

Material. — Over 100 specimens in thin sections.

Association. — *Involutina turgida*, *I. farinacciae*, *Trocholina umbo*, *Ophthalmidium leischneri*, *O. walfordi*, *Planiinvoluta carinata*, *Trochammina* sp. and nodosariids (*Astacolus*, *Frondicularia*, *Lenticulina* and *Nodosaria*).

Description. — as given by KOEHN-ZANINETTI (1969) and PILLER (1978).

Dimensions of the test (in μm):

	pl. 38:1	pl. 38:5	pl. 38:15
diameter	520	650	580
thickness	190	280	260
diameter of the proloculus	60	120	70

Remarks. — *I. liassica* is characterized by umbilical masses composed of numerous pillars (pl. 38:7–8). The appearance of pillars is a new element in evolution of Involutinidae, typical of the so-called "post-Triassic" involutinids. The dimorphism is clearly marked in this species. Megalospheric forms (pl. 38:5, 15) are characterized by large proloculus (about 100 μm in diameter) and, usually, three whorls, and the microspheric — by almost twice smaller proloculus (about 60 μm in diameter) and up to 6 whorls. This species was previously recorded in the Lias of the West Carpathians by MIŠIK (1961). It should be noted, however, that the form figured as *Involutina* cf. *liassica* from Dachstein Limestone of Muránska planina by MIŠIK (1961, pl. 30:2) does not display features typical of this species (e.g. pillars are almost completely missing) and it most probably represent *Aulotortus communis* (KRISTAN).

Occurrence. — West Carpathians (Velká Fatra Mts., section: 1 — Rúbaň Skala; Tatra Mts., sections: 17 — Velká Furkaska Mt., 20–21 — Strążyska Valley I and II): Hettangian — ?Sinemurian (*leischneri* and *walfordi* Zone).

It is known also from the Rhaetian of Hohen Wand and Fischerwiese in Austria (KRISTAN 1957, KRISTAN-TOLLMANN 1964) and fairly often from the Lias of Eastern, Western and Southern Alps (LEISCHNER 1961, KRISTAN-TOLLMANN 1962, CITA 1965, FABRICIUS 1966, PAPP and TURNOVSKY 1970, COUSIN and NEUMANN 1971, ZANINETTI 1977, PILLER 1978); Apennines (FARINACCI and RADOIČIĆ 1964), Karawanken Mts. (RAMOVŠ and REBEK 1970), Croatia (GUŠIĆ 1975), Dinaric Alps (RADOIČIĆ 1966), Tunisia (BISMUTH *et al.* 1967), Taurus Mts. (BRÖNNIMANN *et al.* 1970), Western Highlands of Papua New Guinea (HAIG 1979) and from epicontinental basin of north-western Europe (FRANKE 1936, DREXLER 1958, BROUWER 1969 and SCHLOZ 1972).

Genus *Triasina* MAJZON, 1954
Triasina hantkeni MAJZON, 1954
(pl. 27:2; pl. 28:2; pl. 30:2–6; pl. 25:7–17)

1954. ***Triasina hantkeni*** MAJZON: 245, pl. 1:1–2, pl. 2:3–5, pl. 3:6.
1954. ***Triasina hantkeni*** var. *elliptica* MAJZON: 245, pl. 3:7.
1976. ***Triasina hantkeni*** MAJZON; ZANINETTI: 172, pl. 15:2–3 (with synonymy).
1978. ***Triasina hantkeni*** MAJZON; PILLER: 70, pl. 15:1–15 (with synonymy).

Material. — Over 1000 specimens in thin sections; locally forming very large, rock-forming accumulations.

Association. — Most often with involutinids (*Auloconus permodiscoides*, *Aulotortus communis*, *A. gaschei*, *A. impressus*, *A. pragsoides*, *A. sinuosus*, *A. tenuis* and *A. tumidus*); also with *Glomospira sinensis*, *Glomospirella friedli*, *Glomospirella parallela*, *Tolypammina gregaria*, "*Tetrataxis*" *inflata*, *Ophthalmidium* sp., "*Frondicularia woodwardi*", *Nodosaria* sp. and *Diplotremina* sp.

Description. — as given by MAJZON (1954) and PILLER (1978).

Dimensions of the test (in μm):

	pl. 35:10	pl. 35:12	pl. 35:14
diameter	760	1,000	1,500
diameter of the proloculus	90	—	—

Remarks. — *Triasina hantkeni* is a well know species which makes it easy to be identifies in thin sections. It is primarily characterized by segmentation of deuteroloculus, well visible in sections (pl. 35:9–12). The segmentation of deuteroloculus is a new element in evolution of

Late Triassic involutinids. About 7 to 8 whorls were recorded. *T. hantkeni* was previously reported from the West Carpathians by SALAJ *et al.* (1967) and GAŹDZICKI (1970).

Occurrence. — West Carpathians (Strážovská hornatina Mts., sections: 22 — Norovica Mt., 24 — Tŕstie; Malá Fatra Mts., sections: 9 — Suchá Valley, 15 — Zázrivská Valley; Velká Fatra Mts., sections: 11 — Dedošova Valley, 12 — Križna Valley, 13 — Belianska Valley; Tatra Mts., sections: 17 — Velká Furkaska Mt., 18 — Lejowa Valley I, 26 — Chochołowska Valley, 27 — Wielka Sucha Valley, 28 — Lejowa Valley II; Slovenské rudohorie Mts., section: 30 — Skalka; Slovenský kras, section: 32 — Bleskový prameň): Rhaetian (*friedli* and *hantkeni* Zone; the conodont *posthernsteini* Zone).

This species is also known from the Rhaetian (the ammonoid *haueri* and *marshi* Zones; the conodont *posthernsteini* Zone) of Bakony Forest, Gerecse Mts and Vértes Mts (MAJZON 1954), Lower Austria (OBERHAUSER and PLÖCHINGER 1968, KRISTAN-TOLLMANN 1970, PAPP and TURNOVSKY 1970), Northern Limestone Alps (HAGN 1955, OBERHAUSER 1964, FABRICIUS 1966, TOLLMANN 1976, HOHENEGGER and PILLER 1977*b*, SCHÄFER and SENOWBARI-DARYAN 1978, PILLER 1978, SCHÄFER 1979), Lombardian Alps (WIDEMAYER 1963), Dolomites (CROS and NEUMANN 1964, BOSELLINI and BROGLIO LORIGA 1965), Northern Italy (ANONYMOUS, 1959, FUGANTI and MOSNA 1966), Dinaric Alps (PANTIĆ and RAMPNOUX 1972, PANTIĆ-PRODANOVIĆ 1975), Croatia (GUŠIĆ 1975), Stara Planina Mts. (UROŠEVIĆ and ANDELKOVIĆ 1970), Eastern Hellenic Zone (CHRISTODOULOU and TSAILA-MONOPOLIS 1972), Rif Mts. (RAOULT 1962), Eastern Atlas Mts. (SALAJ and STRANIK 1970), Taurus Mts (ZANINETTI 1976), Sichuan of China (HE YAN 1980), and Calamian Islands, Philippines (FONTAINE *et al.* 1979).

Triasina oberhauseri KOEHN-ZANINETTI and BRÖNNIMANN, 1968
(fig. 21a, b)

1968. *Triasina oberhauseri* KOEHN-ZANINETTI and BRÖNNIMANN: 1, pl. 1:1–2, fig. 1.
1976. *Triasina oberhauseri* KOEHN-ZANINETTI and BRÖNNIMANN; ZANINETTI: 173, pl. 14: 23, pl. 15:1 (with synonymy).
1979. *Triasina oberhauseri* KOEHN-ZANINETTI and BRÖNNIMANN; GAŹDZICKI *et al.* 1979a: pl. 1:9.

Material. — Five specimens in thin sections.

Association. — Co-occurring with *Aulotortus communis, A. gaschei, A. sinuosus, A. tumidus, Auloconus permodiscoides, Tolypammina gregaria* and *Nodosaria* sp.

Description. — as given by KOEHN-ZANINETTI and BRÖNNIMANN (1968).

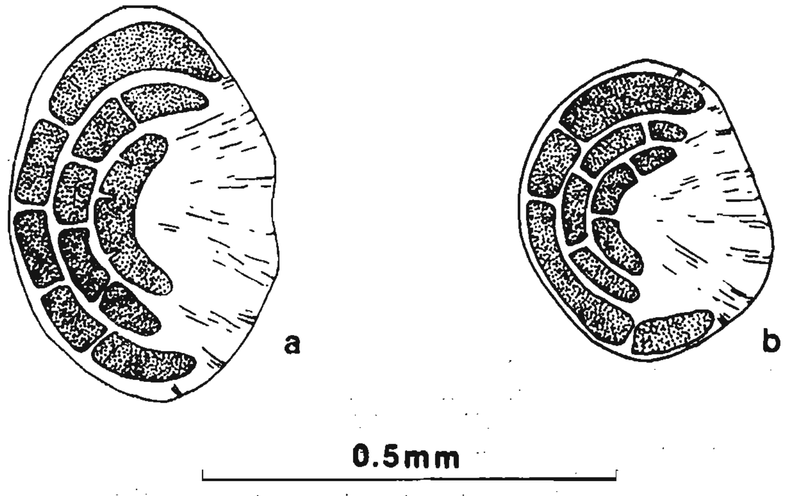

Fig. 21
Triasina oberhauseri KOEHN-ZANINETTI and BRÖNNIMANN, subaxial sections. Hybe (section 25, sample 8). Lowermost part of Hybe Beds. Norian (Sevatian). ZPAL F. XXVIII/25–8.

Dimensions of test (in μm):

	fig. 21a	fig. 21b
diameter	440	360
thickness	320	280

Remarks. — The tests of *Triasina oberhauseri* (fig. 21a, b) studied are almost identical with representatives of this species from the Upper Norian of Northern Limestone Alps (KOEHN-ZANINETTI and BRÖNNIMANN 1968, fig. 1). The Carpathian specimens are characterized by 3–5 whorls and an underdeveloped segmentation of deuteroloculus best visible in the case of the last whorls.

It is worth to note that *Triasina oberhauseri*, first described by KOEHN-ZANINETTI and BRÖNNIMANN (1968), represents a transitional form between involutinid *Aulotortus pragsoides* and *Triasina hantkeni*, the existence of which has been earlier inferred by OBERHAUSER (1964, fig. 1) in this theoretical analysis. It should be also noted here that the existence of such transitional form gives support to the allocation of Triasina in the family Involutinidae BÜTSCHLI. The form recently described and figured as *Triasina hantkeni* MAJZON from the Upper Norian ("Maantang" Formation) of Sichuan (China) by HE YAN (1980, pl. 73:11), displays underdeveloped segmentation of deuteroloculus, so it is assigned here to *Triasina oberhauseri* KOEHN-ZANINETTI and BRÖNNIMANN, 1968.

Occurrence. — West Carpathians (Nizke Tatry Mts., section: 25 — Hybe): Upper Norian (Sevatian) (*oberhauseri* Zone).

T. oberhauseri is also known from the Norian of Bakony Forest (GAŹDZICKI unpublished), Caucasus Mts. (EFIMOVA 1974) and from the Upper Norian of Northern Limestone Alps (KOEHN-ZANINETTI and BRÖNNIMANN 1968, KOEHN-ZANINETTI 1969), Taurus Mts. (BRÖNNIMANN *et al.* 1970) and Sichuan province of China (HE YAN 1980).

Genus *Auloconus* PILLER, 1978

Auloconus permodiscoides (OBERHAUSER, 1964)

(pl. 30:2; pl. 35:1–6)

1964. *Trocholina permodiscoides* OBERHAUSER: 207, pl. 2:13–15, 18, 20, 22; pl. 3:1.
1976. *Trocholina permodiscoides* OBERHAUSER; ZANINETTI: 178, pl. 10: pl. 12:9–11 (with synonymy).
1978. *Auloconus permodiscoides* (OBERHAUSER); PILLER: 74, pl. 20:1–8 (with synonymy).

Material. — Over 200 well preserved specimens in thin sections.

Association. — Commonly with *Triasina hantkeni*, *Aulotortus sinuosus*, *A. communis*, *A. gaschei*, *A. impressus*, *A. tumidus*, *A. tenuis*, *Tolypammina gregaria*; sometimes with *Glomospira* sp., *Glomospirella friedli*, *G. parallela*, "*Tetrataxis*" *inflata*, *Ophthalmidium* sp., and "*Frondicularia woodwardi*".

Description. — as given by OBERHAUSER (1964) and PILLER (1978).

Dimensions of the test (in μm):

	pl. 35:1	pl. 35:4	pl. 35:5
diameter of the base	560	840	760
height	280	560	680

Remarks. — The specimens studied are characterized by conical shape with rounded apical part and elongate base in axial (vertical) sections (pl. 35:1–6). Trochospiral coiling; number of whorls usually ranging from 6 to 8. These features, along with the lack of pillars, well match the diagnosis of *Auloconus permodiscoides*. One of the specimens figured (pl. 35:3), displaying not more than three whorls, may represent a megalospheric form. Some of the specimens studied are low-trochospirally coiled, except for planispiral coiling of first 2–3 whorls (pl. 35:1). Such features bring them closer to the genus *Aulotortus*. This gives support to the interpretation of trocholinids as trochospirally coiled involutinids (see OBERHAUSER 1964, KOEHN-ZANINETTI 1969, and GUŠIĆ 1975).

Occurrence. — West Carpathians (Nizke Tatry Mts., section: 25 — Hybe): Norian (*oberhauseri* Zone); Strážovská hornatina Mts., sections: 6 — Hireška, 22 — Norovica Mt., 24 — Tŕstie; Malá Fatra Mts., section: 9 — Suchá Valley; Velká Fatra Mts., sections: 12 — Križna Valley, 13 — Belianska Valley; Nizke Tatry Mts., section: 25 — Hybe; Tatra Mts., sections: 17 — Velká Furkaska Mt., 18 — Lejowa Valley I, 26 — Chochołowska Valley, 28 — Lejowa Valley II; Slovenské rudohorie Mts., section: 30 — Skalka): Rhaetian (*friedli* and *hantkeni* Zone; the conodont *posthernsteini* Zone).

A. permodiscoides is also known from the Norian-Rhaetian strata of Northern Limestone Alps (OBERHAUSER 1964, KOEHN-ZANINETTI 1969, PILLER 1978, SCHÄFER 1979), Dolomites (BOSELLINI and BROGLIO LORIGA 1965), Croatia (GUŠIĆ 1975), Dinaric Alps (PANTIĆ and RAMPNOUX 1972, PANTIĆ-PRODANOVIĆ 1975), Taygète Mts. in Greece (ZANINETTI and THIEBAULT 1975), Taurus Mts. (BRÖNNIMANN *et al.* 1970), Caucasus Mts. (EFIMOVA 1974), Kuh-e-Nayband Mts. in Iran (ZANINETTI and BRÖNNIMANN 1974), Kyaukme-Longtawkno area in Burma (BRÖNNIMANN *et al.* 1975), Yunnan and Sichuan provinces of China (HO YEN and HU LAN-YING 1977, HE YAN 1980).

Genus *Trocholina* PAALZOV, 1922
Trocholina umbo FRENTZEN, 1941
(pl. 39:3–4)

1941. *Trocholina umbo* FRENTZEN: 306, pl. 1:12.
1941. *Trocholina granosa* FRENTZEN: 304, pl. 1:11.
1978. *Trocholina umbo* FRENTZEN; PILLER: 81, pl. 20:9–11, 13–14, 16–17 (with synonymy).

Material. — Twenty specimens in thin sections.

Association. — Commonly with *Involutina liassica, I. turgida, I. farinacciae, Ophthalmidium leischneri, O. walfordi, Nodosaria* sp., *Astacolus* sp., and *Lenticulina* sp.

Description. — as given by FRENTZEN (1941) and PILLER (1978).

Dimensions of the test (in μm):

	pl. 39:3	pl. 39:4
diameter of the base	300	280
height	130	120

Remarks. — The specimens studied are characterized by a conical shape with markedly rounded apical part in axial (vertical) sections (pl. 39:3–4), deuteroloculus markedly semitubular in shape (pl. 39:3), trochospiral coiling and a number of discernible whorls equalling 4–6, so they fully match the diagnosis of *Trocholina umbo.*

Occurrence. — West Carpathians (Velká Fatra Mts., section: 1 — Rubaň Skala; Tatra Mts., sections: 17 — Velká Furkaska Mt., 20–21 — Strążyska Valley I and II): Hettangian — ?Sinemurian (*leischneri* and *walfordi* Zone).

T. umbo was reporter from a pebble of Lias limestone from conglomerates of the Santonian-Campanian age of Slovakia (SAMUEL *et al.* 1972). It is also known from the Lias of Eastern and Western Alps (LEISCHNER 1961, KRISTAN-TOLLMANN 1962, PAPP and TURNOVSKY 1970, TOLLMANN 1976, ZANINETTI 1977, PILLER 1978), Apennines (FARINACCI 1967), Karavenken Mts. (RAMOVŠ and KRISTAN-TOLLMANN 1967), Dinaric Alps RADOIČIĆ 1966), Croatia (GUŠIĆ 1975), and from the epicontinental basin of the north-western Europe (BROUWER 1969, SCHLOZ 1972).

Trocholina turris FRENTZEN, 1941
(pl. 39:7)

1941. *Trocholina turris* FRENTZEN: 306, pl. 1:13.
1975. *Trocholina turris* FRENTZEN; GUŠIĆ: 25, pl. 8:1–7 (with synonymy).
1978. *Trocholina turris* FRENTZEN; PILLER: 83, pl. 20: 12, 15, 16 (with synonymy).

Material. — Four poorly preserved specimens in thin sections.
Association. — *Nodosaria* sp., *Lenticulina* sp., *Astacolus* sp., and *Ophthalmidium* sp.
Description. — as given by FRENTZEN (1941) and PILLER (1978).
Dimensions of the test (in μm):

	pl. 39:7
diameter of the base	200
height	160

Remarks. — *T. turris* was identified is single subaxial and oblique sections only. The preservation is unsatisfactory because of an advanced recrystallization (sparitization) of tests but, nevertheless, high trochospiral coiling (pl. 39:7) and whorl number equalling 6–8 make the assignment of the specimens to *T. turris* possible. This species was hitherto unknown from the Carpathians.
Occurrence. — West Carpathians (Slovenský kras, section: 32 — Bleskový prameň): Pliensbachian.

It is also known from the Lias of Eastern, Western and Southern Alps (KRISTAN-TOLLMANN 1962, PAPP and TUROVSKY 1970, COUSIN and NEUMANN 1971, TOLLMANN 1976, ZANINETTI 1976, 1977*a*; PILLER 1978), Karavanken Mts. (RAMOVŠ and REBEK 1970), Croatia (GUŠIĆ 1975), Dinaric Alps (RADOIČIĆ 1966), Taurus Mts. (BRÖNNIMANN *et al.* 1970), and also from the epicontinental basin of the north-western Europe (FRENTZEN 1941).

Family **Planispirillinidae** PILLER, 1978
Genus *Semiinvoluta* KRISTAN, 1957
Semiinvoluta sp.
(pl. 39:1)

Material. — Two specimens in thin sections.
Association. — *Nodosaria* sp., *Lenticulina* sp., *Geinitzinita* sp., and *Ophthalmidium* sp.
Description. — Test consisting of proloculus and planispirally coiled deuteroloculus with umbilical depression on one side. In axial (vertical) sections (pl. 39:1), whorls are symmetrically crescent, with rounded ends. Number of whorls ranges from 4 to 5. Wall calcareous.
Dimensions of the test (in μm):

	pl. 39:1
diameter	360
maximum thickness	130

Remarks. — The form studied is most close to *Semiinvoluta* sp. 2 described by GUŠIĆ (1975, pl. 11:1–3) from the Lias of Medvednica Mt., Northern Croatia.
Occurrence. — West Carpathians (Slovenský kras, section: 32 — Bleskový prameň): Pliensbachian.

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EXPLANATION OF PLATES 27–41

PLATE 27

1. Abundant foraminifers *Glomospirella friedli* KRISTAN-TOLLMANN in coral-crinoid-brachiopod biomicrite. Tatra Mts., Lejowa Valley I (section 18, sample 49); Fatra Formation, upper biostrome; Rhaetian, ZPAL F. XXVIII/18–49.

2. Foraminifer biosparite with *Triasina hantkeni* Majzon. Tatra Mts., Velká Furkaska Mt. (section 17, sample 338); Fatra Formation, lower biostrome; Rhaetian. ZPAL F. XXVIII/17–338.
3. Biosparrudite composed of pelecypod and gastropod debris with onkolitic envelopes and sessile foraminifers *Tolypammina gregaria* Wendt. Velká Fatra Mts., Dedošova Valley (section 11, sample 3); Fatra Formation, lower biostrome, GUSAV 268/3.

All × 10

PLATE 28

1. Numerous foraminifers *Glomospirella friedli* Kristan-Tollmann in crinoid-brachiopod-pelecypod biosparite. Strážovská hornatina Mts., Norovica Mt. (section 22, sample 25); Norovica Formation, Mojtin Limestone Member; Rhaetian, GUSAV N/25.
2. Foraminifer assemblage enclosing *Triasina hantkeni* Majzon, *Aulotortus sinuosus* Weynschenk, *A. tumidus* (Kristan-Tollmann), *A. gaschei* (Koehn-Zaninetti and Brönnimann) and *Auloconus permodiscoides* (Oberhauser) in brachiopod-crinoid biosparite containing bioclass with onkolitic crusts. Tatra Mts., Lejova Valley I (section 28, sample 13); Norovica Formation, Mojtin Limestone Member; Rhaetian. ZPAL F. XXVIII/28–13.
3. Biosparrudite composed of pelecypod and gastropod debris with onkolitic crusts; ooids and rare foraminifers *Aulotortus sinuosus* Weynschenk, "*Tetrataxis*" *inflata* Kristan and *Ophthalmidium* sp. are also visible. Slovenské rudohorie Mts. (Muránska planina), Skalka (locality 30, sample 1); Dachstein Limestone; Rhaetian. ZPAL F. XXVIII/30–1.

All × 10

PLATE 29

1. Foraminifer assemblage enclosing *Involutina liassica* (Jones), *Nodosaria* sp., *Frondicularia* sp., *Astacolus* sp., *Lenticulina* sp. and *Ophthalmidium* sp. seen in crinoid biomicrite. Velká Fatra Mts., Rúbaň Skala (locality 1, sample 9718) Lias of the Tatricum in the Velká Fatra Mts., Sinemurian. PFUK 9719.
2. Crinoid-gastropod biopelmicrite with foraminifers *Ophthalmidium leischneri* (Kristan-Tollmann), *Involutina liassica* (Jones), *Involutina farinacciae* Brönnimann and Koehn-Zaninetti, *Nodosaria* sp. and *Lenticulina* sp. Tatra Mts., Strążyska Valley I (section 20, sample S_{26}); Kopieniec Formation, lower limestones; Hettangian —? Sinemurian. ZPAL F. XXVIII/20–S_{26}.
3. Crinoid biomicrite with rare foraminifers *Nodosaria* sp. and *Lenticulina* sp. Slovenský kras, Bleskový prameň (section 32, sample BP-2); Lias of the Silicicum in the Slovenský kras. Pliensbachian. ZPAL F. XXVIII/32–BP–2.

All × 10

PLATE 30

1. Strongly recrystallized tests of *Aulotortus tumidus* (Kristan-Tollmann). Velká Fatra Mts., Dedošova Valley (section 11, sample 8); Fatra Formation, lower biostrome; Rhaetian. GUSAV 268/8.
2. Obliteration of internal structure through recrystallization in *Triasina hantkeni* Majzon, *Aulotortus sinuosus* Weynschenk and *Auloconus permodiscoides* (Oberhauser). Strážovská hornatina Mts., Tŕstie (section 24, sample 23); Morovica Formation, Mojtin Limestone Member; Rhaetian. GUSAV T/23.
3. Various stages of progressing recrystallization (sparrytization) of *Triasina hantkeni* Majzon tests. Tatra Mts., Lejowa Valley (section 18, sample 17/; Fatra Formation, lower biostrome; Rhaetian. ZPAL F. XXVIII/18–17.
4. Tests of foraminifers *Triasina hantkeni* Majzon with oolitic coatings (arrowed) in bioosparite. Strážovská hornatina Mts., Norovica Mt. (section 22, sample 15); Norovica Formation, Mojtin Limestone Member; Rhaetian. GUSAV N/15.

5. Numerous test of foraminifers *Triasina hantkeni* MAJZON with onkolitic envelopes (arrowed). West Tatra Mts., Velká Furkaska Mt. (section 17, sample 338); Fatra Formation, lower biostrome; Rhaetian. ZPAL F. XXVIII/17–338.
6. Compactional deformation of *Triasina hantkeni* MAJZON tests (arrowed) in marly limestone. Tatra Mts., Wielka Sucha Valley (locality 27, sample 2); Norovica Formation, Mojtín Limestone Member; Rhaetian. ZPAL F. XXVIII/27–2.

All × 10

PLATE 31

1. *Glomospirella pokornyi* (SALAJ) in pelecypod-crinoid biomicrite. Štefanský žlab (section 19, sample 10). Fatra Formation. Rhaetian. PFUK 298/10. × 30.
2. *Glomospirella pokornyi* (SALAJ), subaxial section. Štefanský žlab (section 19, sample 10). Fatra Formation. Rhaetian. PFUK 298/10. × 80.
3. *Ammodiscus multivolutus* REITLINGER with oolitic envelopes, axial section. Hireška (section 6, sample 24). Fatra Formation. Rhaetian. GUSAV 119/24. × 80.
4. *Glomospirella pokornyi* (SALAJ), axial section. Tŕstie (section 24, sample 20). Norovica Formation. Rhaetian. GUSAV T/20. × 80.
5. *Glomospirella pokornyi* (SALAJ), equatorial section. Štefanský žlab (section 19, sample 10). Fatra Formation. Rhaetian. PFUK 298/10. × 80.
6. *Glomospirella* sp., axial section. Tŕstie (section 24, sample 15). Norovica Formation. Rhaetian. GUSAV T/15. × 90.
7. *Glomospirella expansa* KRISTAN-TOLLMANN, axial section. Chochołowska Valley (section 26, sample 14a). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26–14a. × 80.
8. *Glomospirella expansa* KRISTAN-TOLLMANN, axial section. Velká Furkaska Mt. (section 17, sample 389). Fatra Formation. Rhaetian. PFUK 352/389. × 80.
9. Foraminifer biopelsparite with numerous *Glomospira* and *Glomospirella*. Hireška (section 6, sample 23). Fatra Formation. Rhaetian. GUSAV 119/23. × 30.
10. *Glomospira* sp. Hireška (section 6, sample 23), Fatra Formation. Rhaetian. GUSAV 119/23. × 160.

11–13. *Glomospirella facilis* Ho, *11* — axial section, *12* — oblique section, *13* — equatorial section. Hireška (section 6, sample 23). Fatra Formation. Rhaetian. GUSAV 119/23. × 160.

14. *Glomospira sinensis* Ho. Przysłop Miętusi (section 29, sample 5). Norovica Formation. Rhaetian. ZPAL F. XXVIII/29–5. × 180.
15. *Glomospira sinensis* Ho. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. × 180.
16. *Glomospirella shengi* Ho. Velká Furkaska Mt. (section 17, sample 344). Fatra Formation. Rhaetian. PFUK 352/344. × 180.

PLATE 32

1. Foraminifer biomicrite with *Glomospirella friedli* KRISTAN-TOLLMANN. Lejowa Valley I (section 18, sample 49). Fatra Formation. Rhaetian. ZPAL F. XXVIII/18–49. × 30.

2–4. *Glomospirella friedli* KRISTAN-TOLLMANN; *2* — equatorial section, *3* — axial and equatorial sections, *4* — oblique section. Lejowa Valley I (section 18, sample 49). Fatra Formation. Rhaetian. ZPAL F. XXVIII/18–49. × 80.

5. *Glomospirella friedli* KRISTAN-TOLLMANN, oblique section. Široka Valley (section 8, sample 13). Fatra Formation. Rhaetian. GUSAV 062/13. × 110
6. *Glomospirella friedli* KRISTAN-TOLLMANN, oblique section. Norovica Mt. (section 22, sample 25). Norovica Formation. Rhaetian. GUSAV N/25. × 80.

7–8. *Glomospirella* sp., oblique sections. Norovica Mt. (sections 22, sample 24). Norovica Formation. Rhaetian. GUSAV N/24. × 80.

9–10. *Aulotortus gaschei* (KOEHN-ZANINETTI and BRÖNNIMANN), *9* — axial section, *10* — subaxial section. Velká Furkaska Mt. (section 17, sample 392). Fatra Formation. Rhaetian. ZPAL F. XXVIII/17–392 × 80.

11. *Aulotortus gaschei* (KOEHN-ZANINETTI and BRÖNNIMANN), oblique section. Chochołowska Valley (locality 26, sample II-5). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26–II-5. × 50.

12–14. *Aulotortus gaschei* (KOEHN-ZANINETTI and BRÖNNIMANN), *12* — equatorial section, *13—14* — subequatorial sections. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. × 50.

15. *Aulotortus gaschei* (KOEHN-ZANINETTI and BRÖNNIMANN), subaxial section. Chochołowska Valley (locality 26, sample II–5). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26–II–5. × 50.

16. *Aulotortus gaschei* (KOEHN-ZANINETTI and BRÖNNIMANN), subaxial section. Lejowa Valley I (section 18, sample 38). Fatra Formation. Rhaetian. ZPAL F. XXVIII/18–38. × 60.

PLATE 33

1. *Aulotortus communis* (KRISTAN), axial section. Lejova Valley II (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. × 60.

2. *Aulotortus* sp., subaxial section. Chochołowska Valley (locality 26, sample II-5). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26–II–5. × 50.

3. *Aulotortus tumidus* (KRISTAN-TOLLMANN), subaxial section. Chochołowska Valley (locality 26, sample II–5). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26–II–5. × 35.

4–5. *Aulotortus tumidus* (KRISTAN-TOLLMANN), *4* — axial section, *5* — oblique section. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. 4 × 75, 5 × 40.

6. *Aulotortus tumidus* (KRISTAN-TOLLMANN), axial section. Lejowa Valley II (section 18, sample 12). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–12. × 65.

7. *Aulotortus tumidus* (KRISTAN-TOLLMANN), subaxial section. Suchá Valley (section 9, sample 2). Fatra Formation. Rhaetian. GUSAV 088/2. × 50.

8. *Aulotortus tumidus* (KRISTAN-TOLLMANN), subaxial section. Široka Valley (section 8, sample 5). Fatra Formation Rhaetian. GUSAV 062/5. × 65.

9. *Aulotortus tenuis* (KRISTAN), axial section. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. × 65.

10. *Aulotortus tenuis* (KRISTAN), axial section. Velká Furkaska Mt. (section 17, sample 392). Fatra Formation. Rhaetian. ZPAL F. XXVIII/17–392. × 75.

11. *Aulotortus tenuis* (KRISTAN), axial section. Tŕstie (section 24, sample 21). Norovica Formation. Rhaetian. GUSAV T/21. × 50.

12. ?*Semiinvoluta* sp., axial section. Velká Furkaska Mt. (section 17, sample 392). Fatra Formation. Rhaetian. ZPAL F. XXVIII/17–392. × 65.

13. *Aulotortus* sp., subaxial section. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian· ZPAL F. XXVIII/28–13. × 40.

14. *Aulotortus* sp., subequatorial section. Velká Furkaska Mt. (section 17, sample 392). PFUK 352/392. × 75.

15. *Aulotortus* sp., subaxial section. The last whorls of the test settled by *Tolypammina gregaria* WENDT (arrowed). Križna Valley (section 12, sample 7). Fatra Formation. Rhaetian. GUSAV 253/7. × 50.

16. *Aulotortus* sp. with test encrusted by *Girvanella*. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. × 45.

PLATE 34

1. *Aulotortus* cf. *pragsoides* (OBERHAUSER), axial section. Test with oolitic envelopes. Norovica Mt. (section 22, sample 19). GUSAV N/19.

2–3. *Aulotortus sinuosus* WEYNSCHENK, axial sections. Chochołowska Valley (locality 26, sample II–5). ZPAL F. XXVIII/26–II–5.

4. *Aulotortus impressus* (KRISTAN-TOLLMANN), subaxial section. Lejowa Valley II (section 28, sample 13). ZPAL F. XXVIII/28–13.

5. *Aulotortus sinuosus* WEYNSCHENK, subaxial section. Test with onkolitic crusts. Lejowa Valley II (section 28, sample 13). ZPAL F. XXVIII/28–13.
6. *Aulotortus* sp., axial section. Chochołowska Valley (locality 26, sample II-5). ZPAL F. XXVIII/26–II–5.
7–9. *Aulotortus sinuosus* WEYNSCHENK, subaxial sections. Chochołowska Valley (locality 26, sample II-5). ZPAL F. XXVIII/26–II–5.
10. *Aulotortus sinuosus* WEYNSCHENK, oblique section. Lejowa Valley II (section 28, sample 13). ZPAL F. XXVIII/28–13.
11–12. *Aulotortus sinuosus* WEYNSCHENK, *11* — oblique section, *12* — subequatorial section. Chochołowska Valley (section 26, samples 6/11/ and 7/12/). ZPAL F. XXVIII/26–6 and 7.

Norovica Formation, Rhaetian

All × 40

PLATE 35

1–2. *Auloconus permodiscoides* (OBERHAUSER), subaxial sections. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. × 75.
3. *Auloconus permodiscoides* (OBERHAUSER), subaxial section. Lejowa Valley (locality 28, sample II-6). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–II–6. × 80.
4. *Auloconus permodiscoides* (OBERHAUSER), subaxial section. Chochołowska Valley (locality 26, sample II-5). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26–II–5. × 50.
5. *Auloconus permodiscoides* (OBERHAUSER), axial section. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. × 50.
6. *Auloconus permodiscoides* (OBERHAUSER), axial section. Tŕstie (section 24, sample 25). Norovica Formation. Rhaetian. GUSAV T/25. × 50.
7. *Triasina hantkeni* MAJZON. Test encrusted by *Girvanella*. Chochołowska Valley (locality 26, sample II-5). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26–II–5. × 50.
8. *Triasina hantkeni* MAJZON. Test deformed by compaction. Wielka Sucha Valley (locality 27, sample 2). Norovica Formation. Rhaetian. ZPAL F. XXVIII/27-2. × 40.
9. *Triasina hantkeni* MAJZON. Chambers of the test inhabited by sessile foraminifer *Tolypammina gregaria* WENDT (arrowed). Lejowa Valley (section 28, sample 13). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–13. × 50.
10–15. *Triasina hantkeni* MAJZON, equatorial and oblique sections. Obliteration of internal structure through progressing recrystallization of tests.
10 — Norovica Mt. (section 22, sample 13). Norovica Formation. Rhaetian. GUSAV N/13. × 65.
11 — Chochołowska Valley (section 26, sample 5a). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26–5a. × 75.
12 — Lejowa Valley II (locality 28, sample II-6). Norovica Formation. Rhaetian. ZPAL F. XXVIII/28–II–6. × 50
13 — Velká Furkaska Mt. (section 17, sample 338). Fatra Formation. Rhaetian. ZPAL F. XXVIII/17–338. × 40.
14 — Norovica Mt. (section 22, sample 20). Norovica Formation. Rhaetian. GUSAV N/20. × 30.
15 — Tŕstie (section 24, sample 23). Norovica Formation. Rhaetian. GUSAV T/23, × 30.

PLATE 36

1. *Planiinvoluta carinata* LEISCHNER, vertical section. Chochołowska Valley (section 26, sample 8). Norovica Formation Rhaetian. ZPAL F. XXVIII/26–8. × 80.
2. *Tolypammina gregaria* WENDT, vertical section. Hireška (section 6, sample 21). Fatra Formation. Rhaetian. GUSAV 119/21. × 80.
3. *Tolypammina gregaria* WENDT, vertical section. Przysłop Miętusi (section 29, sample 5). Norovica Formation. Rhaetian. ZPAL F. XXVIII/29–5. × 55.
4. *Tolypammina gregaria* WENDT, vertical section. Lejowa Valley II (section 28, sample 13). Norovica Formation. Rhaetian ZPALF. XXVIII/28–13. × 75.

5. *Tolypammina gregaria* WENDT, vertical section. Hireška (section 6, sample 21). Fatra Formation. Rhaetian. GUSAV 119/21. × 30.
6. *Tolypammina gregaria* WENDT, vertical section. Dedošova Valley (section 11, sample 3). Fatra Formation. Rhaetian. GUSAV 268/3. × 35.
7. *Trochammina alpina* KRISTAN-TOLLMANN, vertical section. Malý Mlynský vrch Mt. (section 31, sample 1). Zlambach Beds. Upper Norian (Sevatian) — *Misikella hernsteini* — Assemblage — Zone. ZPAL F. XXVIII/31-1. × 190.
8. *Trochammina* sp., vertical section. Velká Furkaska Mt. (section 17, sample 375). Fatra Formation. Rhaetian. PFUK 352/375. × 150.
9. ?*Trochammina* sp., transversal section. Chochołowska Valley (section 26, sample 3). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26-3. × 200.
10. "*Tetrataxis*" sp., transversal section. Velká Furkaska Mt. (section 17, sample 376). Fatra Formation. Rhaetian. PFUK 352/376. × 80.
11. "*Tetrataxis*" *inflata* KRISTAN, vertical section. Velká Furkaska Mt. (section 17, sample 335). Fatra Formation. Rhaetian. PFUK 352/335. × 80.
12. "*Tetrataxis*" *inflata* KRISTAN, vertical section. Velká Furkaska Mt. (section 17, sample 332). Fatra Formation. Rhaetian. PFUK 352/332. × 80.
13. "*Tetrataxis*" sp., oblique section. Tŕstie (section 24, sample 4). Norovica Formation. Rhaetian. GUSAV T/4. × 100.
14. *Ammobaculites* sp., axial section. Bleskový prameň (section 32, sample 166/3-D_1). Limestone of Bleskový prameň. Rhaetian. ZPAL F. XXVIII/32-166/3-D_1. × 60.
15. *Ammobaculites* cf. *rhaeticus* KRISTAN-TOLLMANN, section through planispiral part. Tŕstie (section 24, sample M-23). Norovica Formation. Rhaetian. GUSAV T/M-23. × 60.
16. *Ammobaculites* sp., axial section. Norovica Mt. (section 22, sample 21). Norovica Formation. Rhaetian. GUSAV N/21. × 60.
17. *Ammobaculites rhaeticus* KRISTAN-TOLLMANN, axial section. Tŕstie (section 24, sample M-21). Norovica Formation. Rhaetian. GUSAV T/M-21. × 50.

PLATE 37

1. *Agathammina austroalpina* KRISTAN-TOLLMANN and TOLLMANN in dolomicrite. Lejowa Valley I (section 18, sample 1). Upper dolomites of Carpathian Keuper Group. Rhaetian. ZPAL F. XXVIII/18-1. × 40.

2–4. *Agathammina austroalpina* KRISTAN-TOLLMANN and TOLLMANN, oblique sections. Lejowa Valley I (section 18, sample 1). Upper dolomites of Carpathian Keuper Group. Rhaetian. ZPAL F. XXVIII/18-1. × 130.

5. *Agathammina austroalpina* KRISTAN-TOLLMANN and TOLLMANN, axial section. Palenica Lendacka Mt. (section 6, sample 3 *in* GAŹDZICKI 1974). Fatra Formation. Upper Norian (?Sevatian). ZPAL F. XXVIII/1974:6-3. × 110.
6. "*Frondicularia woodwardi*" HOWCHIN, subaxial sections. Norovica Mt. (section 22, sample 17). Norovica Formation. Rhaetian. GUSAV N/17. × 80.
7. "*Frondicularia woodwardi*" HOWCHIN, axial section. Tŕstie (section 24, sample 8). Norovica Formation. Rhaetian. GUSAV T/8. × 80.
8. *Nodosaria* sp., axial section. Velká Furkaska Mt. (section 18, sample 388). Fatra Formation. Rhaetian. PFUK 352/388. × 120.

9–10. *Ophthalmidium carpathicum* (GAŹDZICKI), axial sections. Malý Mlynský vrch Mt. (section 31, sample 4). Zlambach Beds. Norian (Sevatian). ZPAL F. XXVIII/31-MWV-4. × 130.

11. *Ophthalmidium* cf. *carpathicum* (GAŹDZICKI), axial section. Bleskový prameň (section 32, sample 166/5-D_4). Limestone of Bleskový prameň. Rhaetian. ZPAL F. XXVIII/32-166/5-D_4. × 200.
12. *Ophthalmidium martanum* FARINACCI, subaxial section. Bleskový prameň (section 32, sample 166/2). Limestone of Bleskový prameň. Rhaetian. ZPAL F. XXVIII/32-166/2. × 120.
13. *Ophthalmidium* sp., axial section. Velká Furkaska Mt. (section 17, sample 335). Fatra Formation. Rhaetian. PFUK 352/335. × 200.
14. *Ophthalmidium* sp., axial section. Chochołowska Valley (section 26, sample 8). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26-8. × 80.
15. *Galeanella* cf. *tollmanni* (KRISTAN), oblique section. Bleskový prameň (section 32, sample 166/2). Limestone of Bleskový prameň. Rhaetian. ZPAL F. XXVIII/32-166/2. × 80.
16. *Diplotremina* sp., subequatorial section. Chochołowska Valley (section 26, sample 12). Norovica Formation. Rhaetian. ZPAL F. XXVIII/26-12. × 80.

PLATE 38

1–2. *Involutina liassica* (JONES), axial sections, microspheric forms. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. 1 — × 80, 2 — × 70.

3. *Involutina liassica* (JONES), axial section, microspheric form. Velká Furkaska Mt. (section 17, sample 422). Kopieniec Formation. Lias (Hettangian-?Sinemurian). PFUK 352/422. × 80.

4. *Involutina liassica* (JONES), axial section. Rúbaň Skala (locality 1, sample 9720). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9720. × 80.

5. *Involutina liassica* (JONES), axial section, megalospheric form. Rúbaň Skala (locality 1, sample 9720). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9720. × 80.

6. *Involutina liassica* (JONES), subaxial section. Rúbaň Skala (locality 1, sample 9718). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9718. × 80.

7–8. *Involutina liassica* (JONES), oblique sections. Rúbaň Skala (locality 1, sample 9720). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9720. 7 — × 80, 8 — × 90.

9–10. *Involutina liassica* (JONES), subequatorial sections. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. × 80.

11. *Involutina liassica* (JONES), equatorial section, microspheric form. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. ×80.

12. *Involutina liassica* (JONES), equatorial section. Rúbaň Skala (locality 1, sample 9720). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9720. × 50.

13. *Involutina farinacciae* BRÖNNIMANN and KOEHN-ZANINETTI, axial section. Test with thin uniform onkolitic envelopes. Strążyska Valley I (section 20, sample S_{2b}). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/20-S_2b. × 135.

14. *Involutina turgida* KRISTAN, axial section. Test with onkolitic crusts. Strążyska Valley I (section 20, sample S_2). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/20-S_2. × 80.

15. *Involutina liassica* (JONES), axial section, megalospheric form. Test with thick irregular onkolitic coatings. Strążyska Valley I (section 20, Sample S_{2b}). Kopieniec Formation. Lias (Hettangian-Sinemurian). ZPAL F. XXVIII/20-S_{2b}. × 80.

16. *Involutina* sp., axial section. Test with oolitic envelopes. Strążyska Valley (section 20, sample S_2). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/20-S_2. × 80.

PLATE 39

1. *Semiinvoluta* sp., axial section. Bleskový prameň (section 32, sample BP-2). Lias of the Silicicum in the Slovenský kras. Pliensbachian. ZPAL F. XXVIII/32-BP-2. × 80.

2. ?*Involutina* sp., axial section. Strążyska Valley II (section 21, sample 13). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/21-13. × 150.

3. *Trocholina umbo* FRENTZEN, subaxial section. Strążyska Valley I (section 20, sample S_{2a}). Kopieniec Formation Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/20-S_{2a}. × 200.

4. *Trocholina umbo* FRENTZEN, axial section. Test with onkolitic coatings. Strążyska Valley II (section 21, sample 13). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/21-13. ×160.

5. *Trocholina* sp., axial section. Rúbaň Skala (section 1, sample 9720). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9720. × 80.

6. *Trocholina* cf. *umbo* FRENTZEN, subaxial section. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. × 90.

7. *Trocholina turris* FRENTZEN, axial section. Bleskový prameň (section 32, sample BP-3). Lias of the Silicicum in the Slovenský kras. Pliensbachian. ZPAL F. XXVIII/32-BP-3. × 200.

8. *Planiinvoluta carinata* LEISCHNER, vertical section. Strążyska Valley I (section 20, sample S_2). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/20-S_2. × 200.

9. ?*Planiinvoluta* sp., vertical section. Strążyska Valley I (section 20, sample S_2). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/20-S_2. × 150.

10. *Ophthalmidium* sp., axial section. Velká Furkaska Mt. (section 17, sample 421). Kopieniec Formation. Lias (Hettangian- ?Sinemurian). PFUK 352/421. × 170.

11. *Ophthalmidium martanum* FARINACCI, axial section. Rúbaň Skala (locality 1, sample 9861). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9861. × 130.

12. *Ophthalmidium* cf. *leischneri* (KRISTAN-TOLLMANN), axial section. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. × 150.
13. *Ophthalmidium* sp., subequatorial section. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. × 80.
14. *Glomospira* sp. Kopieniec Starorobociański Mt. (section 3, sample 16). Lias of the Tatricum in the Tatra Mts. Hettangian-Sinemurian. IGP/16. × 190.
15. *Trochammina* sp., oblique section. Lejowa Valley I (section 18, sample L-8). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/18-L-8. × 150.
16. *Cyclogyra* sp., subequatorial section. Lejowa Valley I (section 18, sample L-4). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/18-L-4. × 190.
17. *Textularia* sp., axial section. Bobrowiec Mt. (locality 2, sample I/7). Lias of the Tatricum in the Tatra Mts. Hettangian-Sinemurian. IGP/I/7. × 100.

PLATE 40

Ophthalmidium leischneri (KRISTAN-TOLLMANN)

1. axial section, megalospheric form. Velká Furkaska Mt. (section 17, sample 421). PFUK 352/421. × 150.
2. axial section, megalospheric form. Lejowa Valley I (section 18, sample L-8). ZPAL F. XXVIII/18-L-8. × 150.
3. axial section, Strążyska Valley I (section 20, sample S_{2b}). ZPAL F. XXVIII/20-S_{2b}. × 150.
4. axial section, Strążyska Valley I (section 20, sample S_2). ZPAL F. XXVIII/20-S_2. × 150.
5. axial section, microspheric form. Strążyska Valley I (section 20, sample S_2). ZPAL F. XXVIII/20-S_2 . × 150.
6. subaxial section, microspheric form. Strążyska Valley I (section 20, sample S_{2b}). ZPAL F. XXVIII/20-S_{2b}. × 150.
7. oblique section, megalospheric form. Lejowa Valley I (section 18, sample L-8). ZPAL F. XXVIII/18-L-8. × 150.
8. equatorial section. Lejowa Valley I (section 18, sample L-8). ZPAL F. XXVIII/18-L-8. × 150.

9–10. subequatorial sections, Lejowa Valley I (section 18, sample L-8). ZPAL F. XXVIII/18-L-8. × 150.

11. axial section; a specimen with attached foreign test. Strążyska Valley I (section 20, sample S_{2b}). ZPAL F. XXVIII/20-S_{2b}. × 150.
12. axial section: a specimen with regenerated last chamber (arrowed), situated asymmetrically to the foregoing chambers. Strążyska Valley I (section 20, sample S_{2b}). ZPAL F. XXVIII/20-S_{2b}. × 150.

Ophthalmidium walfordi HÄUSLER

13. axial section. Lejowa Valley I (section 18, sample L-8). ZPAL F. XXVIII/18-L-8. × 100.
14. axial section. Strążyska Valley II (section 21, sample 13). ZPAL F. XXVIII/21-13. × 100.
15. subaxial section. Strążyska Valley I (section 20, sample S_{2a}). ZPAL F. XXVIII/20-S_{2a}. × 100.
16. subequatorial section. Lejowa Valley I (section 18, sample L-8). ZPAL F. XXVIII/18-L-8. × 100.

All from Kopieniec Formation. Lias (Hettangian-?Sinemurian)

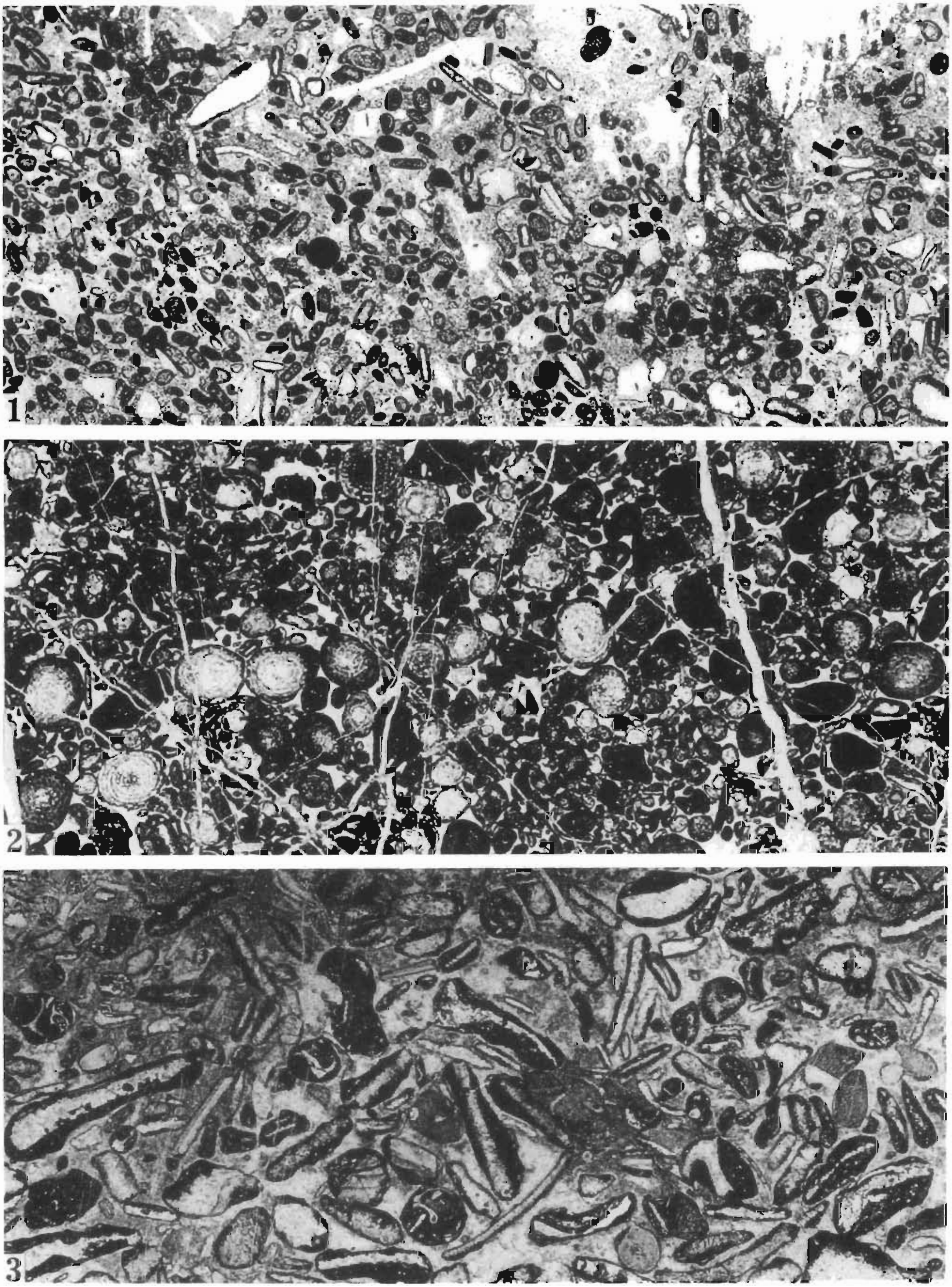
PLATE 41

1. *Nodosaria* cf. *metensis* TERQUEM, transversal section. Test with thin uniform onkolitic envelopes. Strążyska Valley (section 20, sample S_{2a}). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/20-S_{2a}. × 150.
2. *Nodosaria* cf. *metensis* TERQUEM, oblique section. Test with onkolitic envelopes. Strążyska Valley I (section 20, sample S_{2b}). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/20-S_{2b}. × 150.
3. *Nodosaria* cf. *claviformis* TERQUEM, longitudinal section. Test with onkolitic crusts. Strążyska Valley II (section 21, sample 13). Kopieniec Formation. Lias (Hettangian-?Sinemurian). ZPAL F. XXVIII/21–13. × 100.
4. *Nodosaria* cf. *nitidana* BRAND, longitudinal section. Rúbaň Skala (locality 1, sample 9718). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9718. × 80.
5. *Geinitzinita* sp., longitudinal section. Bleskový prameň (section 32, sample BP-2). Lias of the Silicicum in the Slovenský kras. Pliensbachian. ZPAL F. XXVIII/32-BP-2. × 100.
6. *Frondicularia* sp., longitudinal section. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. × 80.

7. ?*Geinitzinita* sp., longitudinal section. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. × 80.
8. *Nodosaria* sp., longitudinal section. Rúbaň Skala (locality 1, sample 9861). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9861. × 80.
9. ?*Nodosaria* sp., longitudinal section. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. × 50.

10–12. *Astacolus* sp., sections in coiling plane. Rúbaň Skala (locality 1, sample 9719 (*10* and *12*) and 9718 (*11*). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719 and 9718. *10*– ×40, *11* — × 50, 12– × 80.

13. *Lenticulina* sp., subaxial section. Bleskový prameň (section 32, sample BP-2). Lias of the Silicicum in the Slovenský kras. Pliensbachian. ZPAL F. XXVIII/32-BP-2. × 50.
14. *Lenticulina* sp., section in plane of coiling. Bleskový prameň (section 32, sample BP-2). Lias of the Silicicum in the Slovenský kras. Pliensbachian. ZPAL F. XXVIII/32-BP-2. × 80.
15. *Lenticulina* sp., section in plane of coiling. Rúbaň Skala (locality 1, sample 9719). Lias of the Tatricum in the Velká Fatra Mts. Sinemurian. PFUK 9719. × 100.
16. *Lenticulina* sp., section in plane of coiling. Bleskový prameň (section 32, sample BP-2). Lias of the Silicicum in the Slovenský kras. Pliensbachian. ZPAL F. XXVIII/32-BP-2. × 80.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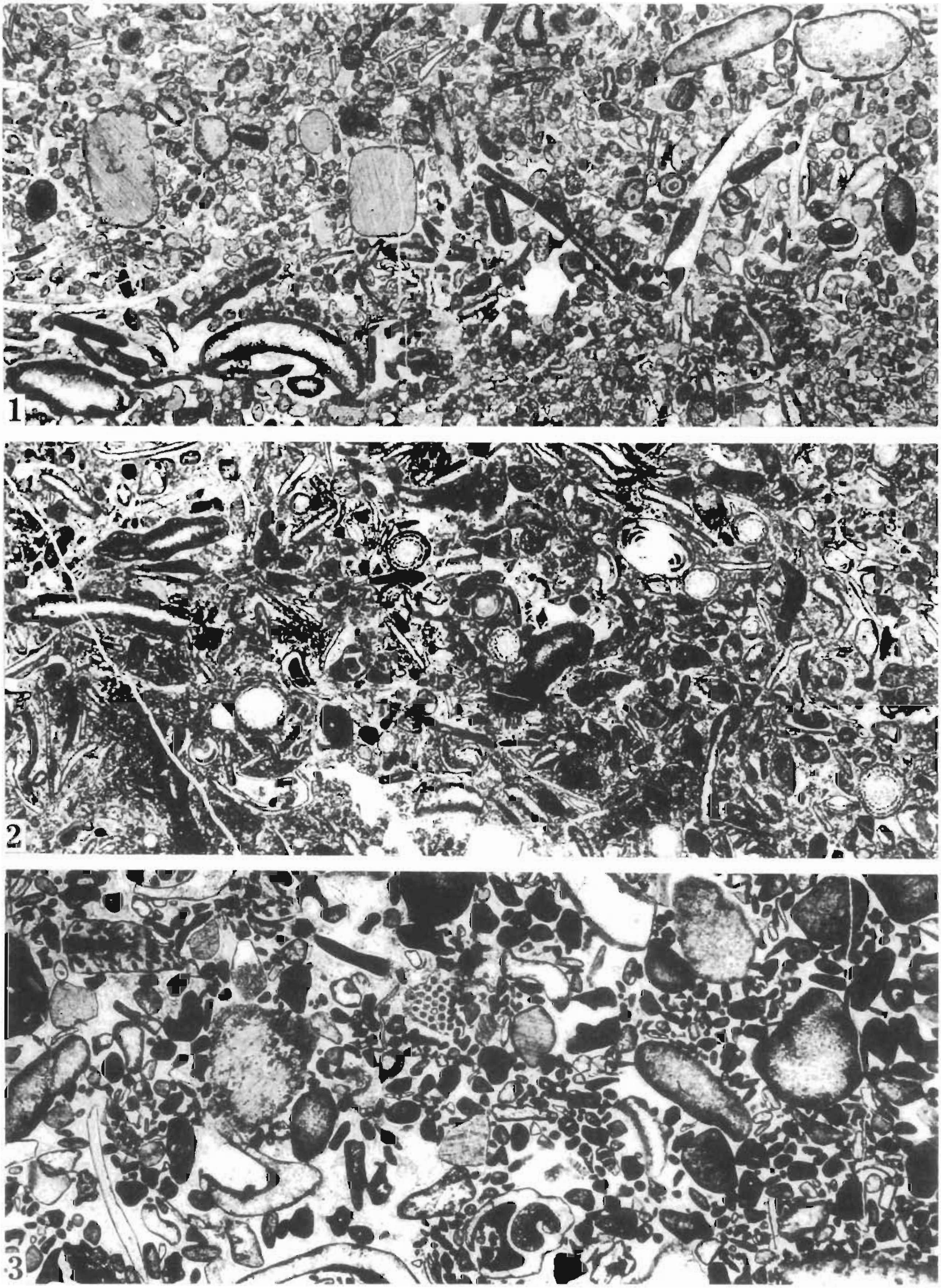
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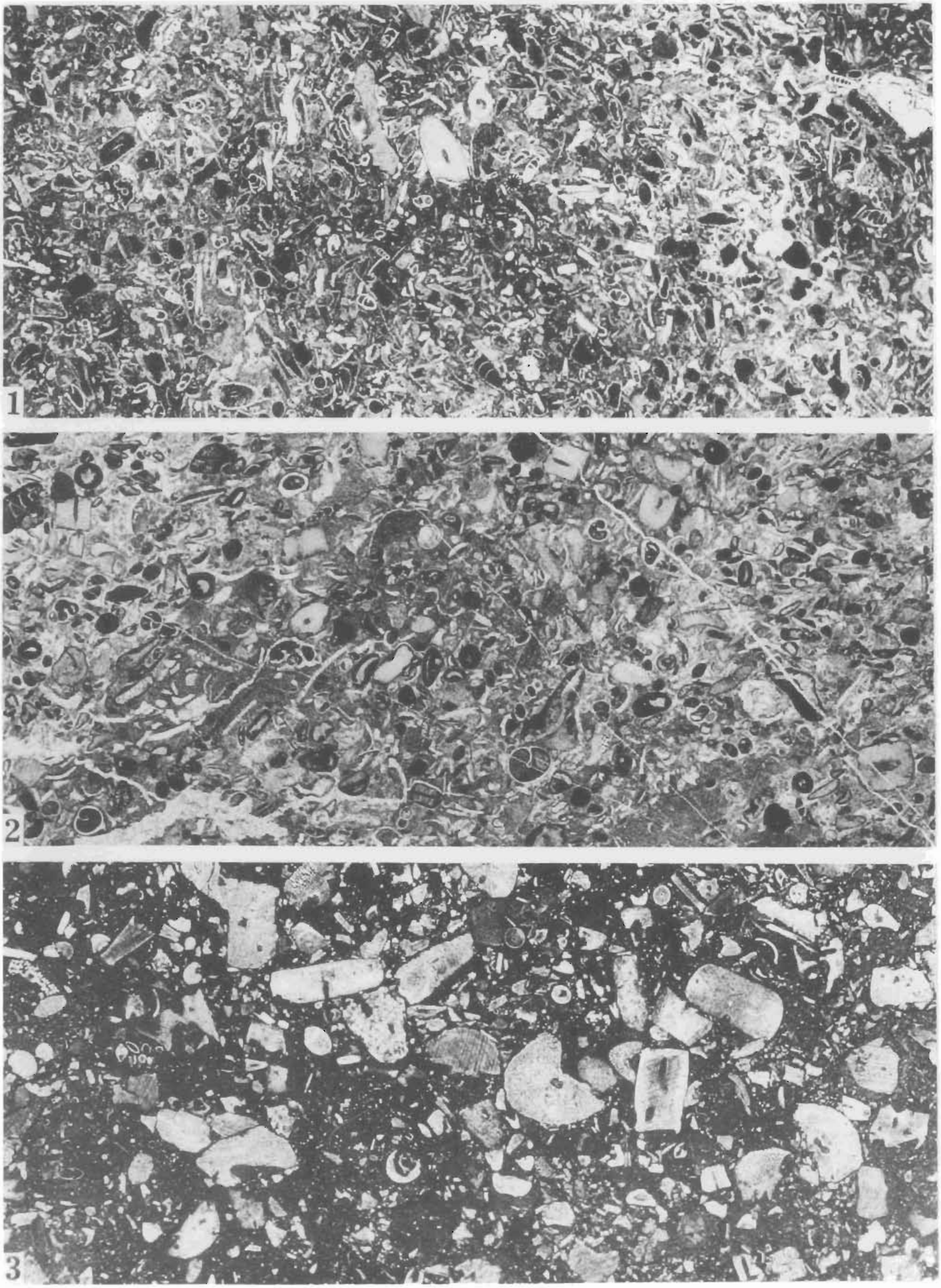
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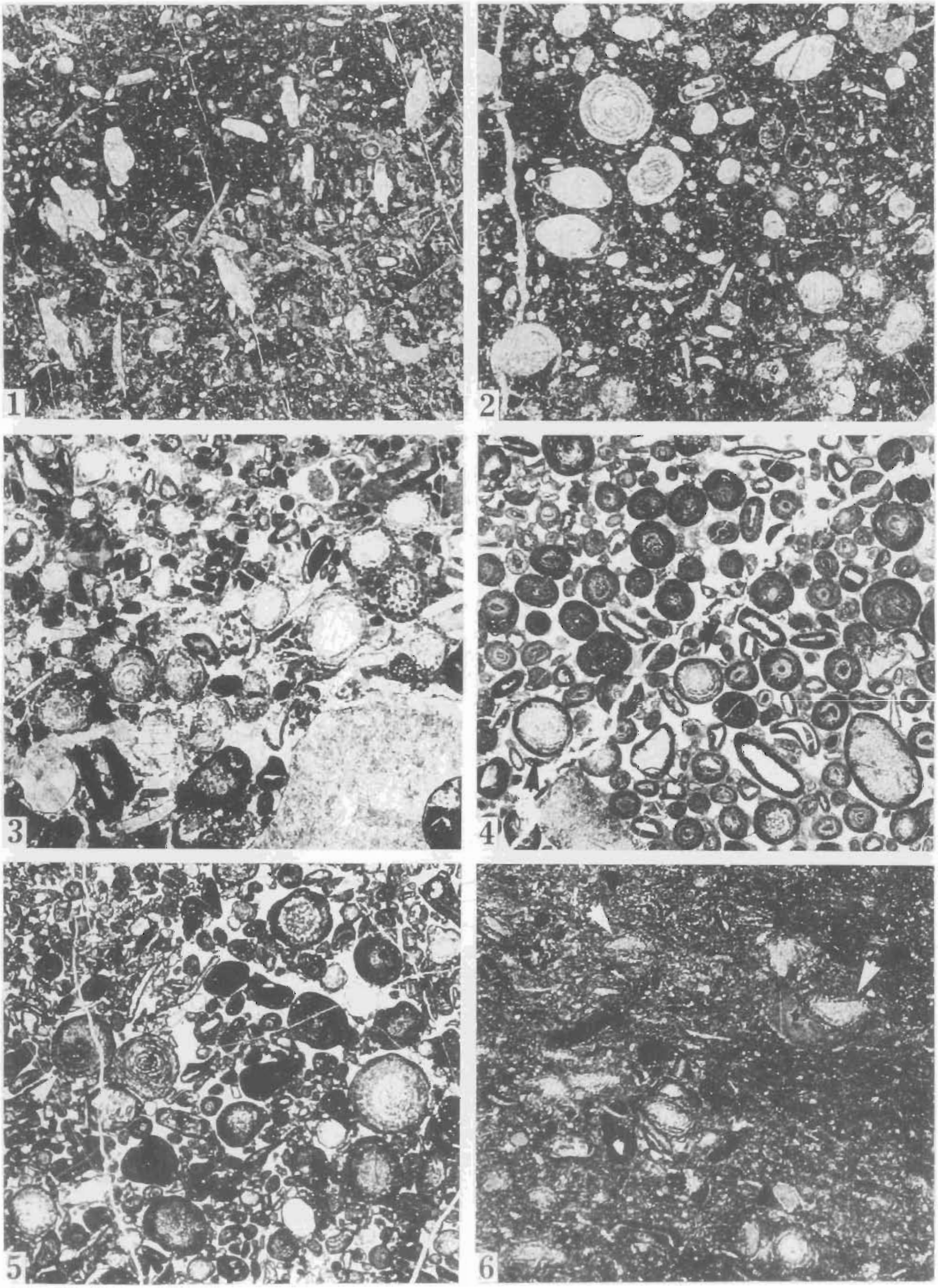
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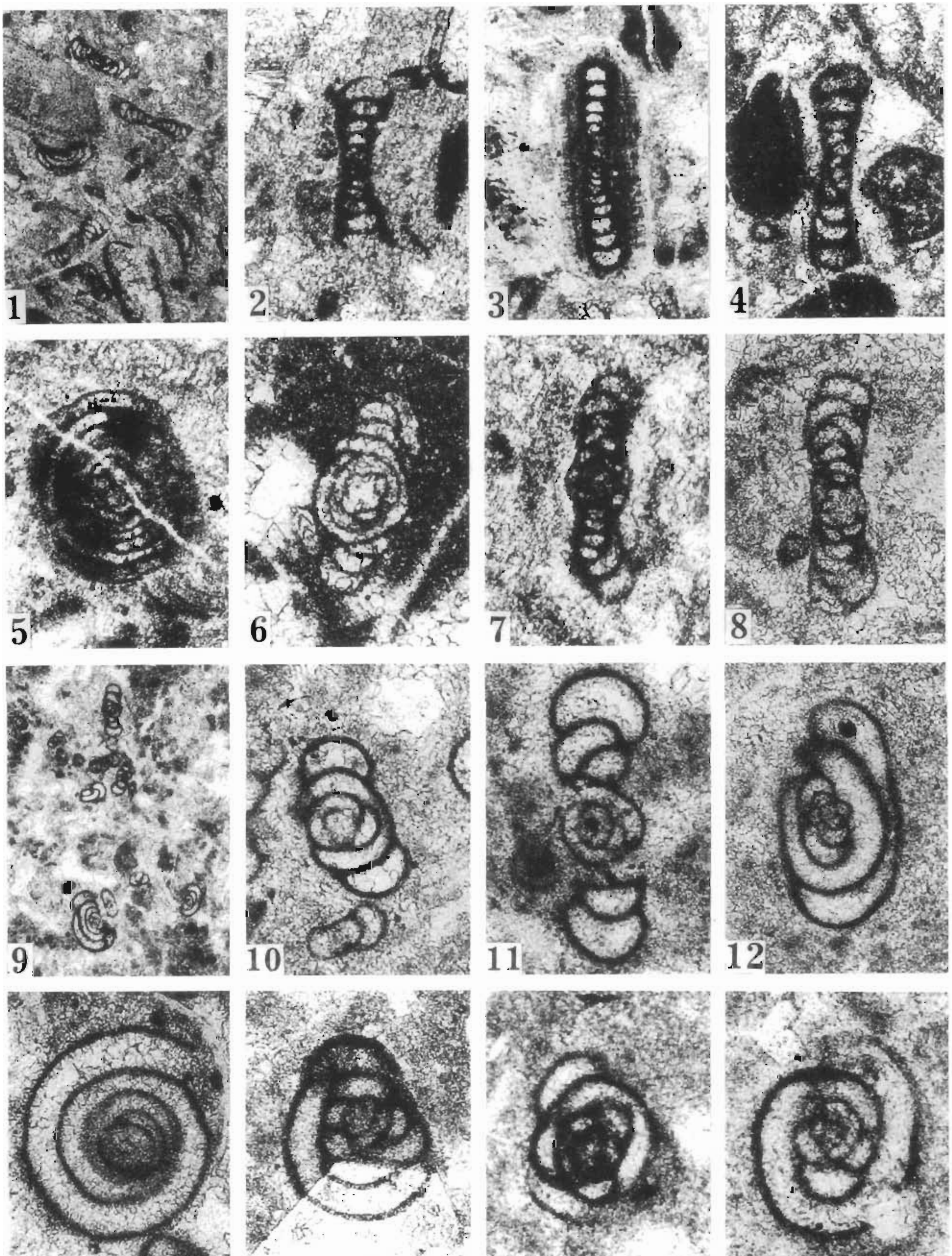
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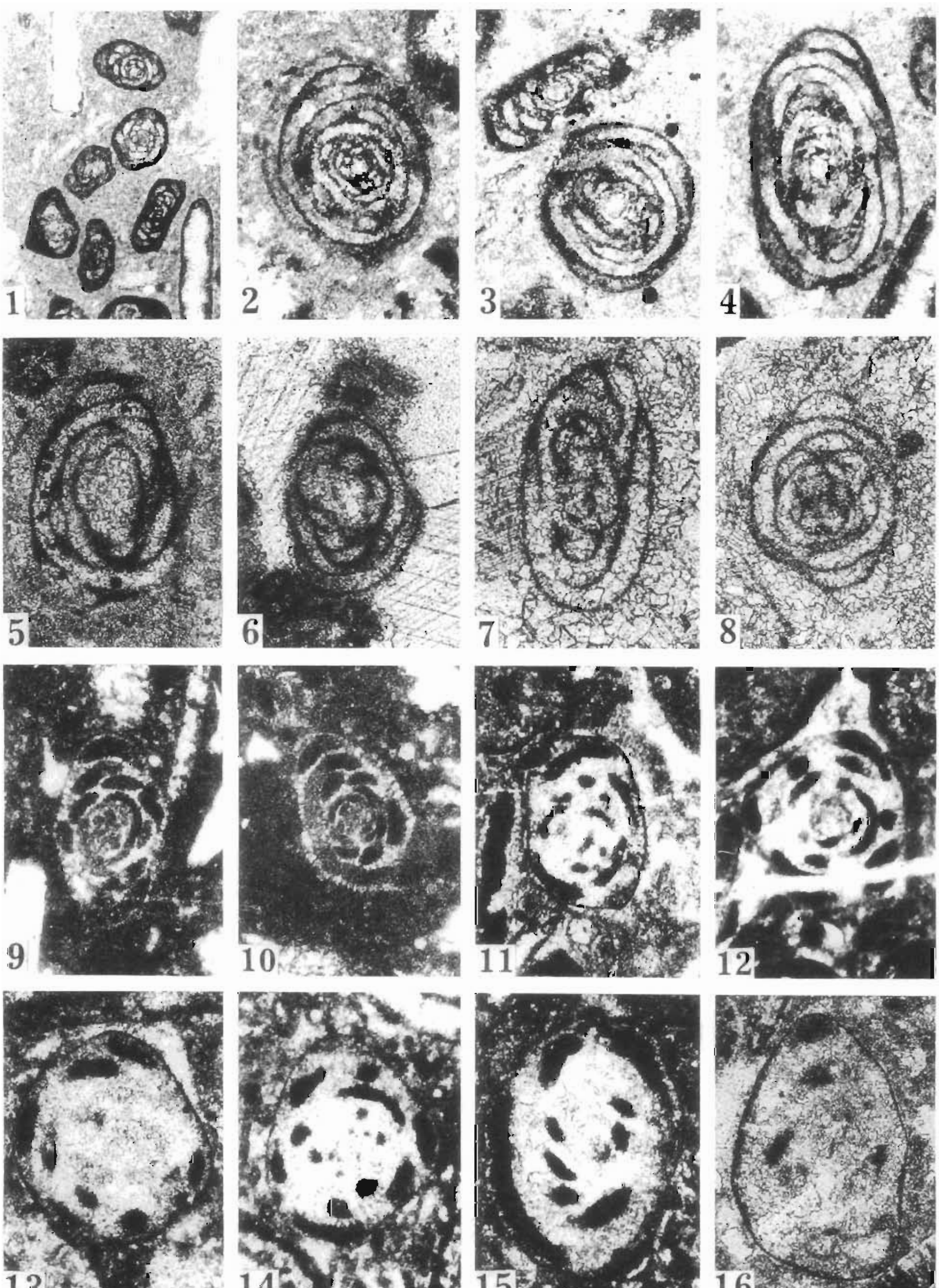
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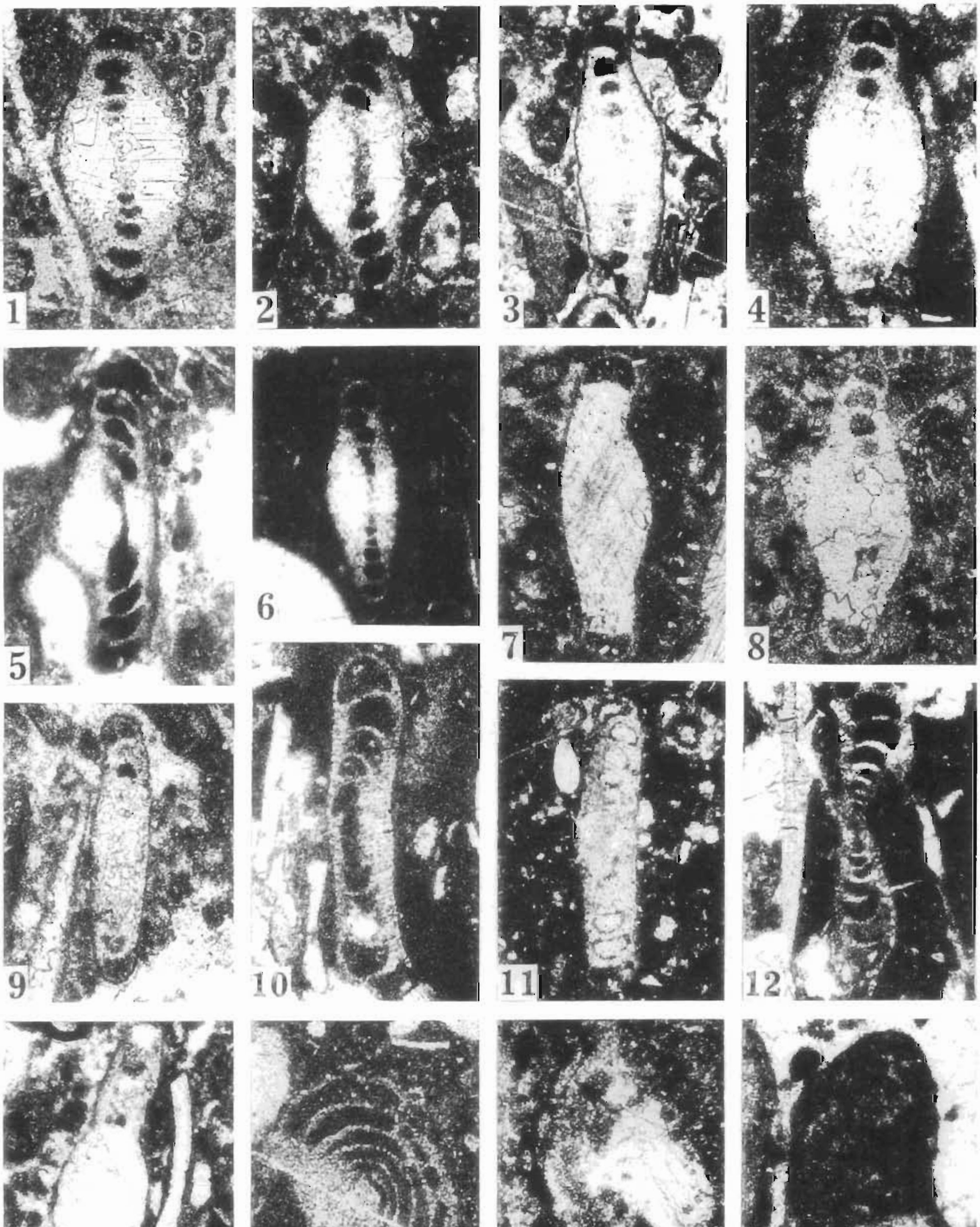
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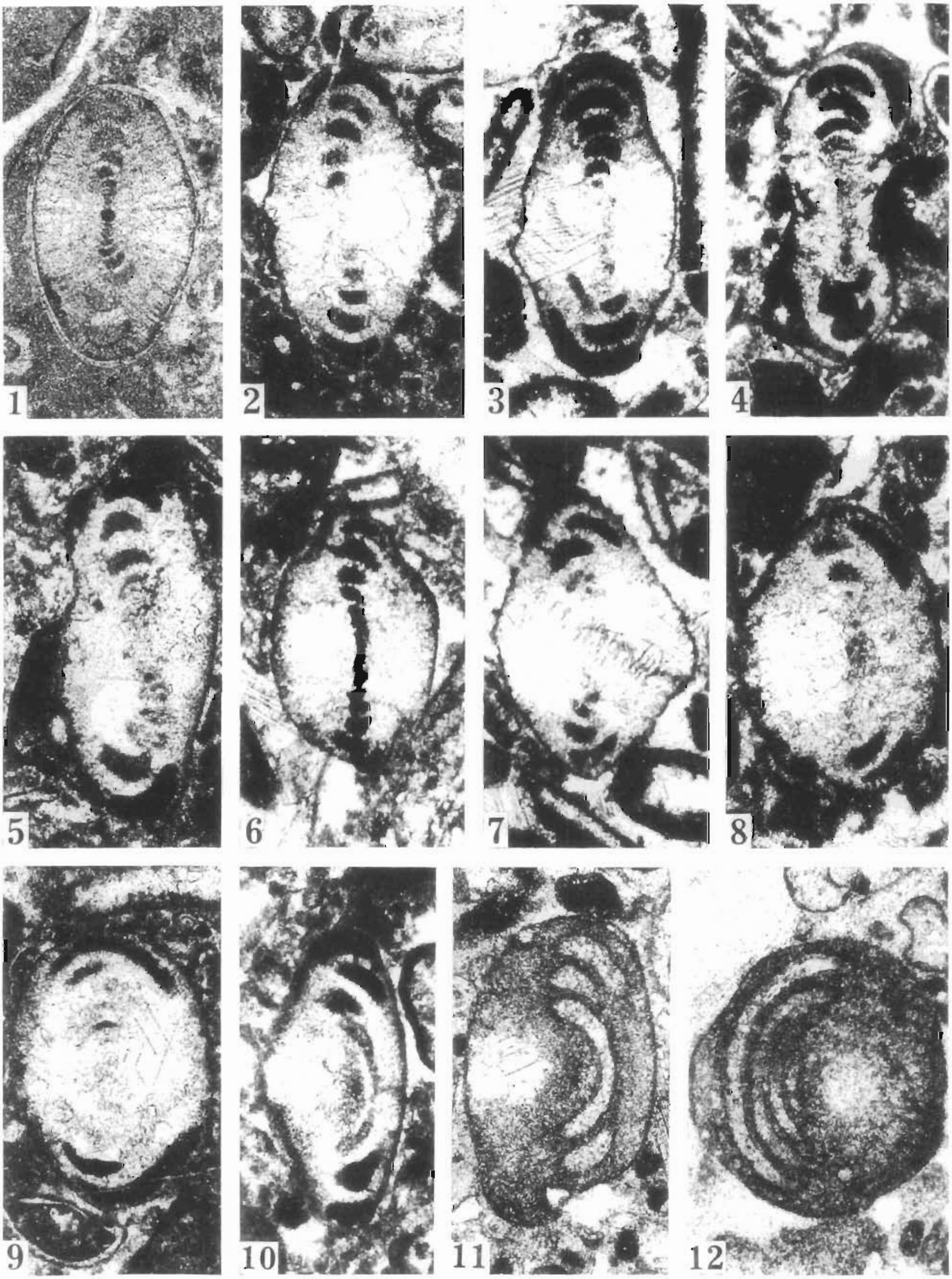

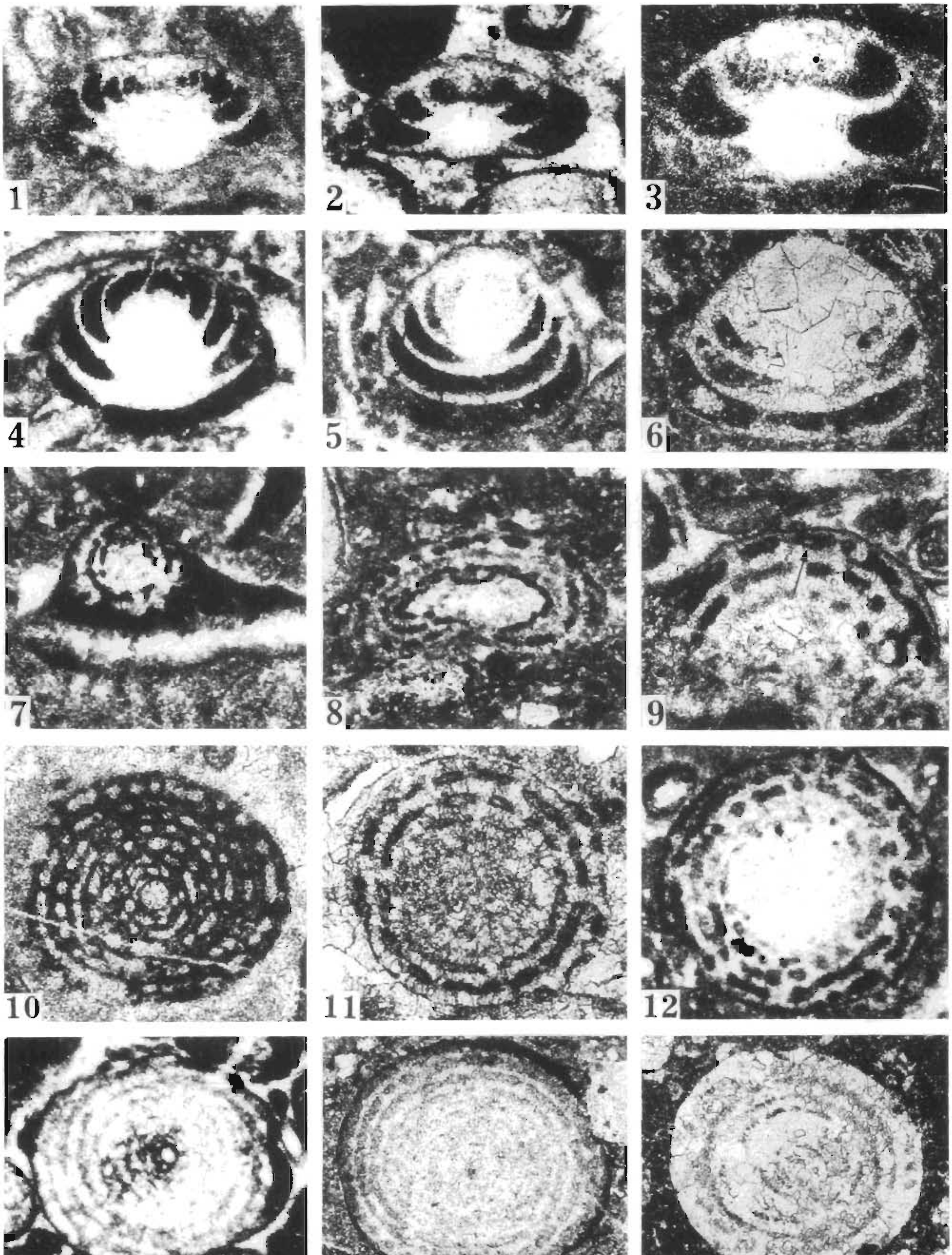
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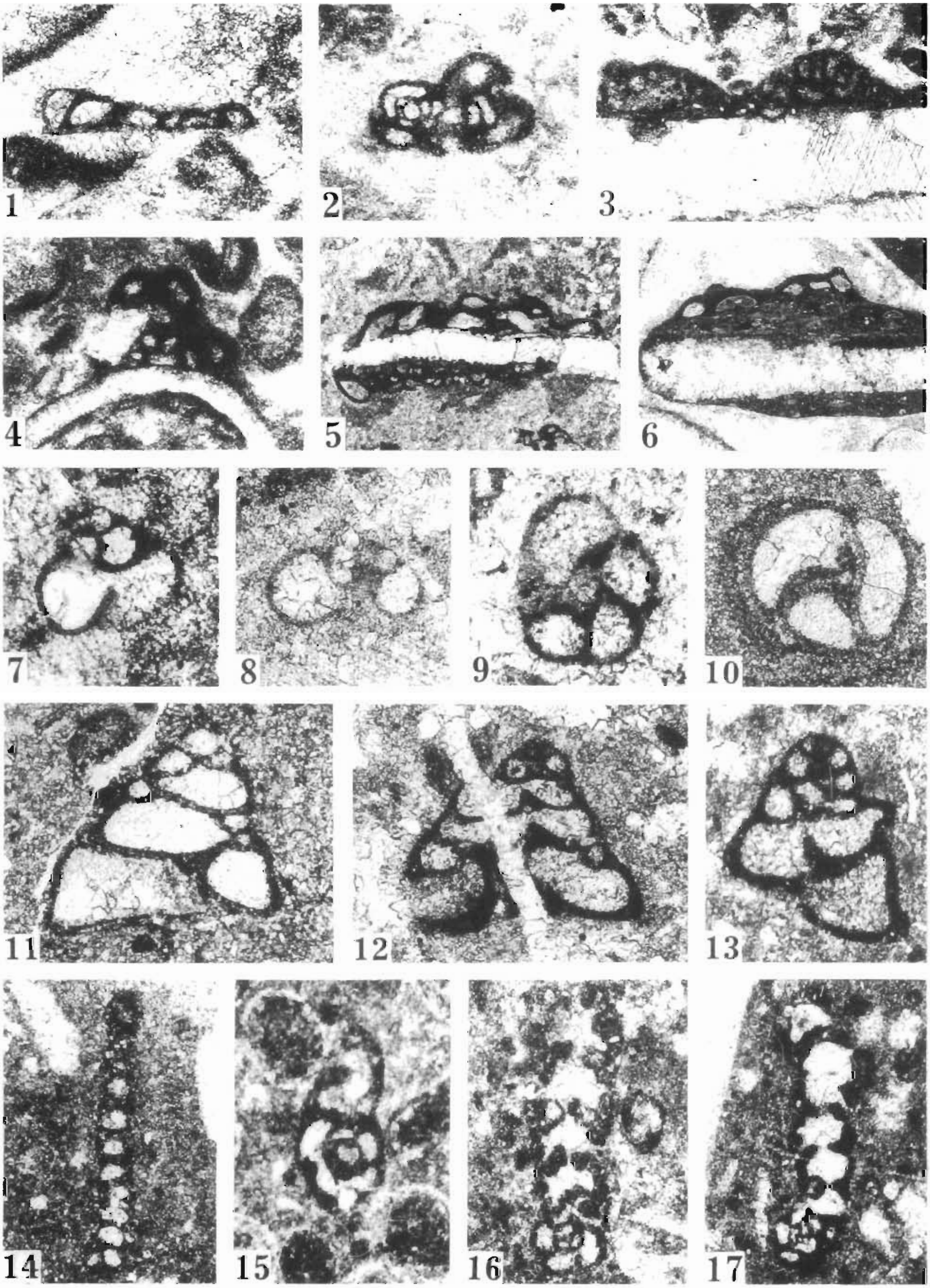
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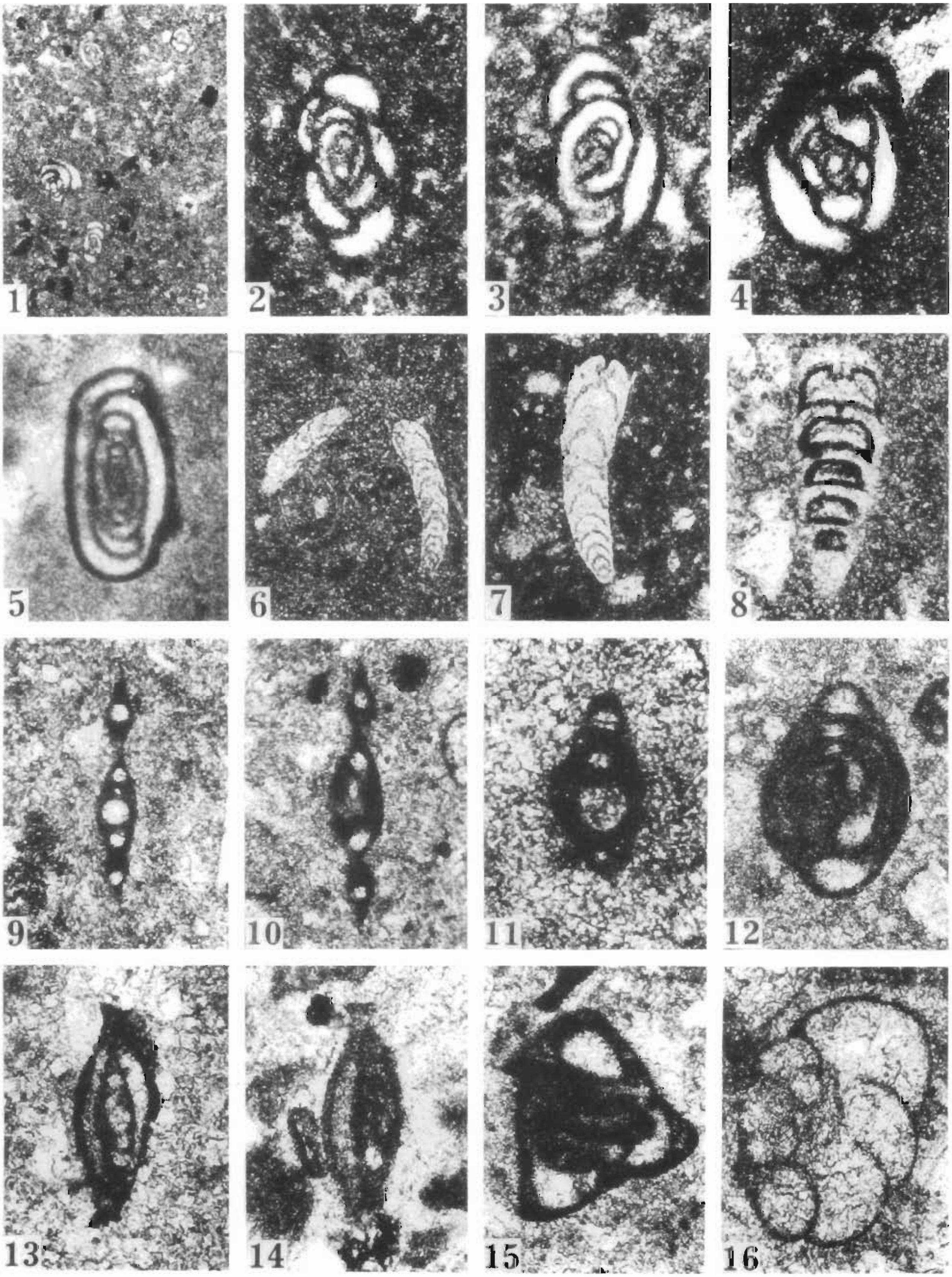
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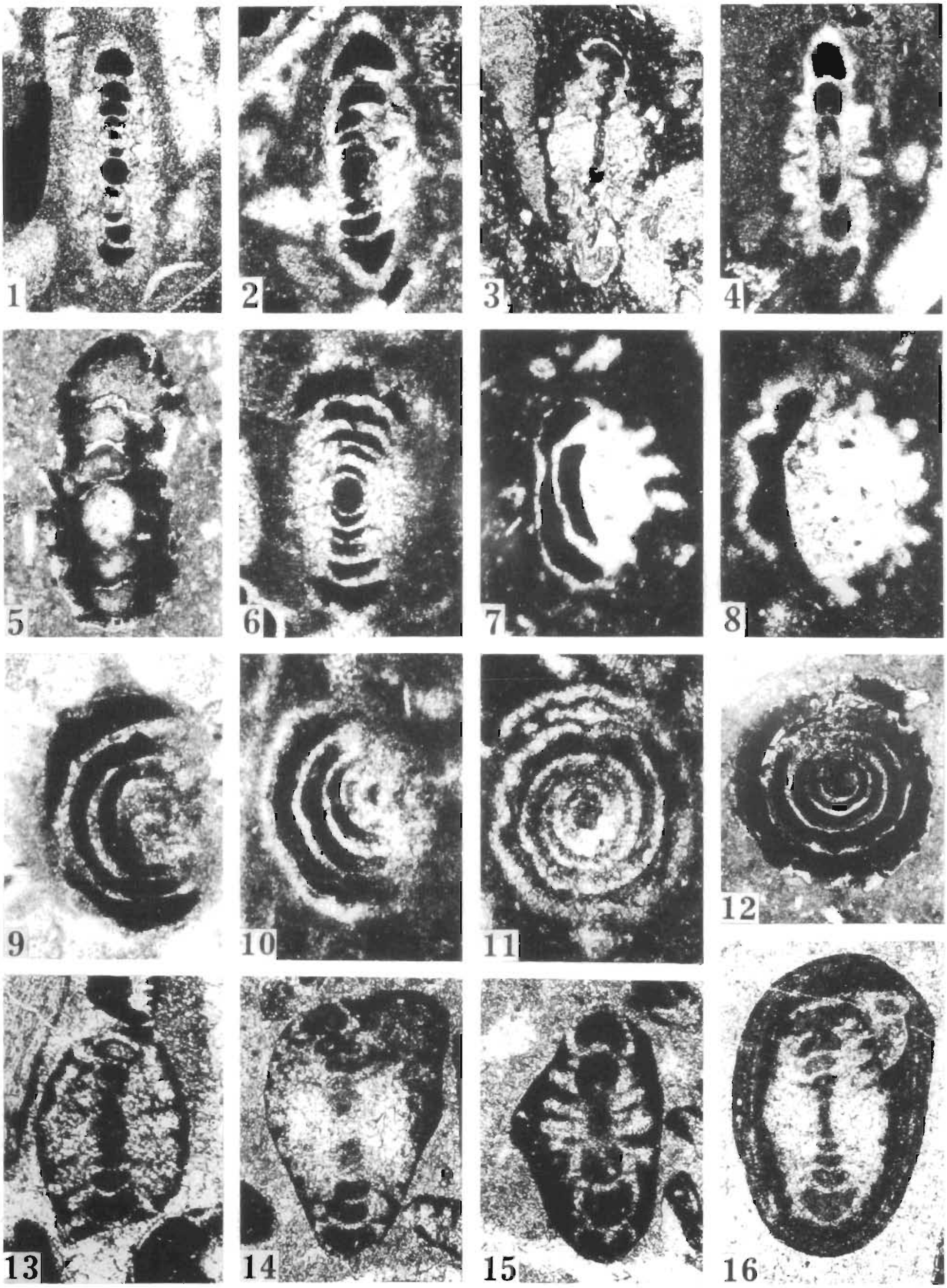
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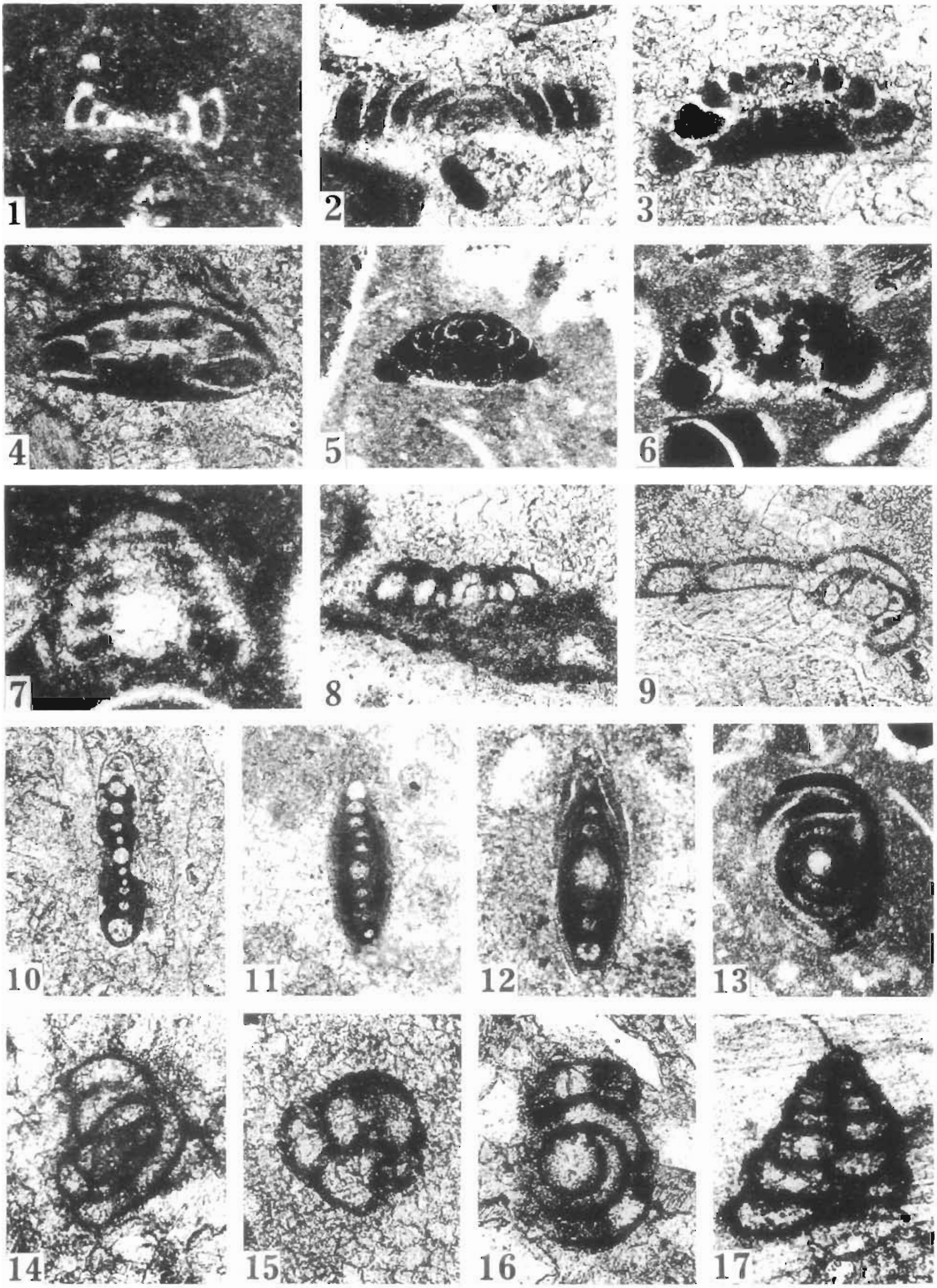
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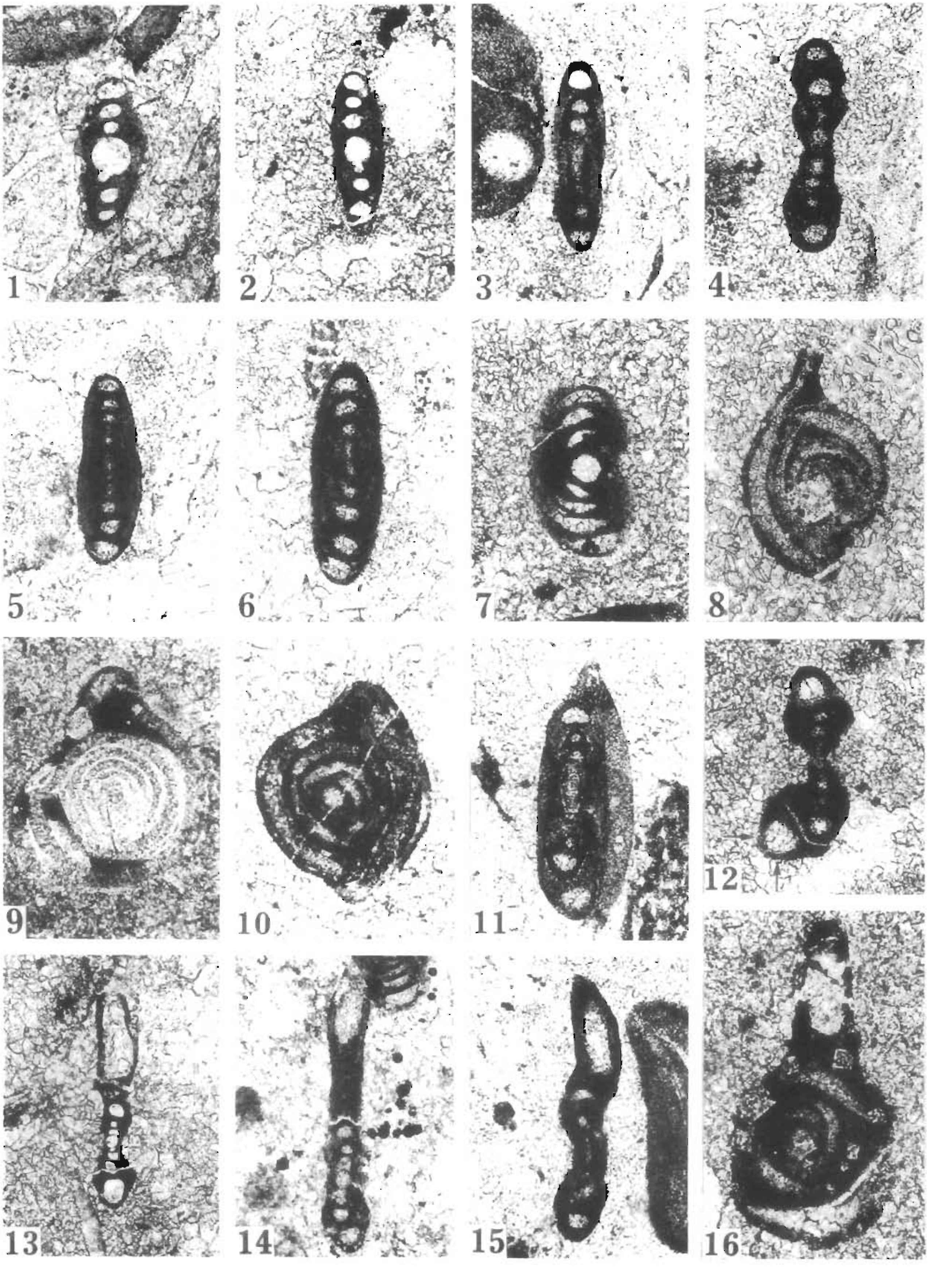
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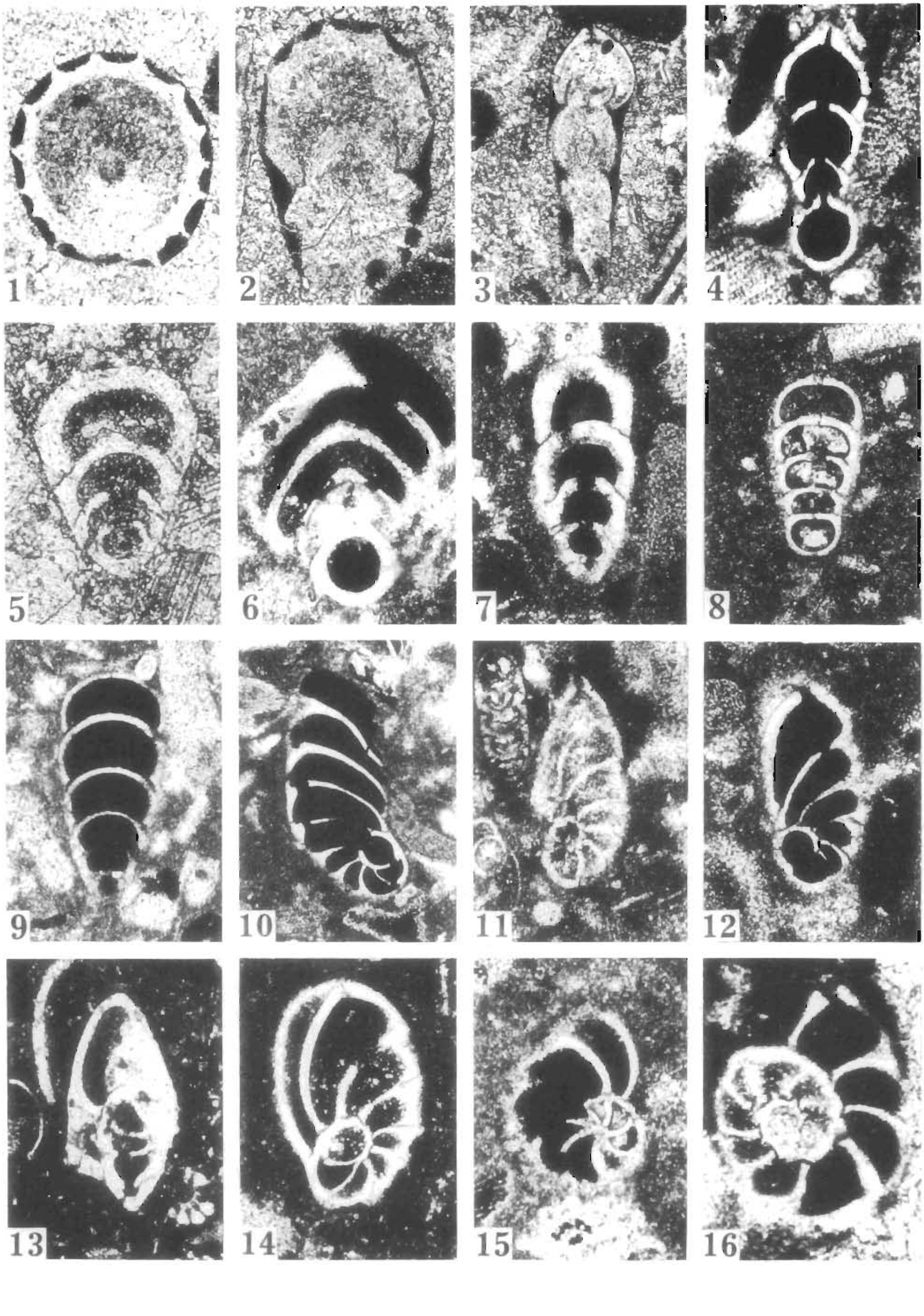
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