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EXOTIC TRIASSIC PELAGIC LIMESTONE PEBBLES FROM THE PIENINY KLIPPEN BELT OF POLAND: A FURTHER EVIDENCE FOR EARLY MESOZOIC RIFTING IN WEST CARPATHIANS

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Abstract: Exotic Triassic limestone pebbles from Upper Cretaceous conglomerates yielded microfaunal (mainly conodont and holothurian) evidence for pelagic conditions of sedimentation in the Pieniny Klippen Belt Basin, Carpathians, Poland, during the Carnian and Norian stages, the topmost Norian (topmost Sevatian) *Misikella hernsteini* — *Parvigondolella andrusovi* Assemblage Zone inclusively. These Triassic rocks are developed in grey spotty limestone facies, lithologically very similar to the Fleckenkalk-Fleckenmergel facies of Lower-Middle Jurassic in Tethyan realm. This may suggest persistence of open-sea carbonate sedimentation conditions in the axial part of the Klippen Belt Basin right through the Triassic (Rhaetian) — Liassic (Hettangian) boundary. Together with earlier published data from the Pieniny Klippen Belt of Slovakia, our results support the view that opening of the Klippen Belt Basin by oceanic-type rifting occurred prior to Late Triassic, probably already during the Anisian. The pelagic exotic Middle-Upper Triassic limestones, nowhere present at the surface in the Pieniny Klippen Belt, had probably been derived by erosional destruction of an accretion prism built of Triassic and Jurassic basinal deposits obducted as a result of Late Creataceous subduction of oceanic-type crust of the Klippen Belt Basin under the Exotic Andrusov Cordillera.

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INTRODUCTION

Triassic limestone fragments (pebbles) which occur in Upper Cretaceous clastic deposits (conglomerates, flysch) of the Pieniny Klippen Belt, Carpathians, have long been considered as derived from an exotic massif which bordered the Klippen sedimentary basin from the south (e.g., Andrusov, 1938, 1945, 1953; Birkenmajer, 1954, 1958, 1960). This massif is now being termed the Exotic Andrusov Massif resp. Cordillera (Birkenmajer, 1986, 1988). Most of these Triassic limestones display lithologic and microfacies characteristics typical for shallow–marine carbonate platform compatible with restricted–basin or submerged ridge environments. There occur, however, apparently less frequent, pelagic Triassic limestone fragments, first recognized by Mišík *et al.* (1977), incompatible with either carbonate–platform or submerged–ridge environments, and pointing to the presence in the West Carpathians of oceanic–type rift domain already during the Middle–Late Triassic.

In a plate–tectonic evolutionary model of the Pieniny Klippen Belt Basin for Middle–Late Triassic times, the pelagic–type carbonates (Reifling Limestone, Hallstatt- and nodular–cherty limestones) occupied the axial zone of the basin, presumably an oceanic–rift area which opened during Anisian–Norian times; this rift was bordered from the south and north by carbonate platforms (Birkenmajer, 1986, 1988; Kozur & Mock, 1988). Open–sea, deep–water conditions continued through Jurassic and Early Cretaceous times in this axial zone of the basin which partly corresponded to the present Pieniny Succession, but mainly to its deepest, „ultra–Pieniny" variety, known at present only from exotic rock fragments. During the Early to Late Cretaceous southward–directed subduction of the Klippen Basin, a part of pelagic Triassic and Jurassic deposits was torn off their oceanic basement and piled up as an accretion prism in front of the overriding Andrusov Cordillera, then, together with the latter, subjected to subaerial erosion and denudation supplying clastics to the fore–arc Late Cretaceous Klippen Basin (Birkenmajer, 1985, 1986, 1988).

The present paper aims at further reconstructing early oceanic–type rifting stages in the Western Carpathians, on the basis of microfacies and micropalaeontological analysis of pelagic Triassic carbonates which occur as exotic pebbles within the Upper Cretaceous clastics of the Pieniny Klippen Belt of Poland.

GEOLOGICAL SITE DESCRIPTION

The exotic limestone fragments (pebbles) described in the present paper have been collected from Upper Cretaceous conglomerates and pebbly mudstones of the Pieniny Klippen Belt of Poland (Figs. 1 & 2) at three sites: Gróbka Stream near Sromowce (Gróbka Member, Sromowce Formation, Lower Turonian); Skalski Stream near Jaworki (Bukowiny Gravelstone Member, Sromowce Formation, Upper Santonian); Biały Dunajec River bank, Szaflary (Jarmuta Formation, Maastrichtian). The first two sites are within the Branisko and Niedzica successions (nappes), respectively, the third one is from the Klippen mantle (see Fig. 3).

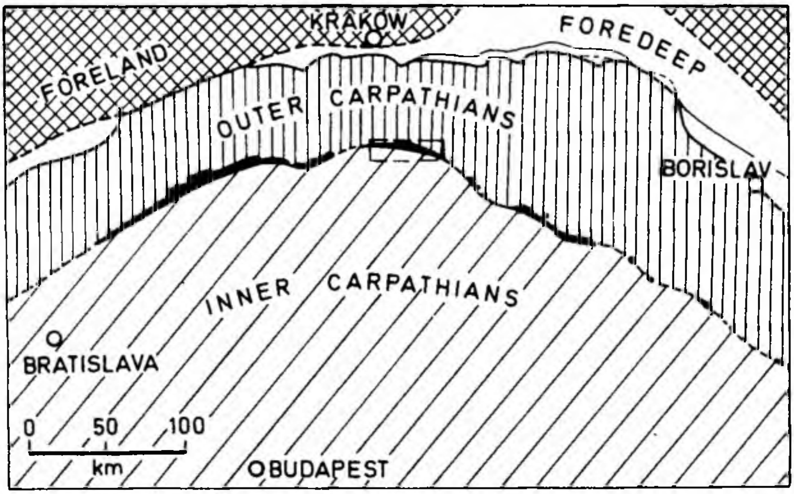

Fig. 1. Key map to show location of the Pieniny Klippen Belt (*in black*) in the Carpathians. Rectangle — see Fig. 2

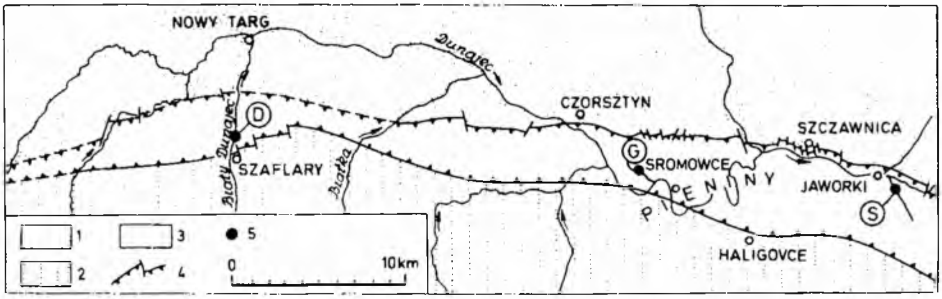

Fig. 2. Location of sampling sites with exotic limestone pebbles in the Pieniny Klippen Belt, Poland. *1* — Magura Palaeogene flysch (Magura Nappe); *2* — Podhale Palaeogene flysch (autochthonous); *3* — Pieniny Klippen Belt; *4* — northern and southern tectonic boundaries of the Pieniny Klippen Belt; *5* — sampling sites; (*D* — Bialy Dunajec River, Szaflary; *G* — Gróbka Stream, Sromowce; *S* — Skalski Stream, Jaworki)

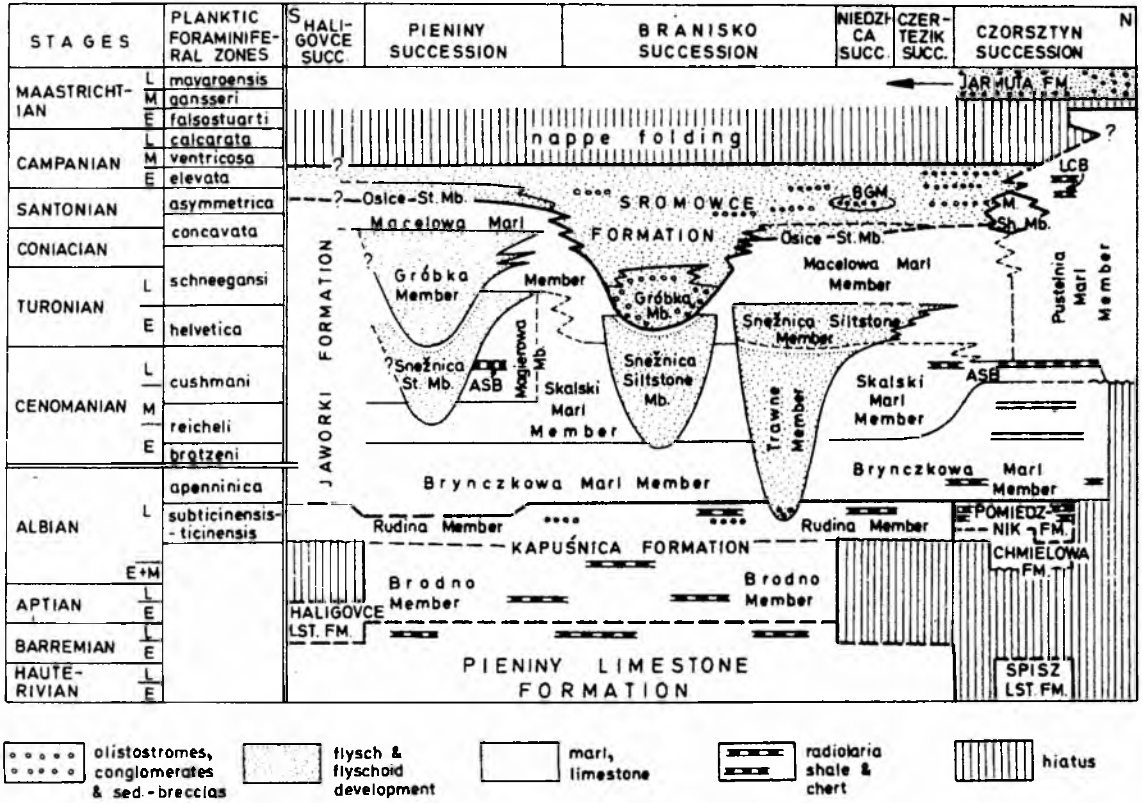

Fig. 3. Position of exotic-bearing conglomerates (Gróbka Member, Bukowiny Gravelstone Member; Jarmuta Formation) in Upper Cretaceous lithostratigraphic standard of the Pieniny Klippen Belt of Poland (after Birkenmajer & Jednorowska, 1987). *ASB* — Altana Shale Bed; *BGM* — Bukowiny Gravelstone Member; *LCB* — Lorencowe Chert Bed; *M.Sh.Mb.* — Malinowa Shale Member

GRÓBKA STREAM (SROMOWCE)

Conglomerates with exotic rock fragments (pebbles, cobbles) crop out in the middle and lower course of the Gróbka Stream, and the middle course of the Limbargowy Stream near Sromowce. They belong to the Gróbka Member, Sromowce Formation (flysch) of the Branisko Nappe (Figs. 4, 5). Their age, based on foraminiferal assemblages recovered from associated rocks, corresponds to Lower Turonian (Birkenmajer & Jednorowska, 1983). These conglomerates represent submarine slumps of gravel originally deposited as submarine delta close to the coast of the Exotic Andrusov Ridge. The gravel diameter is from 0.3 to 30 cm, with 0.3 — 3 cm grade prevailing, high-degree of rounding and Zingg's parameters

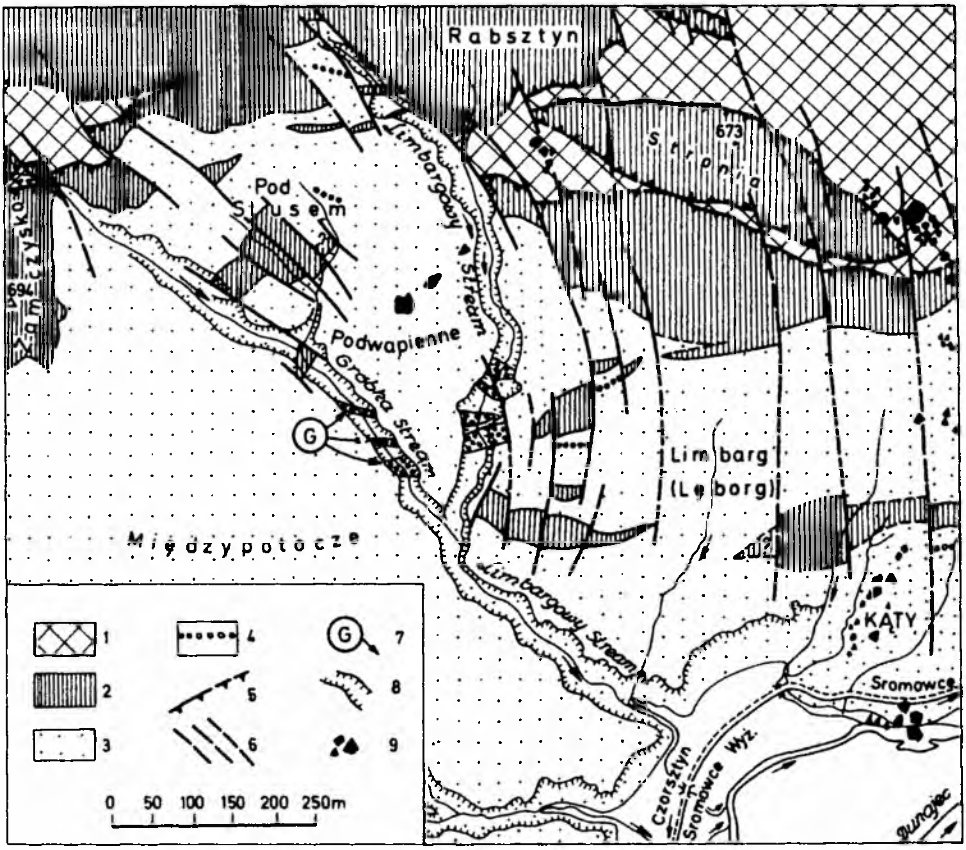

Fig. 4. Position of exotic-bearing conglomerates of the Gróbka Member (Sromowce Formation) in geological map of the Gróbka Stream area, Sromowce (after Birkenmajer & Jednorowska, 1983). *1* — Czorsztyn Unit (Jurassic and Cretaceous); *2*, *3* — Branisko Nappe (*2* — Jurassic and Neocomian; *3* — Albian-Lower Campanian); *4* — conglomerate intercalations and horizons; *5* — major overthrusts; *6* — faults; *7* — sampling site of exotic limestone pebbles: *8* — escarpments; *9* — large loose limestone blocks from the Czorsztyn Unit

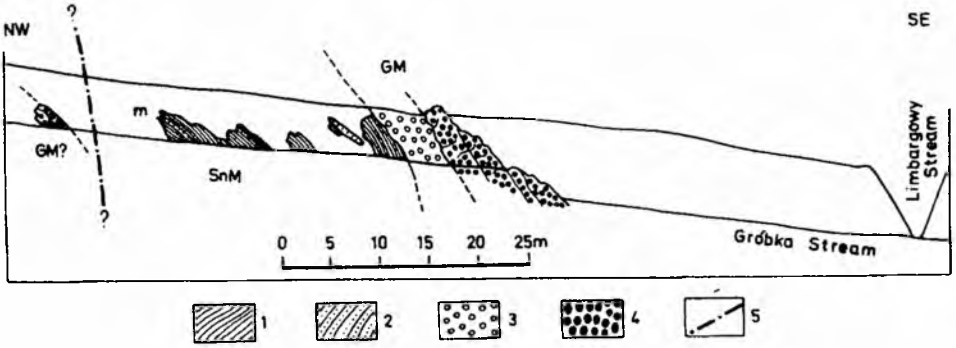

Fig. 5. Exposure of exotic limestone-bearing conglomerates of the Gróbka Member (Sromowce Formation), Gróbka Stream, Sromowce (after Birkenmajer & Jednorowska, 1983). *1* — shales, marly shales; *2* — sandstones and siltstones (*m*); *3* — loosely-cemented conglomerate; *4* — hard, well-cemented conglomerate; *5* — faults: *GM* — Gróbka Member; *SnM* — Snežnica Siltstone Member;

indicate fluvial and nearshore primary environments of transportation and deposition of the gravel (Radwański, 1978). Comparatively rich exotic rock spectrum has been described (Radwański, 1978; Sikora & Wieser, 1979; Birkenmajer, 1988, Tab. 2).

SKALSKI STREAM (JAWORKI)

Pebbly-mudstone representing submarine slumps, belonging to the Bukowiny Gravelstone Member, Sromowce Formation flysch of the Niedzica Nappe (Figs. 6 — 8), is well exposed in the lower course of the Skalski Stream near Jaworki (Birkenmajer, 1977, 1979; Radwański, 1978). The age of the member, as based on foraminifera, corresponds to Upper Santonian (Jednorowska, 1981). The gravel in the submarine slump is characterized by high degree of roundness (0.7 — 0.9) and sphericity (0.4 — 0.9, mean about 0.75), with discoidal and spheroidal pebbles predominating (Radwański, 1978; Birkenmajer & Wieser, 1990). Exotic rock-spectra have been presented by Wieser (1958), Birkenmajer & Lefeld (1969), Radwański (1978), Birkenmajer (1988, Table 2) and Birkenmajer & Wieser (1990).

BIAŁY DUNAJEC RIVER (SZAFLARY)

Several exotic limestone pebbles have been collected from coarse-grained sandstone to conglomerate with large Jurassic radiolarite olistoliths, belonging to the Jarmuta Formation, at the right bank of the Biały Dunajec River at Szaflary, north of the road-bridge (for detailed location see Birkenmajer, 1985). The Jarmuta Formation, of Maastrichtian age (Birkenmajer, 1977), represents Klippen mantle, post-dating and partly synorogenic with the first Late Cretaceous nappe folding in the Pieniny Klippen Belt of Poland. The clastic material, besides the exotic one, consists to a great extent of local Jurassic and Cretaceous rock fragments. The Jarmuta Formation unconformably covers eroded lithostratigraphical units of the Branisko Nappe (Fig. 9A,B).

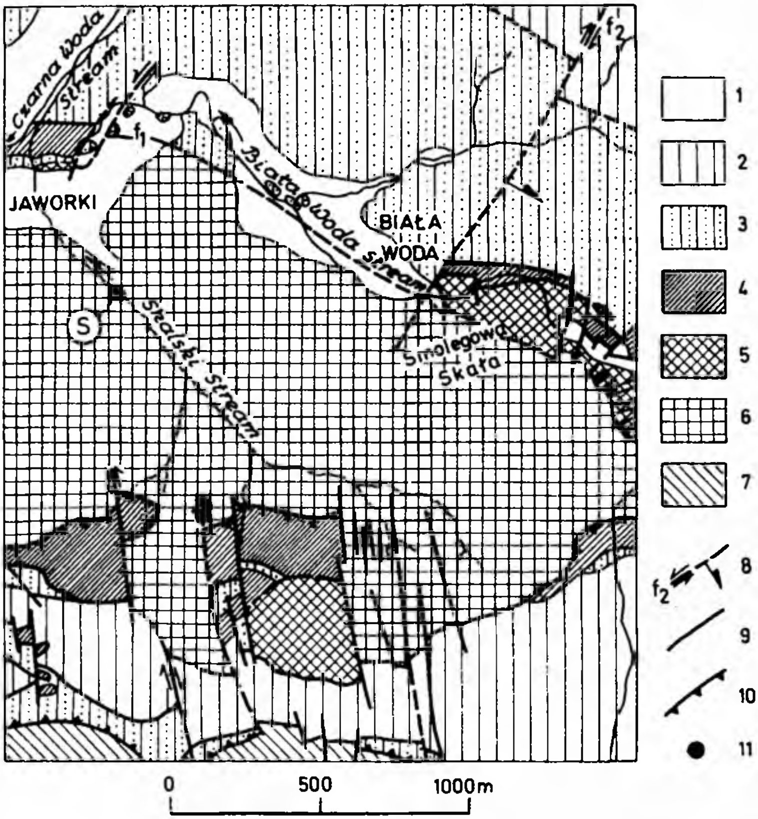

Fig. 6. Geological sketch-map of the Pieniny Klippen Belt, Skalski Stream area, Jaworki (after Birkenmajer, 1979). *1* — Quaternary cover; *2* — Magura Palaeogene flysch (Magura Nappe and Klippen mantle); *3*, *4* — Grajcarek Unit (*3* — Jarmuta Formation and Malinowa Shale Formation, Upper Cretaceous; *4* — Jurassic and Lower Cretaceous deposits); *5* — Czorsztyn Unit (Jurassic and Cretaceous); *6* — Niedzica Nappe (Jurassic and Cretaceous); *7* — Branisko Nappe (Jurassic and Cretaceous); *8* — Late Tertiary strike-slip faults; *9* — Late Tertiary faults and overthrusts; *10* — Late Cretaceous — Early Tertiary overthrusts; *11* — exotic limestone-bearing site at Skalski Stream (Bukowiny Gravelstone Member, Sromowce Formation)

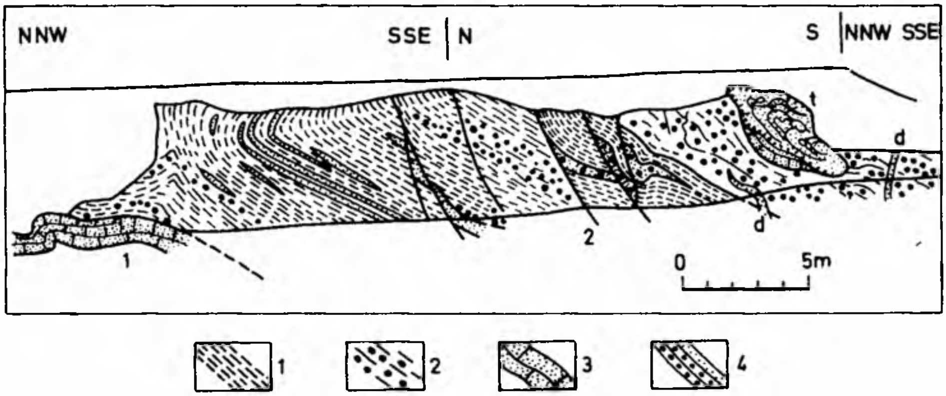

Fig. 7. Exposure of the Bukowiny Gravelstone Member (Sromowce Formation, Niedzica Nappe) at Skalski Stream, Jaworki (after Birkenmajer, 1979). *1* — Sromowce Formation, sandstones; *2* — Bukowiny Gravelstone Member (lithological signatures: *1* — clayshales, clays and marls *2* — gravelly mudstone; *3* — sandstone; *4* — graded sandstone and conglomerate; *d* — clastic dyke; *t* — sandstone slump ball)

TYPES OF TRIASSIC EXOTIC PELAGIC LIMESTONES, THEIR FOSSILS AND AGE

GRÓBKA STREAM SECTION

Sromowce Formation, Gróbka Member (Turonian): pebbly mudstone; Branisko Nappe (see Figs. 4 & 5).

Sample 49A-21-9-86

Lithology: Dark-grey hard marl to marly limestone.

Fossils: *Neohindeodella summesbergeri summesbergeri* Kozur et Mostler, 1970.

Age: This species is widely distributed in the Norian of Eurasiatic Tethys.

Facies indicators: The genus *Neohindeodella* is present both in pelagic- and in restricted-basin sediments.

Sample 51-21-9-86

Lithology: Light-grey limestone with infrequent darker spots.

Fossils: Only holothurian sclerites have been found in this sample:

„Stueria" multiradiata Mostler, 1971,

Theelia immisorbicula Mostler, 1968,

Theelia petasiformis Kristan-Tollmann, 1964.

Age: Typical representatives of *„Stueria" multiradiata* are restricted to the Sevatian. The two other species are long-ranging forms that occur from the Middle Triassic up to the Rhaetian. Taking this into account, a Sevatian age is suggested.

Facies indicators: Holothurian sclerites of this type occur both in pelagic and shallow-marine sediments.

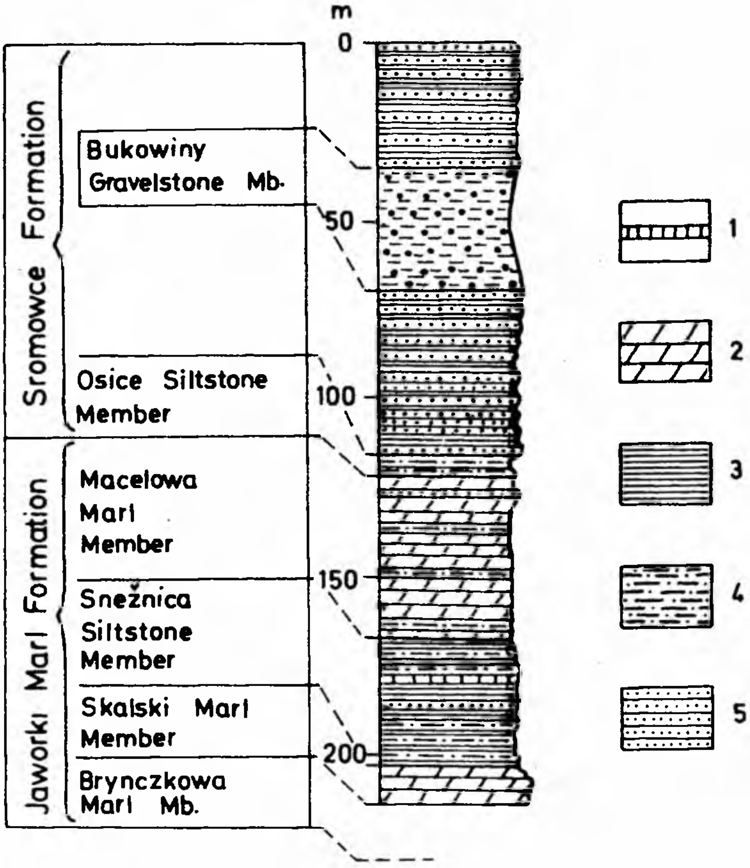

Fig. 8. Lithostratigraphic column of the Jaworki Formation and the Sromowce Formation at Skalski Stream — Bukowiny showing position of the Bukowiny Gravelstone Member (after Birkenmajer, 1977). *1* — sideritic limestone; *2* — marl, marly limestone; *3* — shale, marly shale; *4* — siltstone; *5* — sandstone

Sample 54-21-9-86

Lithology: Grey marly limestone with infrequent dark spots, lithologically resembling Jurassic spotty marls and limestones (Fleckenkalk & Fleckenmergel facies).

Fossils:

Conodonts

Misikella hernsteini (Mostler, 1967), very frequent,
Grodella delicatula (Mosher, 1968),
Neohindeodella cf. *triassica* (Müller, 1956),
Norigondolella steinbergensis (Mosher, 1968), frequent,
Oncodella paucidentata (Mostler, 1967), frequent.

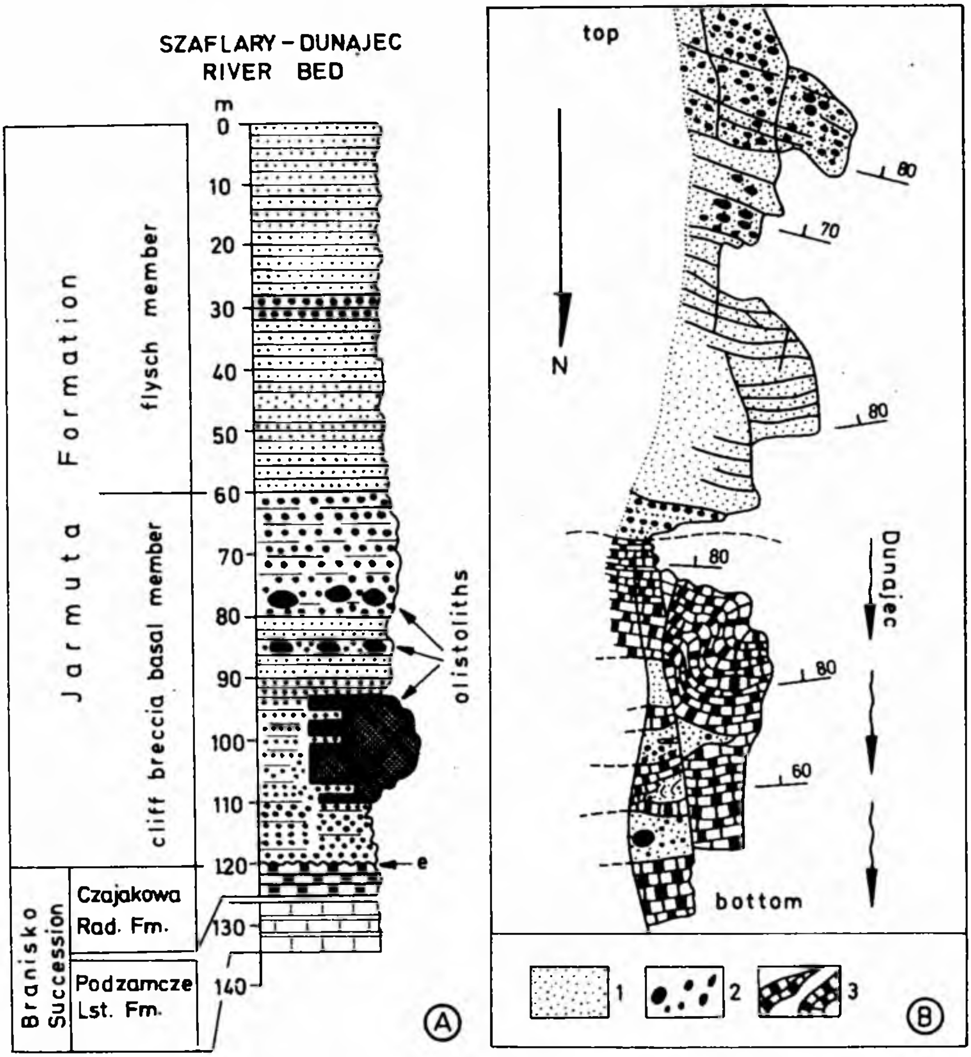

Fig. 9. Jarmuta Formation (Maastrichtian, Klippen mantle) at Szaflary, Dunajec River bed (after Birkenmajer, 1985). *A* — lithostratigraphic column; *B* — exposure at right bank of the river: *1* — sandstone; *2* — conglomerate; *3* — radiolarite olistoliths; *e* — erosional unconformity

Holothurian sclerites

Acanthotheelia minima Kozur et Mock n. sp.,
Achistrum sp.,
Biacumina multiperforata Kozur et Mock n. sp.,
Canisia mostleri Kozur et Mock n. sp.,
„Eocaudina” cf. *longa* Kozur et Mock, 1972,
Fissobractites subsymmetricus Kristan-Tollmann, 1963,

Kuehnites andrusovi Kozur et Mock, 1972,
Punctatites triangularis (Mostler, 1968),
Praeeuphronides multiperforatus Mostler, 1968,
Semperites cf. *ungersteinensis* Mostler, 1970,
„Stueria" multiradiata Mostler, 1971,
Tetravirga n. sp.,
Theelia immisorbicula Mostler, 1968,
Theelia kristanae Mostler, 1969,
Theelia patinaformis Mostler, 1970,
Theelia petasiformis Kristan-Tollmann, 1964,
Theelia cf. *planorbicula* Mostler, 1968,
Theelia pseudoplanata Kozur et Mock, 1972,
Theelia rosetta Kristan-Tollmann, 1963,
Theelia simoni Kozur et Mock, 1972,
Theelia stellifera stellifera Zankl, 1966,
Theelia stellifera bistellata Kozur et Mock, 1972,

Microproblematica

Argonevis nuda Kozur et Mostler, 1973.

Moreover, sponge spicules, foraminifers, ophiuroid- and echinoid remains have also been found.

Age: This fauna is characteristic for the topmost Sevatian *Misikella hernsteini — Parvigondolella andrusovi* A.Z. (Assemblage Zone) (Kozur, *in press, b*). The Sevatian age is indicated not only by conodonts, but also by holothurian sclerites and microproblematica. According to Kozur & Mock (1974c), the following species are restricted to, or begin in, the Sevatian: *Fissobractites subsymmetricus, Theelia kristanae*, and *T. stellata bistellata*. The same age is also indicated by the presence of *Tetravirga* n. sp. (Kozur, Mostler & Spieler, in preparation). Other holothurian sclerites have either their maximum distribution in the Sevatian, or their pre-Sevatian occurrences are doubtful, e.g. the genus *Biacumina* Mostler, and the species *Theelia patinaformis, T. simoni* and *T. stellifera stellifera*; these species are also very frequent in the Rhaetian.

The microproblematicum *Argonevis nuda* is restricted to the Sevatian.

Facies indicators: Extremely rich, fully pelagic conodont fauna indicates an open-sea (pelagic) environment. This is also confirmed by very diversified holothurian fauna.

Remarks: The conodont fauna of the discussed sample is the richest so far known conodont fauna of topmost Sevatian age. In our small pebble dissolved, there occurred about 1 conodont per gramme.

Sample 55-21-9-86

Lithology: Grey marly limestone with infrequent dark spots.
Fossils:

Conodonts

Ozarkodina tortilis Tatge, 1956,
Neohindeodella sp.

Holothurian sclerites

Theelia cf. *barkeyi* Kozur et Simon, 1972.

Age: Late Ladinian to Cordevolian.

Facies indicators: This microfauna is not indicative of facies type.

Sample 56-21-9-86

Lithology: Grey micritic marly limestone veined with calcite, weathered yellowish-brown.

Fossils (Conodonts): *Gladigondolella* sp.

Age: Middle Triassic to Middle Carnian.

Facies indicators: The genus *Gladigondolella* is characteristic of fully pelagic environment; it has never been found either in shallow-marine platform carbonates or in intra-platform basin sediments.

Sample 57-21-9-86

Lithology: Grey marly limestone.

Fossils (Conodonts):
Gladigondolella tethydis (Huckriede, 1958),
Neohindeodella sp.,
Compound conodonts of the apparatus with *Neogondolella* or *Paragondolella*.

Age: Middle Triassic to Middle Carnian.

Facies indicators: The above mentioned conodonts indicate fully pelagic conditions.

Sample 58-21-9-86

Lithology: Dark-grey marly limestone (very small pebble).

Fossils (Conodonts): *Epigondolella abneptis* (Huckriede, 1958), juvenile forms.

Age: Topmost Carnian to lower Early Norian.

Remarks: Very slightly metamorphic, CAI 3.

Summary conclusions

Out of 10 investigated limestone pebbles, 7 have been determined as Triassic, based on conodont and holothurian faunas. The majority of the pebbles were dark-grey marly limestones, often with still darker spots, very similar to Jurassic spotty marls and limestones (Fleckenkalk & Fleckenmergel facies). The age of the limestones in question is either Norian (Lower Norian to topmost Norian) or it is not younger than Middle Carnian. The majority of samples yielded open-sea, fully pelagic microfaunas; in some samples such an environment cannot be excluded, however it was not proven. No shallow-marine platform carbonate indicators were recognized in the investigated rocks. The topmost Norian rich fauna of the *Misikella hernsteini* — *Parvigondolella andrusovi* A.Z. is the youngest conodont fauna so-far recognized in the Pieniny Klippen Belt. A rich joint occurrence of *M. hernsteini* and *Paragondolella steinbergensis* is the first record of this type of assemblage from the whole Western Carpathians. The only comparable association has been recorded from Hernstein, Austria (see Mostler, 1967), in a facies transitional from the Hallstatt Limestone Formation to the Zlambach Marl Formation.

SKALSKI STREAM SECTION

Sromowce Formation, Bukowiny Gravelstone Member (Santonian): pebbly mudstone; Niedzica Nappe (see Figs. 6 — 8).

Sample 63-22-9-86

Lithology: Grey to light-grey limestone with black chert nodules.

Fauna (Conodonts):

Paragondolella polygnathiformis noah (Hayashi, 1968), juvenile specimen,

Gladigondolella sp.

Moreover, Radiolaria (*Tiborella* sp.) were found.

Age: Julian.

Facies indicators: The conodont fauna determined, moreover the radiolarians, indicate fully pelagic conditions of sedimentation during Julian stage.

Remarks: The association of *P. polygnathiformis noah* and *Gladigondolella* without *Budurovignathus* is characteristic for Middle Carnian (= Julian).

Sample 64-22-9-86

Lithology: Dark-grey marly limestone (a frequent facies type among exotic pebbles from this locality).

Fauna (Conodonts): *Gladigondolella* sp., modified prioniodiniform (= cypridodelliform) element = *Prioniodina (Cypridodella) venusta* (Huckriede, 1956).

Age: Middle Triassic to Julian.

Facies indicators: The above mentioned conodonts indicate pelagic conditions of sedimentation.

Remarks: The conodonts are brownish-black, with very slight metamorphic overprint CAI 3.

Sample 65-22-9-86

Lithology: Light-grey micritic limestone.

Fossils:

Conodonts

Paragondolella inclinata (Kovács, 1983),

Paragondolella foliata Budurov, 1975;

Holothurian sclerites

Theelia immisorbicula Mostler, 1968,

Theelia cf. *liptovskaensis* Kozur et Mock, 1978.

Age: Latest Ladinian or Early Carnian.

Facies indicators: The above mentioned conodonts and holothurian sclerites indicate pelagic sedimentary conditions.

Remarks: Budurov (1975) regarded *P. foliata* as Late Ladinian guide-form, but the first appearance of this species is not known before the highest Ladinian; it ranges upward into the lower part of Middle Carnian. The most frequent occurrence of this species is in the latest Ladinian and Cordevolian.

Sample 71-22-9-86

Lithology: Brownish-grey to bluish-grey micritic marly limestone.

Fossils (Conodonts): *Budurovignathus hungaricus* (Kozur et Végh, 1972).

Age: Lower part of Longobardian.

Facies indicators: *B. hungaricus* occurs both in pelagic and restricted-basin environments.

Remarks: There is evidence of very slight metamorphism, CAI 3.

Summary conclusions

Four out of 9 investigated pebbles have yielded Triassic conodonts. Their age is different from those of the Grόbka Stream collection. The oldest sample from Skalski Stream indicates Longobardian age of a limestone which was formed either in restricted or pelagic basinal conditions. The other samples indicate latest Ladinian to Middle Carnian ages in pelagic limestone facies.

Table 1

Middle Triassic conodont zonation (pelagic Eurasiatic Tethys)

STAGE	SUBSTAGE	CONODONT ZONATION
LADINIAN	LONGOBARDIAN	*Budurovignathus mungoensis* AZ
		Budurovignathus hungaricus AZ
	FASSANIAN	*Budurovignathus truempyi* AZ
		Neogondolella transita AZ
		Neogondolella mesotriassica – *N. praetrammeri* AZ
ANISIAN	ILLYRIAN	*Neogondolella constricta* AZ
		Neogondolella bifurcata AZ
	PELSONIAN	*Neogondolella bulgarica* – *Nicoraella kockeli* AZ
	BITHYNIAN	*Nicoraella germanica* AZ
		Neogondolella regalis AZ
	AEGEAN	*Chiosella timorensis* AZ

AZ — Assemblage Zone

BIAŁY DUNAJEC RIVER, SZAFLARY

Jarmuta Formation (Maastrichtian): conglomerate of the Klippen mantle (post–nappe) — see Fig.9 A,B.

Sample BD-1

Lithology: Grey micritic limestone.

Fossils (Conodonts):

Gladigondolella malayensis Nogami, 1968.

Compound conodonts of the *Gladigondolella* apparatus

Paragondolella polygnathiformis (Budurov et Stefanov, 1965); only one broken specimen.

Age: Middle Carnian (Julian).

Facies indicators: The above mentioned conodonts indicate pelagic sedimentary conditions.

STRATIGRAPHIC EVALUATION OF FAUNA FROM EXOTIC TRIASSIC LIMESTONES

The age our exotic limestones has been determined mainly on conodonts, using the conodont zonation of Tethyan realm correlated with Triassic stage/substage subdivision by Kozur (1980a; species figured by Kovács & Kozur, 1980), the most recent results by Kozur (in press, b) included (see Tables 1 & 2). For some samples, also holothurian sclerites yielded reliable stratigraphic data. Stratigraphic evaluation of the holothurian sclerites was based on papers by Mostler (1973), Kozur & Mock (1972b, 1974c) and Kozur & Simon (1972), in which such evaluation was given tu full extent. As an exception, the position of the Norian–Rhaetian boundary, one of several still unsolved major problems in stratigraphy of the Triassic, will be discussed to elucidate age-assignment of Sample 54–21–9–86.

Table 2

Late Triassic conodont zonation (after Kozur, *in press, b*)

STAGE	SUBSTAGE	CONODONT ZONATION
RHAETIAN		*Neohindeodella detrei* Zone
		Misikella ultima AZ
		Misikella koessenensis AZ
		Misikella posthernsteini AZ
NORIAN	SEVATIAN	*Misikella hernsteini* – *Parvigondolella andrusovi* AZ
		Mockina bidentata Zone
	ALAUNIAN	*Mockina postera* AZ
		Mockina multidentata AZ
	EARLY NORIAN	*Epigondolella triangularis* – *Norigondolella hallstattensis* AZ
		Epigondolella abneptis AZ
		Epigondolella pseudodiebeli – *Metapolygnathus communisti* AZ
CARNIAN	TUVALIAN	*Epigondolella nodosa* AZ
		Paragondolella carpathica AZ
		Paragond. polygnathiformis noah AZ
	JULIAN	*Gladigondolella tethydis* AZ
	CORDEVOLIAN	*Budurovignathus diebeli* Zone

AZ — Assemblage Zone

THE NORIAN-RHAETIAN BOUNDARY

During the latest Triassic, near the traditional Norian–Rhaetian boundary, the sedimentary regimes had changed considerably over large parts of both the Tethyan realm (the future Alpine orogen) and the stable Europe. Increasing influx of clastic material caused by marked differentiation of the relief of border lands as a result of Eo–Cimmerian movements, resulted in replacement of condensed Hallstatt limestone by Zlambach marl facies. In the Meliata–Hallstatt rift zone, the Eo–Cimmerian diastrophism resulted in the appearance of turbidite (flysch) sedimentation directly upon Middle–Late Triassic pelagic deep–water radiolarite–diabase sequences (Kozur & Mock, 1985, 1987a, 1988). On the contrary, in areas of shallow–marine carbonate platform sedimentation (Hauptdolomit and Dachstein limestone facies), several restricted basins appeared, characterized by the Kössen Formation. In some areas, the Dachstein Limestone facies continued through the Rhaetian, its facies equivalents even through the Early Liassic. In the Germanic Basin, clastic sediments (sandstones) prograded onto depositional area of the Steinmergelkeuper.

Striking lithological changes observable in the highest Triassic over large parts of the world, and especially in the Alpine orogenic zone, and over extra–Alpine platform of Europe, simultaneous with strong faunal changes, were the reason for Gümbel (1859) to introduce the Rhaetian, the first stage ever distinguished within the Triassic system. It was found later that such lithological changes were not exactly simultaneous: e.g., deposition of the Zlambach Marl Formation *s.l.* (lower part with *Cochloceras suessi*) already commenced in some areas, while in others, deposition of the highest part of the Hallstatt Limestone Formation continued. The Kössen Formation is likewise diachronous.

Diachronism of facies, and facies–controlled strong faunal changes near traditional Norian/Rhaetian boundary, forced many specialists to either abandon the Rhaetian stage (or to reduce it to merely a substage of the Norian), or to expand it as to include the whole Late Norian (Sevatian). Both solutions have, however, their disadvantages. The abandonement of the Rhaetian stage violates the rule of priority, which is particularly the case with the first Triassic stage ever introduced. Moreover, despite the problems arising from the Norian/Rhaetian boundary, the Rhaetian stage is well established in many areas of the world and well defined by its distinct facies and faunas, and has been in use for more than a century now. In case the Rhaetian stage be expanded so as to include the whole Late Norian, considerable nomenclature problems will be created: the former Late Norian would become Early Rhaetian; the former Early Rhaetian — Middle or Late Rhaetian; finally, the former Middle Norian would become Late Norian. These nomenclature problems would be lessened if such an expanded Rhaetian be regarded a substage of the Norian; however, in this case, a later-established stage would improperly get priority over an earlier-established one. Moreover, the Rhaetian stage was originally much better defined than the Norian stage which, primarily, was introduced for Ladinian sediments, and comprised both the Ladinian and the later-defined Norian deposits, until it finally replaced the Juvavian stage of Mojsisovics *et al.* (1985).

It seems to us that the only reliable solution of this problem is to preserve both the Late Norian (= Sevatian) and the Rhaetian. As pointed out already by Kozur (1973, 1974a,b), the Rhaetian stage in its original definition (as Kössener Schichten) was clearly younger than the original Sevatian (*metternichi* and *argonautae* faunas). It was only in some sections, that deposits traditionally regarded as representing higher Sevatian and basal Rhaetian, respectively, were in fact contemporaneous. Thus, in some sections, the „type Rhaetian" Kössen Formation is, as a whole, younger than the Norian, whereas in others, the basal sediments of the Kössen Formation are contemporaneous with the *metternichi* fauna of Sevatian age.

The above opinion expressed by Kozur (as above) was in contradiction to the prevailing views held by ammonoid specialists who assumed that Sevatian and Rhaetian were largely contemporaneous (cf. Wiedmann, 1974; Tozer, 1980; Krystyn & Wiedmann, 1986).

Krystyn (1974) even assumed that the lower part of the Kössen Formation of the Weissloferbach section (Lower Rhaetian) could be Middle Norian because *Rhabdoceras suessi*, a long-ranging Late Norian through early Late Rhaetian ammonoid species, appears there for the first time only in the higher part of this formation. However, the first appearance of *R. suessi* in the Kössen Formation is clearly a facies-controlled event, this ammonoid appearing in the Weissloferbach section near its total range upper limit. Moreover, the conodonts from the lower part of the Kössen Formation at Weissloferbach are clearly younger than conodonts from the youngest ammonoid-proven Middle Norian.

It was only the *Choristoceras marshi* Zone that was regarded by a majority of ammonoid specialists as younger than the „type Sevatian". However, in such case, the Rhaetian became reduced to a single ammonoid zone, and subsequently abandoned (cf. Tozer, 1974, 1980). On the other hand, Krystyn (1987) continued to use both Late Norian and Rhaetian in a meaning close to original definitions of these chronostratigraphic units.

According to Kozur (1973, 19746a,b), Gaździcki *et al.* (1979) and Krystyn (1987), the Sevatian can be clearly distinguished from the Rhaetian by both ammonoids and conodonts when original scopes of these chronostratigraphic units are taken into account. Also other fossil groups are important for this time interval: e.g., bivalves yield important guide forms for Late Norian and Rhaetian, however, with the exception of shallow-marine carbonate platform, they are represented by different groups for the Late Norian and the Rhaetian, respectively (e.g., pelagic monotids in Late Norian; mostly non-pelagic, often euryhaline forms in Rhaetian, with the exception of pelagic *Otapiria marshalli alpina* Zapfe). The distribution of the Rhaetian bivalves is largely facies-controlled, however both in pelagic sediments (*Monotis, Otapiria*), and in shallow-marine platform carbonates (megalodontids), they supply important data for correlation of the Norian/Rhaetian boundary; this is especially true for shallow-marine platform carbonates (Végh-Neubrandt, 1982). Brachiopods, ostracods, holothurian sclerites, foraminifers, radiolarians and sporomorphs yield important data for stratigraphy of the Late Norian and the Rhaetian.

Kozur (1973) accepted the Norian/Rhaetian boundary between the *Cochloceras suessi* and *„Choristoceras" haueri* ammonoid zones. Krystyn (1987) accepted this boundary but regarded the *„Ch." haueri* Zone to be merely a subzone (here, against the priority rule) of his later-introduced *Vandaites stuerzenbaumi* Zone. The definition of this Norian/Rhaetian boundary has been discussed by Kozur (1973), Gaździcki *et al.* (1979) and Krystyn (1987) and needs not be repeated here. As a disadvantage of using this boundary it may be stressed that ammonoids are becoming very rare near the Norian–Rhaetian transition. Over the whole Eurasia, it is practically only in the Zlambach Marl Formation (*s.l.*) that this boundary can be fixed based on ammonoids, but not in the „type Rhaetian" Kössen Formation (Kozur, 1973; Gaździcki *et al.*, 1979; Krystyn, 1987). In case *Misikella hernsteini* (Mostler) did not disappear near this boundary, as assumed by Gaździcki *et al.* (1979) and Kozur (1980b), but ranged upward into Rhaetian, as assumed by Krystyn (1987)[1], the discussion about this boundary would remain a purely academic one: such boundary would not be traceable within most sediments of that age.

The conodonts are the only fossil group in which well marked phylomorphogenetic lines can be traced from Late Norian through the Rhaetian on a world-wide scale. Contrary to ammonoids, the conodonts are frequent not only in pelagic, but also in restricted-basin facies (e.g., throughout the whole „type Rhaetian" Kössen Formation, the lower part of which is devoid of ammonoids). The conodonts are frequent in Rhaetian pelagic cherty limestones which are either ammonoid-free or yield such scanty ammonoids that they cannot be used for definition of the Norian/Rhaetian boundary.

Several important events in conodont history have been recognized during the higher Late Norian through Rhaetian time span (Kozur, 1980a,b; *in presss*,b): (1) final replacement of platform-bearing metapolygnathids, e.g. *Mockina bidentata* (Mosher), by their platform-free successors, e.g. *Parvigondolella andrusovi* Kozur et Mock; (2) appearance of worldwide-distributed *Misikella posthernsteini* Kozur et Mock which is an easily distinguishable guide-form for the whole Rhaetian (up to the top of this stage); (3) disappearance of *M. hernsteini* (Mostler) which was an important guide-

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[1] It remains to be solved whether Krystyn's (1987) determination of *M. hernsteini* is correct. In case he misdetermined a conodont from the *Parvigondolella lata/budensis* group as *M. hernsteini*, or recovered recycled specimens of the latter species from allodapic limestones, the diagnostic value of disappearance of *M. hernsteini* as a Norian/Rhaetian boundary indicator would considerably increase.

form for higher Sevatian. Other events were: (4) appearances of *Misikella koessenensis* Mostler and *M. ultima* Kozur et Mock, in the succession; (5) disappearance of all conodonts near the Rhaetian/Liassic boundary.

The first event (boundary between *Mockina bidentata* Zone and the succeeding *Misikella hernsteini — Parvigondolella andrusovi* A.Z.) was of primary importance in the conodont history, as the platform-bearing metapolygnathids yielded worldwide-distributed index species for the majority of higher Early Ladinian through Sevatian conodont zones. Disadvantages in chosing this event for defining the Norian/Rhaetian boundary lie in the fact that recycling of fossils as a result of Eo-Cimmerian movements and related reworking of sediments frequently occurred during the topmost Norian through Rhaetian time span. In case of such phenomena, the Norian/Rhaetian boundary cannot be properly defined, based on disappearance of platform-bearing metypolygnathids only.

The same problems will be apparent if the third event, the disappearance of *Misikella hernsteini* (Mostler), is chosen for defining the Norian/Rhaetian boundary. It should also be mentioned that some Rhaetian *Parvigondolella* species are similar to *M. hernsteini* (the latter distinguishable mainly on quite different character of lower surface, well visible in SEM photos)[2].

Appearances of *Misikella koessenensis* Mostler and *M. ultima* Kozur et Mock are recorded high within the traditional Rhaetian stage. Thus they are not suitable for defining the Norian/Rhaetian boundary. Moreover, *M. koessenensis* is a rare species, so far known only from the Alps, with only one exception (a few specimens found only) from the Csővár section in Hungary (Kozur & Mock, *in press*). Chosing the first appearance of this species for defining the Norian/Rhaetian boundary, would make this boundary non-recognizable in most sections, as in the case with ammonoids. *M. ultima* is a frequent species but is restricted to a higher part of the Rhaetian. Chosing this species for defining the Norian/Rhaetian boundary would result in including the presently used Early Rhaetian to the Norian, and leaving the remaining part of the Rhaetian in a position of a subordinate time-unit with duration too short for a stage. The same would happen in case we chose the first appearance of *M. koessenensis* for defining the discussed boundary, as this species does also appear for the first time high in the traditional Rhaetian.

The second event, i.e., the first appearance of *Misikella posthernsteini* Kozur et Mock, seems to be the best marker for the Norian/Rhaetian boundary. This species is not only easily recognizable but cannot be confused with any other older conodont species. It has evolved along a well known transition series from *M. hernsteini*, and its first appearance, still together with *M. hernsteini*, was not facies-controlled. Moreover, *M. posthernste-*

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[2] As it may be seen from the range-charts of *M. hernsteini* presented by Golebiowski (1986), he misdetermined as *M. hernsteini* a *Parvigondolella* of the *lata* group.

ini is distributed worldwide, showing at the same time a wide ecological tolerance: it occurs in deep-water radiolarites of Japan, in fully pelagic Hallstatt Limestone Formation, in open-sea Zlambach Marl Formation, in pelagic cherty limestones, moreover in the Kössen Formation formed under restricted-basin conditions, and even in the Germanic-type Rhaetian. This form frequently occurs throughout the Rhaetian, being present even in its uppermost part. Thus, the first and the last appearances of *M. posthernsteini* will mark the bottom and top limits of the Rhaetian stage, respectively, the species becoming an index form for the Rhaetian stage as such.

Some comments are needed on the problem of correlation of conodont evolution with facies changes at the close of the Triassic system. The first, still quite local appearance of the „Rhaetian facies" (Zlambach Marl Formation *s.l.*; Kössen Formation) coincides with the higher part of *Mockina bidentata* Zone of Late Sevatian age (see Gaździcki *et al.*, 1979); typical Norian facies (e.g., Hallstatt Limestone; Hauptdolomit) still dominate at that time. During the successive *Misikella hernsteini* — *Parvigondolella andrusovi* A.Z., the Hallstatt limestone sedimentation still dominated in the Hallstatt facies zone but the Zlambach marls (*s.l.*) covered increasingly larger and larger areas, locally interfingering with each other. Likewise, the depositional area of the Kössen Formation, was ever growing during this time interval. Nonetheless, the platform carbonate sedimentation clearly prevailed at that time. This situation did not change much at the time of the first appearance of *M. posthernsteini*, however in the Hallstatt facies zone, sediments attributable to the lower part of the Zlambach Marl Formation *s.l.* (with *Cochloceras*) became almost as frequent as the Hallstatt Limestone Formation, sometimes even dominating over the latter. There was also an increase of clay content in the Hallstatt Limestone itself.

The disappearance of *M. hernsteini* roughly coincided in time with the disappearance of the youngest part of the Hallstatt Limestone („Norian") facies. This was the reason why this boundary was chosen by Kozur (1980a,b) as the Norian/Rhaetian boundary, in addition to the fact that *M. hernsteini* occurs mainly in the *Cochloceras suessi* Zone and slightly below it.

The appearances of *Misikella koessenensis* and *M. ultima* (see above) are recognized within the traditional Rhaetian, much above the last appearances of the Hallstatt Limestone facies. The appearance of *M. rhaetica* Mostler is largely facies-controlled, thus it cannot be used as a stratigraphic marker.

Summarizing the above discussion, taking into account both paleontological and lithostratigraphic-facies data, we can state that the first appearance of *M. posthernsteini* Kozur et Mock satisfies requirements for an „ideal" paleontological-chronostratigraphic marker, in this case for the Norian/Rhaetian boundary. This boundary lies within a facies-transition time interval when both the so-called „Norian facies" (e.g., the Hallstatt Limestone Fm.) and the „Rhaetian facies" (e.g., the Zlambach Marl Fm.; Kössen

Fm.) co–existed. Moreover, it lies close to the classic Norian/Rhaetian boundary, near the somewhat diachronous base of the „type Rhaetian" Kössen Formation. This boundary is recognizable worldwide irrespective of facies development, as *Misikella posthernsteini* is a worldwide–distributed and facies–tolerant species. It may be recognized in a variety of facies, most of these devoid of any ammonoids.

The base of the *M. posthernsteini* A.Z., originally defined at the disappearance of *M. hernsteini* Mostler is here redefined as the appearance of *M. posthernsteini* Kozur et Mostler, thus lying slightly lower in time–scale.

The correlation of such established, conodont–based Norian/Rhaetian boundary, placed at the first appearance of *M. posthernsteini*, with ammonoid–based zonation of the same time–span, is yet to be established. A large part of, or even the whole *Cochloceras suessi* Zone (see Kozur, 1973) belongs to a lower part of the *M. posthernsteini* A.Z. (co–occurence of *M. hernsteini, M. posthernsteini* and *Oncodella paucidentata*). Using the first appearance of *M. posthernsteini* as a marker for the Norian/Rhaetian boundary would suggest that this boundary be placed either within the lower part of the *Cochloceras suessi* Zone or between the *Sagenites giebeli* and *Cochloceras suessi* zones, in ammonite stratigraphic standard.

It has to be decided by the Subcommission on Triassic Stratigraphy (IUGS Commission on Stratigraphy) whether the base of the Rhaetian will finally be accepted at the first appearance of *„Choristoceras" haueri* („ammonoid boundary") or at somewhat older first appearance of *Misikella posthernsteini* („conodont boundary"). Both these boundaries are close to traditional Norian/Rhaetian boundary, at the base of the Kössen Formation. Our preference for the „conodont boundary" stems also from the fact of much more facies–independent worldwide application of this boundary, in contrast to a much more restricted application of the „ammonoid boundary", as already discussed above.

AGE OF LATE TRIASSIC EXOTIC LIMESTONE PEBBLES

The above discussion on the Norian/Rhaetian boundary problems clarifies our position on the age of Sample 54-21-9-86 which yielded frequent *Misikella hernsteini* (Mostler), *Oncodella paucidentata* (Mostler) and *Norigondolella steinbergensis* (Mosher), but was devoid of *Misikella posthernsteini* Kozur et Mock. This assemblage is indicative of a latest Norian age of the limestone pebble, notwithstanding whether we used a „conodont boundary" or an „ammonoid boundary" designation for the stages boundary: this conodont fauna is clearly pre-Rhaetian in age.

At this point we cannot follow Krystyn (1987) who regarded the *M. hernsteini* A.Z. *sensu* Mostler *et al.* (1978) as an equivalent of his later-introduced *Norigondolella steinbergensis* Zone within the Early Rhaetian *„Choristoceras" haueri* ammonoid Zone. Contrary to Krystyn's (1987) opinion, the *Misikella hernsteini* A.Z. *s.s.* as redefined by Kozur and Mock (1974b), and in the usage by Mostler *et al.* (1978), are quite identical. We should point out that Kozur and Mock (1972a) have not defined the *M. hernsteini* A.Z. by disappearance of *N. steinbergensis*, but as a sole occurrence of *M. hernsteini* without *Mockina bidentata*. Taking into account that *Misikella posthernsteini* Kozur et Mock, 1974, in 1972 was being still included into *M. hernsteini* (Mostler), the original *M. hernsteini* A.Z. (*sensu lato*) comprised both the *M. hernsteini* A.Z. *s.s.* and the *M. posthernsteini* A.Z., as redefined later by Kozur and Mock (1974b). Mostler *et al.* (1978, Fig. 1) have used the *M. hernsteini* A.Z. *s.s.* exactly in the sense of Kozur and Mock (1974b).

No stratigraphically unimportant accompanying forms have been listed by Kozur and Mock (1972a, 1974b), those being listed only much later by Kozur (1980a). *Norigondolella steinbergensis* listed in the last mentioned paper was not meant to increase the time-range of the *Misikella hernsteini* A.Z. *s.s.*, contrary to Krystyn's (1987) opinion. Thus, *M. hernsteini* A.Z. *s.s.* (*sensu* Kozur & Mock, 1974b; also Mostler *et al.*, 1978) does not correspond to the „*Gondolella steinbergensis*" Zone *sensu* Krystyn (1987), despite erroneous correlation of this zone with the „*Choristoceras*" *haueri* Zone by Mostler *et al.* (1978). (In the last paper even the upper part of the *Mockina bidentata* Zone was correlated with the „*Ch.*" *haueri* Zone; it does not mean, however, that also the upper part of the *M. bidentata* Zone will correlate with the „*Gondolella steinbergensis*" Zone.)

In the opinion of Krystyn (1987), the *Misikella hernsteini* A.Z. *s.s.* should be Rhaetian in age; this view does not seem justified as even the upper part of the *M. hernsteini* A.Z. (*sensu* Kozur & Mock, 1974b), characterized by co-occurrence of *M. hernsteini* and *M. posthernsteini*, is still typical for the *Cochloceras suessi* ammonoid Zone, the latter also considered by Krystyn (1987) as topmost Norian („ammonoid boundary"). The lower part of the *M. hernsteini* A.Z., i.e. without *M. posthernsteini*, would be Late Norian even with the use of the „conodont boundary" (not used by Krystyn, 1987).

Contrary to Krystyn's opinion (1987), Kozur (1980a) did not overlook the fact that the *Misikella hernsteini* A.Z. of Hernstein (type locality) is „succeeded" by *Parvigondolella andrusovi* Kozur et Mock. The reason for placing the *M. hernsteini* A.Z. in a topmost Norian position was that this conodont zone was found to occur within unquestionable *Cochloceras suessi* ammonoid Zone (with index species *Cochloceras suessi*), regarded by Kozur (1973, and later papers), and now also by Krystyn (1987), as the topmost Norian. Being aware that both the *Parvigondolella andrusovi* A.Z. and the *M. hernsteini* A.Z. comprise only short time-intervals, Kozur (in press, b) fused these two zones into a single *M. hernsteini* — *P. andrusovi* A.Z., of the topmost Norian age. Such definition of this zone will be used in this paper.

As follows from the above discussion, the conodont fauna of Sample 54-21-9-86 is clearly indicative of its topmost Norian age, representing at the same time the youngest pelagic Triassic fauna so far recognized in the Pieniny Klippen Belt. Taking into account that in all Eurasian Tethyan sections with pelagic sediments of the *M. hernsteini* — *P. andrusovi* A.Z., also the Rhaetian and Liassic are in pelagic facies, we would expect such pelagic development at the Triassic/Jurassic boundary to be found in the future in the exotic bearing beds in question.

PROVENANCE OF TRIASSIC PELAGIC EXOTIC LIMESTONES

Pelagic Triassic limestone exotic fragments have been interpreted (see Birkenmajer, 1988; Kozur & Mock, 1988) as derived from presently unknown deepest (axial) zone of the Pieniny Klippen Basin situated between the sedimentary areas of the Pieniny Succession in the north, and the Nižná-

Haligovce Succession in the south (Fig. 10). Contrary to the open-sea, pelagic development of the Triassic in the axial zone of the Klippen Basin, both passive margins, i.e. the northern Czorsztyn Ridge, and the southern Andrusov Ridge, showed shallow-marine carbonate-platform development during the Middle and the Late Triassic times, with apearances of Keuper-type fresh-water sedimentation at the close of the Triassic, and with possible breaks at the base of the clastic Liassic (e.g., Birkenmajer, 1988).

The collection of limestone pebbles from exotic-bearing strata (Sromowce Formation, pre-orogenic flysch; Jarmuta Formation, post- and syn-orogenic flysch) here described, largely represents deep-water pelagic limestones of Late Triassic age in spotty limestone and marly spotty limestone facies. This facies is rather unusual for the Triassic basins of the Western Carpathians being, on the other hand, lithologically very similar to spotty limestone-and-marl facies (Fleckenkalk and Fleckenmergel facies) characteristic of the Liassic and Dogger. Such facies development indicates the existence, at least during Late Triassic, of a wide zone adjacent to, or covering probably already inactive axial oceanic rift in the Klippen Basin which stretched along its whole length, from the Váh Valley in the west, through the Dunajec and Poprad river valleys, probably as far east as Roumania where it would merge with much wider Transylvanian oceanic domain.

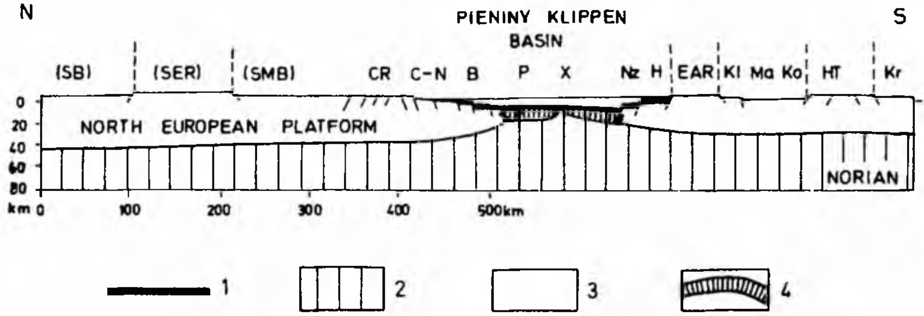

Fig. 10. Position of the Late Triassic oceanic rift in the Pieniny Klippen Belt Basin (after Birkenmajer, 1988). *1* — marine sediments; *2* — mantle; *3* — continental crust; *4* — oceanic crust; (*SB*) — area of future Silesian Basin; (*SER*) — area of future Silesian Exotic Ridge; (*SMB*) — area of future Submagura-Magura Basin; *CR* — area of Czorsztyn Ridge; *C-N* — Czorsztyn-, Czertezik- and Niedzica successions; *B* — Branisko Succession; *P* — Pieniny Succession; *X* — ultra-Pieniny succession (exotic); *Nz* — Nižná Succession; *H* — Haligovce Succession; *EAR* — area of Exotic Andrusov Ridge; *Kl* — Klape Succession; *Ma* — Manín Succession; *Ko* — Kostelec Succession; *HT* — Hightatric Succession; *Kr* — Krížna Succession

The depth of the oceanic portion of the Klippen Basin during the Late Triassic times, as indicated by the spotty limestone-marl facies and its conodont-holothurian-radiolarian fauna, would correspond to shelf-break and slope above calcite compensation depth (CCD). No radiolarites and associated deep-sea lutites of Triassic age, corresponding to depths about or below CCD, have so far been recognized among the exotic fragments studied; their possible presence should be checked on radiolarian content of chert pebbles.

Despite careful sampling, no Hallstatt-type limestones have been found by us in either of the three localities studied. Such limestones have been reported from the Slovak sector of the Pieniny Klippen Belt as exotic pebbles from the Kýsuca Succession (Mišík *et al.*, 1977; Mišík & Sýkora, 1981; see also Birkenmajer, 1988, Tab. 3). It should be pointed out, however, that only two pebbles attributed to the Hallstatt Limestone developed in *Osteocrinus*-microfacies have been found (Mišík *et al.*, 1977; Mišík & Sýkora, 1981), both containing corroded quartz grains of fine-sand grade and abundant muscovite. Bearing in mind that such clastic admixture is unknown from typical Hallstatt Limestone, the limestone exotics in question would rather correspond to a pink variety of usually grey to dark-grey limestone-marly limestone facies.

The lack of typical Hallstatt Limestone facies among the exotics of the Pieniny Klippen Belt, would suggest that the West Carpathian branch of oceanic Transylvanian domain was much narrower than the latter. Thus, during the Triassic, even the axial, deepest part of this branch corresponding to the future „ultra-Pieniny" succession, would still receive a considerable amount of silt to clay-grade clastic supply from neighbouring lands, rendering impossible the deposition of typical condensed Hallstatt Limestone facies.

The results of investigations here presented, together with those from the Slovak parts of the Pieniny Klippen Belt (see Mišík *et al.*, 1977), indicate that pelagic conditions of sedimentation during Triassic appeared in the Klippen Basin as early as Early Anisian (Mišík *et al.*, 1981; Kozur & Mock, 1987a, 1988). Pelagic sedimentation continued through the Ladinian (e.g., Reifling-type limestones with conodont faunas: Mišík *et al.*, 1977; the present paper), Carnian and Norian (Early and Middle Carnian dark-grey, partly cherty limestones, moreover Carnian and especially Norian spotty limestones here described, with conodonts, holothurian sclerites, etc.), as high as the latest Norian (topmost Sevatian *Misikella hernsteini* — *Parvigondolella andrusovi* A.Z.). Such pelagic development of the uppermost Triassic strata suggests a possibility of finding pelagic Rhaetian limestones and pelagic Lower Liassic rocks in the exotic-bearing strata studied, attributable to the axial zone of the Klippen Basin. It should be noted that Middle to Upper Liassic and Dogger pelagic facies are well known from the Pieniny Succession in Poland and Slovakia (see Birkenmajer, 1977, 1986, 1988).

It should be mentioned that Mišík *et al.* (1981) reported from Albian conglomerates of the Tatric and Fatric tectonic units of West Slovakia, the presence of Middle and Upper Triassic exotic limestone fragments with conodonts and holothurian sclerites. As in our material, their exotic pelagic Triassic limestone fragments were represented exclusively by grey to dark-grey limestones — marly limestones, stratigraphically reaching as high as the latest Norian (latest Sevatian) *Misikella hernsteini* — *Parvigondolella andrusovi* A.Z.; moreover, slight metamorphic changes expressed in higher values of conodont alternation index (CAI) were also noted, as is also the case with our material. The „Southern Exotic Ridge" was regarded by them as the most probable source of the exotic limestone fragments, however they did not totally exclude another hypothetical source — the „Ultratatrid Cordillera" (*sensu* Mišík *et al.*, 1980).

Taking into account that the discussed pelagic Triassic limestone exotics from the Tatrid-Fatrid Albian on one hand, and from Turonian to Maastrichtian conglomerates of the Pieniny Klippen Belt on another, do not essentially differ in facies, microfauna and age, we are inclined to support the opinion that they all had a common source — the Andrusov Cordillera, whose structure, since Aptian-Albian, included not only Exotic Andrusov Ridge but also obducted deep-water Mesozoic deposits derived from axial part of the Pieniny Klippen Belt Basin (see Birkenmajer, 1988; Kozur & Mock, 1988).

TIMING OF OCEANIC-TYPE RIFTING IN THE PIENINY KLIPPEN BELT BASIN

It has been assumed that oceanic-type rifting in the Pieniny Klippen Belt Basin started sometime during the Triassic, either close to the Triassic-Jurassic boundary (Birkenmajer, 1985, 1986) or slightly earlier, during Ladinian-Norian times (Birkenmajer, 1988, p. 25). Evidence for continuous pelagic deposition in the deepest parts of this basin, taken from previously published and new data here presented, points to the opening of the basin by oceanic-type rifting prior to Early Anisian, probably already at the Scythian-Anisian boundary. If this is true, then the opening of the Klippen Basin branch of the Transylvanian ocean would be simultaneous with the formation of the oldest oceanic crust of the latter.

Expansion of the Transylvanian oceanic domain of the Tethys due to crust accretion on both sides of mid-oceanic rift continued from Anisian through Late Triassic, possibly also through Jurassic and even ?Neocomian, as evidenced by subsequently younger and younger deep-water deposits coming into direct contact with oceanic-type crust of the Transylvanian nappes (see Săndulescu & Russo-Săndulescu, 1979; Săndulescu *et al.*, 1981). On the contrary, the rifting episode which could produce oceanic-type crust in the Klippen Belt, was certainly of much shorter duration, possibly restricted to either Middle Triassic or Middle Triassic — beginning Late Triassic time span. This rift was relocated northward during Early Jurassic or even Late Triassic times, causing opening of a new Magura Trough, and leaving behind — in the Klippen Basin, its then inactive oceanic crust. The Klippen and the Magura Basins became separated by the Czorsztyn Ridge — a splinter of North European Platform with attenuated continental crust base (Birkenmajer, 1985, 1986).

CONCLUSIONS

The above data on the presence of pelagic Triassic limestone deposition in the Pieniny Klippen Belt Basin of Poland, taken together with already published data from the Slovak parts of the Belt, allow to formulate the following conclusions:

(1) There was a uniform pelagic sedimentation of spotty limestones and marly limestones of Early Anisian through Late Norian ages in the axial part of the Pieniny Klippen Belt Basin, traceable over several hundred kilometres of its length, from West to East Slovakia, across southern Poland;

(2) This pelagic Triassic development was a result of oceanic-type opening of the Klippen Basin at about Scythian/Anisian boundary in form of a branch which propagated westwards from the Transylvanian ocean domain;

(3) Very similar facies development of pelagic Triassic carbonates (in exotic pebbles), and also Middle to Late Liassic and Dogger basinal deposits (in the Klippen successions) in form of spotty marly limestones and marls (Fleckenkalk-Fleckenmergel facies) indicates a possibility of continuous pelagic sedimentation in the deepest part of the Klippen Basin across the Triassic/Jurassic boundary. Sedimentary breaks and regression related to Eo-Cimmerian uplift were restricted in this basin to its passive margins represented by the Czorsztyn Ridge (in the north) and the Andrusov Ridge (in the south);

(4) The appearance of pelagic Triassic limestone pebbles in the Klippen Basin and the Manín Basin (*sensu lato*) during the Cretaceous, since Aptian-Albian, was a result of uplift and subaerial erosion of obducted deepest parts of the Klippen Basin accreted from the north to the Andrusov Ridge (Cordillera) — a result of Late Jurassic through Early Cretaceous subduction. We follow a model (see Birkenmajer, 1988) that the Andrusov Ridge, together with deep-water „ultra-Pieniny" sedimentary wedge accreted to it from the north, separated during the Mid-Upper Cretaceous time the Klippen Basin in the north, from the Klape-Manín-Kostelec Basin (Manín Basin *s.l.*) in the south.

Acknowledgments

The samples were collected in the field in 1986; the microfossils were recovered from exotic limestone fragments at the Geological Institute of the J.A. Comenius University, Bratislava. The Scanning Electron Microscope (SEM) micrographs were taken at the Department of Geology, Palermo University.

TAXONOMIC PART

(by H. Kozur and R. Mock)

CONODONTA

The taxonomy of the stratigraphically most important platform conodonts is adapted from Kozur (1988, and *in press*,a). The diagnoses of two new genera introduced by Kozur (*in press*,a) are repeated here.

Genus *Mockina* Kozur n. gen.

Type species: *Tardogondolella abneptis postera* Kozur et Mostler, 1971.

Diagnosis: Small metapolygnathid platform element that builds in most specimens a single element apparatus. The platform is mostly well developed in the posterior part of the unit, but missing in the anterior one. In the youngest representatives, the platform is reduced to a denticle on both sides of the carina, and in transitional forms to *Parvigondolella* Kozur et Mock — to a single denticle on one side of the carina. Posterior end of the platform variable, but mostly pointed or narrowly rounded, rarely broadly rounded or even blunt. The platform surface bears at least one long denticle, but generally on each side 1 — 2 to more denticles. Microreticulation irregular and weak, often completely missing.

Posterior end of „keel" pointed or narrowly rounded, rarely broadly rounded or even blunt, but never symmetrically bifurcated. The „keel" ends considerably before the platform end. Basal cavity in the anterior third of the platform, with or without indistinct secondary elevation.

Carina in the anterior part very high, in the posterior part low. Boundary between these two parts of the carina is often very sharp, in other taxa gradual.

Occurrence: Middle and Late Norian.

Comparisons: *Epigondolella* Mosher, 1968, has a symmetrically bifurcated posterior end of „keel", this bifurcation becomes more and more asymmetrical in transitional forms to *Mockina* only.

Parvigondolella Kozur et Mock, 1972, has no platform rudiments. *Mockina* n. gen. has an intermediate position in phylomorphogenetic line: *Epigondolella* — *Mockina* — *Parvigondolella*.

Genus *Norigondolella* Kozur n. gen.

Type species: *Paragondolella navicula steinbergensis* Mosher, 1968.

Diagnosis: Typical gondolellid apparatus that comprises, except for the platform element, the ozarkodiniform, enantiognathiform, cypridodelliform, metaprioniodiniform and hibbardelliform elements. Platform element large to very large, with moderately high anterior carina and low, mostly totally fused posterior carina. Main cusp distinct, mostly terminal. Platform surface without coarse sculpture, but with distinct microreticulation, except for smooth stripes on both sides of the carina. Lower platform side with trough-like depressed „keel" and funnel-like subterminal basal cavity, marginally only slightly elevated.

Occurrence: Norian to lower part of Late Rhaetian, only in fully pelagic limestones and cherts.

Comparisons: *Norigondolella* n. gen. has most probably evolved from *Paragondolella* Mosher, 1968. It is distinguished from this genus by trough-like depressed „keel"; moreover, its anterior carina is not as high as in the latter genus.

HOLOTHURIAN SCLERITES

The base for the Triassic holothurian sclerite taxonomy is provided in numerous papers by Mostler (e.g., 1968, 1969, 1970, 1971, 1972). The taxonomy of holothurian sclerites used in the present paper is based on the above, and on some additional data by Kozur and Mock (1972b, 1974c). Three new species are being described, the remaining ones are only listed without description.

Genus *Acanthotheelia* Frizzell et Exline, 1956
Type species: *Acanthotheelia spinosa* Frizzell et Exline, 1956

Acanthotheelia minima Kozur et Mock n. sp.
(Pl. IV, Figs. 11 — 13)

Name derivation: From small size.

Holotype: Specimen illustrated in Pl. IV, Fig. 13; Rep. No CK/151188 III-25, Geological Institute, University of Innsbruck (Austria).

Type locality: Grόbka Stream section (Branisko Nappe, Pieniny Klippen Belt, Poland).

Type stratum: Pebbly mudstone of the Grόbka Member, Sromowce Formation (Lower Turonian) — olistolith of grey marly limestone with lighter spots, Sample No 54-21-9-86. Topmost Norian *Misikella hernsteini* — *Parvigondolella andrusovi* conodont A.Z.

Material: 21 specimens.

Diagnosis: Outer rim low, with short spines opposite to every interspoke space. Inner margin of rim with numerous small spines, generally 2 spines in an interspoke space. Hub large, flat. 10 — 12 short spokes of equal width throughout their length.

Occurrence: Norian of Tethyan realm.

Comparisons: *Acanthotheelia rhaetica* Kristan-Tollmann, 1963, has more spokes (about 14) and smooth inner margin of rim.

Acanthotheelia pulchra Kozur et Mock, 1972, is considerably larger; it has only one denticle in each interspoke space on inner margin of rim.

Genus *Biacumina* Mostler, 1970
Type species: *Biacumina inconstans* Mostler, 1970

Biacumina multiperforata Kozur et Mock n. sp.
(Pl. IV, Figs. 5, 6)

Name derivation: From large number of pores.

Holotype: Specimen in Pl. IV, Fig. 6; Rep. No CK/151188 III-1, Geological Institute, Innsbruck University (Austria).

Type locality and stratum: As for *Acanthotheelia minima* n. sp.

Material: 12 specimens.

Diagnosis: Sieve plate slightly curved, very broad, moderately long to short, broader than long or as broad as long. Round pores very numerous. In the middle sector of the upper part of the sieve plate, a larger pore is surrounded by a ring of smaller pores. In the lower part of the sieve plate, the pores are always small. Arms at the upper corner of the sieve plate long, broad, only weakly to moderately upward-bent. The arms bear few, narrow, elongated pores.

Occurrence: Known only from Sample 54-21-9-86 (uppermost Sevatian — topmost Norian).

Comparisons: *Biacumina inconstans* Mostler, 1970, has a narrow sieve plate that is always longer than broad. The number of pores is considerably smaller, and the pore pattern different (no larger pore surrounded by a ring of smaller pores occurs in the upper sector of the sieve plates). In *Biacumina inconstans*, the arms are, in general, more upward-bent.

Genus *Canisia* Mostler, 1972

Type species: *Ludwigia symmetrica* Mostler, 1969

Canisia mostleri Kozur et Mock n. sp.

(Pl. IV, Fig. 9)

Name derivation: In honour of Professor Dr H. Mostler (University of Innsbruck), the leading specialist on fossil holothurians.

Holotype: Specimen illustrated in Pl. IV, Fig. 9; Rep. No. CK/151188 III-34, Geological Institute, Innsbruck University (Austria).

Type locality and stratum: As for *Acanthotheelia minima* Kozur et Mock n. sp.

Material: 3 specimens.

Diagnosis: Outline subquadrate. Median bar of the x-shaped inner frame strongly reduced. Pores relatively small, all about the same size. Opposite to the pores, very large and broad outer spines occur.

Occurrence: So-far known only from the topmost Norian limestone pebble of the type locality.

Comparisons: *Canisia quadrispinosa* (Mostler, 1969) has subcircular outline, its spines are situated opposite to radii of inner frame.

REFERENCES

Andrusov, D., 1938. Geologický výzkum vnitřního bradlového pásma v Západniích Karpatech. III. Tektonika (Étude géologique de la Zone des Klippes Internes des Carpathes Occidentales. III. Tectonique). *Rozpr. St. Geol. Úst. ČSR (Praha)*, 9: 1 — 135.

Andrusov, D., 1945. Geologický výzkum vnútorného bradlového pásma v Západních Karpatech. IV. Stratigrafia doggeru a malmu. V. Stratigrafia kriedy. *Pr. Št. Geol. Úst. (Bratislava)*, 13: 1 — 176.

Andrusov, D., 1953. Étude géologique de la zone des Klippes internes des Carpathes Occidentales. IV & V. *Geol. Pr. Slov. Akad. Ved Úm. (Bratislava)*, 34: 1 — 149.

Birkenmajer, K., 1954. O wieku tak zwanych margli puchowskich na tle stratygrafii osłony pienińskiego pasa skałkowego (On the age of the so-called „Púchov Marls" in the Pieniny, Central Carpathians, and stratigraphy of the Pieniny Klippen Belt mantle). *Biul. Inst. Geol.*, 88: 1 — 79.

Birkenmajer, K., 1958. *Przewodnik geologiczny po pienińskim pasie skałkowym*, I — IV. Wyd. Geol., Warszawa.

Birkenmajer, K., 1960. Geology of the Pieniny Klippen Belt of Poland (A review of latest researches). *Jb. geol. Bundesanst. (Wien)*, 103 (1): 1 — 36.

Birkenmajer, K., 1977. Jurassic and Createaceous lithostratigraphic units of the Pieniny Klippen Belt, Carpathians, Poland. *Stud. Geol. Polon.*, 45: 1 — 159.

Birkenmajer, K., 1979. *Przewodnik geologiczny po pienińskim pasie skałkowym*, Wyd. Geol., Warszawa, 236 pp.

Birkenmajer, K., 1985. *In: Guide to Excursion 2, Main Geotraverse of the Polish Carpathians (Kraków — Zakopane)*, K. Birkenmajer ed. XIII Congr. Carpatho-Balkan Geol. Assoc. (Kraków, 1985). Inst. Geol., Warszawa, 188 pp.

Birkenmajer, K., 1986. Stages of structural evolution of the Pieniny Klippen Belt, Carpathians, *Stud. Geol. Polon.*, 88: 7 — 32.

Birkenmajer, K., 1988. Exotic Andrusov Ridge: its role in plate-tectonic evolution of the West Carpathian foldbelt. *Stud. Geol. Polon.*, 91: 7 — 37.

Birkenmajer, K. & Jednorowska, A., 1983. Stratygrafia górnej kredy płaszczowiny braniskiej okolic Sromowiec Wyżnych w Pieninach (Upper Cretaceous stratigraphy in the Branisko Nappe at Sromowce Wyżne, Pieniny Klippen Belt of Poland). *Stud. Geol. Polon.*, 77: 7 — 26.

Birkenmajer, K. & Jednorowska, A., 1987. Late Cretaceous foraminiferal biostratigraphy of the Pieniny Klippen Belt (Carpathians, Poland). *Stud. Geol. Polon.*, 92: 7 — 28.

Birkenmajer, K. & Lefeld, J., 1969. Exotic Urgonian limestones from the Pieniny Klippen Belt of Poland. *Bull Acad. Polon. Sci., Géol, Géogr.*, 17 (1): 13 — 15.

Birkenmajer, K. & Wieser, T., 1990 . Okruchy skał egzotycznych z osadów gőrnej kredy pienińskiego pasa skałkowego (Exotic rock fragments from Upper Cretaceous deposits near Jaworki, Pieniny Klippen Belt, Carpathians, Poland). *Stud. Geol. Polon.*, 97: 7 — 67.

Budurov, K., 1975. *Paragondolella foliata* sp. n. (Conodonta) von der Trias des Ostbalkans. *Rev. Bulg. Geol. Soc.*, 36 (1): 79 — 81.

Gaździcki, A., Kozur, H. & Mock, R., 1979. The Norian-Rhaetian boundary in the light of micropalaeontological data. *Geologija* (Ljubljana), 22 (1): 71 — 112.

Golebiowski, R., 1986. Neue Misikellen-Funde (Conodonta) und ihre Bedeutung für die Abgrenzung des Rhäts *s. str.* in den Kössener Schichten. *Sitzber. Österr. Akad. Wiss.*, I, 195 (1 — 5): 53 — 65.

Gümbel, C.W., 1859. Über die Gleichsetzung der Gesteinsmassen in den nord-östlichen Alpen mit ausseralpinischen Flötzschichten. *Verh. Ges. Deutsch. Naturforsch. u. Ärzte (Karlsruhe)*, 54: 80 — 88.

Jednorowska, A., 1981. Mikrofauna i wiek żwirowca z Bukowin (formacja sromowiecka, górna kreda), pieniński pas skałkowy (Microfauna and age of the Bukowiny Gravelstone Member, Sromowce Formation, Upper Cretaceous, Pieniny Klippen Belt, Carpathians), *Stud. Geol. Polon.*, 70: 51 — 54.

Kovács, S. & Kozur, H., 1980. Stratigraphische Reichweite der wichtigsten Conodonten (ohne Zahnreihenconodonten) der Mittel- und Obertrias. *Geol. Paläont. Mitt. Innsbruck*, 10 (2): 47 — 78.

Kozur, H., 1972. Vorläufige Mitteilungen zur Parallelisierung der germanischen und tethyalen Trias sowie einige Bemerkungen zur Stufen- und Unterstufengliederung der Trias. *Mitt. Ges. Geol. Bergbaustud. (Innsbruck)*, 21 (1): 262 — 412.

Kozur, H., 1973. Beiträge zur Stratigraphie von Perm und Trias. *Geol. Paläont. Mitt. Innsbruck* 3 (3): 1 — 31.

Kozur, H., 1974a. Probleme der Triasgliederung und Parallelisierung der germanischen und tethyalen Trias. I: Abgrenzung und Gliederung der Trias. *Freib. Forsch.-H.*, C-298: 139 — 197.

Kozur, H., 1974b. Biostratigraphie der germanischen Mitteltrias. I & II. *Freib. Forsch.-H.*, C-280: 1 — 56 & 1 — 70.

Kozur, H., 1980a. Revision der Conodontenzonierung der Mittel- und Obertrias des tethyalen Faunenreichs. *Geol. Paläont. Mitt. Innsbruck* 10 (3 — 4): 79 — 172.

Kozur, H., 1980b. The main events in the Upper Permian and Triassic conodont evolution and its bearing to the Upper Permian and Triassic stratigraphy. *Riv. Ital. Paleont.*, 85 (3 — 4): 741 — 766.

Kozur, H., 1988. Significance of events in conodont evolution for the Permian and Triassic stratigraphy. *In*: Ziegler, W. (ed.), 1st Int. Senckenberg Conf. & 5th Europ. Conodont Sympos. (ECOS V). Contr. 1, *Contr. Forsch.-Inst. Senckenberg (Frankfurt a.M.)*, 102: 245.

Kozur, H. (*in press, a*). The taxonomy of the gondolellid conodonts in the Permian and Triassic. *Contr. Forsch.-Inst. Senckenberg (Frankfurt a.M.)*.

Kozur, H. (*in press, b*). Significance of events in conodont evolution for the Permian and Triassic stratigraphy. *Contr. Forsch.-Inst. Senckenberg (Frankfurt a.M.)*.

Kozur, H. & Mock, R., 1972a. Neue Conodonten aus der Trias der Slowakei und ihre stratigraphische Bedeutung. *Geol. Paläont. Mitt. Innsbruck* 2 (4): 1 — 20.

Kozur, H. & Mock, R., 1972b. Neue Holothurien-Sklerite aus der Trias der Slowakei. *Geol. Paläont. Mitt. Innsbruck* 2 (12): 1 — 47.

Kozur, H. & Mock, R., 1974a. Zwei neue Conodonten-Arten aus der Trias des Slowakischen Karstes. *Časop. Miner. Geol. (Praha)*, 19 (2): 135 — 139.

Kozur, H. & Mock, R., 1974b. *Misikella posthernsteini* n. sp., die jüngste Conodontenart der tethyalen Trias. *Časop. Miner. Geol.*, 19 (3): 245 — 250.

Kozur, H. & Mock, R., 1974c. Holothurien-Sklerite aus der Trias der Slowakei und ihre stratigraphische Bedeutung. *Geol. Zborn., Geol. Carpathica*, 25 (1): 115 — 145.

Kozur, H. & Mock, R., 1985. Erster Nachweis von Jura in der Meliata-Einheit der südlichen Westkarpaten. *Geol. Paläont. Mitt. Innsbruck* 13 (10): 223 — 238.

Kozur, H. & Mock, R., 1987a. Deckenstrukturen im südlichen Randbereich der Westkarpaten (vorläufige Mitteilung). *Geol. Paläont. Mitt. Innsbruck* 14 (6): 131 — 155.

Kozur, H. & Mock, R., 1987b. Remarks on the occurrence of „Germanic Triassic" in the Mecsek Mts (Southern Hungary) and to the relations between the Germanic and Carpathian Keuper. *Miner. Slov.*, 19 (6): 481 — 497.

Kozur, H. & Mock, R., 1988. Deckenstrukturen im südlichen Randbereich der Westkarpaten und Grundzüge der Alpidischen Entwicklung in den Karpaten. *Acta Geol. Geogr. Univ. Comen., Geol.*, 44: 5 — 100.

Kozur, H. & Mock, R. (*in press*). New conodonts from the Middle Carnian and Rhaetian of Buda Mts, Pilis Mts and Csővar (Hungary), *Geol. Zborn.* (Bratislava).

Kozur, H. & Simon, O.J., 1972. Contribution to the Triassic microfauna and stratigraphy of the Betic Zone (southern Spain). *Rev. Españ. Micropal.*, Num. Extraord., 30 (Aniv. ADARO): 143 — 158.

Krystyn, L., 1974. Probleme der biostratigraphischen Gliederung der alpin-mediterranen Obertrias. *In*: Zapfe, H. (ed.), Die Stratigraphie der alpin-mediterranen Trias, *Schr. Erdwiss. Komm. Österr. Akad. Wiss.* (Wien — New York), 2: 137 — 144.

Krystyn, L., 1987. Zur Rhät-Stratigraphie in den Zlambach-Schichten (vorläufiger Bericht). *Sitzber. Österr. Akad. Wiss., Math.-naturw.*, Kl., I, 196 (1 — 4): 21 — 36.

Krystyn, L. & Wiedmann, J., 1986. Ein *Choristoceras*-Vorläufer aus dem Nor von Timor. *N. Jb. Geol. Paläont. Mh.*, 1986, 1: 27 — 37.

Mišík, M. & Sýkora, M., 1981. Pieninský exotický chrbát rekonštruovaný z valúnov karbonátovych hornín kriedových zlepencov bradlového pásma a manínskej jednotky (Der pieninische exotische Rücken rekonstruiert aus Geröllen karbonatischer Gesteine kretazischer Konglomerate der Klippenzone und der Manín Einheit). *Záp Karp. Geol.*, 7: 7 — 111.

Mišík, M., Mock, R. & Sýkora, M., 1977. Die Trias der Klippenzone der Karpaten. *Geol. Zborn. (Bratislava)*, 28 (1): 27 — 69.

Mišík, M., Jablonský, J., Fejdi, P. & Sýkora, M., 1980. Chromian and ferrian spinels from Cretaceous sediments of the West Carpathians. *Miner. Slov.*, 12 (3): 209 — 228.

Mišík, M., Jablonský, J., Mock, R. & Sýkora, M., 1981. Konglomerate mit exotischen Material in dem Alb der Zentralen Westkarpaten — paläogeographisch und tektonisch Interpretation. *Acta Geol. Geogr. Univ. Comen., Geol.*, 37: 5 — 55.

Mojsisovics, E. v., Waagen, W. & Diener, C., 1895. Entwurf einer Gliederung der pelagischen Sedimente des Trias-Systems. *Sitzber. Österr. Akad. Wiss., Math.-naturw.*, Cl., 54 (1): 1271 — 1302.

Mostler, H., 1967. Conodonten und Holothuriensklerite aus den norischen Hallstätter Kalken von Hernstein (Niederösterreich). *Verh. geol. Bundesanst.*, 1967, 1 — 2: 177 — 188.

Mostler, H., 1968. Holothurien-Sklerite aus oberanisischen Hallstätterkalken. *Ver. Univ. Innsbruck*, 2 (Alpenkundliche Stud., 2): 1 — 45.

Mostler, H., 1969. Entwicklungsreihen triassischer Holothurien-Sklerite. *Ver. Univ. Innsbruck*, 18 (Alpenkundliche Stud., 7): 1 — 53.

Mostler, H., 1970. Über einige Holothurien-Sklerite aus der Süd- und Nordalpinen Trias. *Festbd Geol. Inst., 300-Jahr-Feier Univ. Innsbruck*: 339 — 360.

Mostler, H., 1971. Holothuriensklerite aus anisischen, karnischen und norischen Hallstätterkalken. *Geol. Paläont. Mitt. Innsbruck* 1 (1): 1 — 30.

Mostler, H., 1972. Neue Holothurien-Sklerite aus der Trias der Nördlichen Kalkalpen. *Geol. Paläont. Mitt. Innsbruck* 2 (7): 1 — 32.

Mostler, H., 1973. Holothuriensklerite der alpinen Trias und ihre stratigraphische Bedeutung. *Mitt. Ges. Geol. Bergbaustud.* (Innsbruck), 21 (2): 729 — 744.

Mostler, H., Scheuring, B. & Ulrichs, M., 1978. Zur Mega-, Mikrofauna und Mikroflora der Kössener Schichten (alpine Obertrias) vom Weissloferbach in Tirol unter besonderer Berücksichtigung der in der *suessi*- und *marshi*-Zone auftretenden Conodonten. *In*: Zapfe, H. (ed.), *Beiträge zur Biostratigraphie der Tethys-Trias. Schr. Erdwiss. Komm. Österr. Akad. Wiss.*, 4: 141 — 174.

Radwański, Z., 1978. Środowisko sedymentacyjne fliszu formacji sromowieckiej (górna kreda) w pienińskim pasie skałkowym Polski (Sedimentary environment of the Sromowce Formation flysch deposits, Upper Cretaceous, of the Pieniny Klippen Belt, Carpathians, Poland). *Stud. Geol. Polon.*, 57: 1 — 86.

Săndulescu, M. & Russo-Săndulescu, D., 1979. The ophiolites from the Rarău and Hăgimaş synclines — their structural position, age and geotectonic evolution. *D.S. Inst. Geol. Geofiz.*, (Bucureşti), 66: 103 — 114.

Săndulescu, M., Kräutner, H.G., Balintoni, I., Russo-Săndulescu, D. & Micu, M., 1981. The structure of the East Carpathians. *Guide Exc. B1, Carp.-Balkan. Geol. Assoc., XII Congr. Romania (Bucharest)*, 1 — 92.

Sikora, W. & Wieser, T., 1979. Egzotyczne ofikalcyty z cenomańskich zlepieńców jednostki zlatniańskiej (pieniński pas skałkowy). *Kwart. Geol.*, 23 (2): 495 — 496.

Tozer, E.T., 1974. Definitions and limits of Triassic stages and substages: Suggestions prompted by comparison between North America and the Alpine-Mediterranean region. *Schr. Erdwiss. Komm. Österr. Akad. Wiss.*, 2: 195 — 206.

Tozer, E.T., 1980. Latest Triassic (Upper Norian) ammonoid and *Monotis* faunas and correlations. *Riv. Ital. Paleont.*, 85: 843 — 876.

Végh-Neubrandt, E., 1982. *Triassische Megalodontaceae. Entwicklung, Stratigraphie und Paläontologie.* Budapest, 526 pp.

Wiedmann, J., 1974. Zum Problem der Definition und Abgrenzung von Obernor (Sevat) un Rhät. *Schr. Erdwiss. Komm. Österr. Akad. Wiss.*, 2: 229 — 235.

Wieser, T., 1958. Magmowe i metamorficzne skały egzotyczne z kredy i paleogenu pienińskiego pasa skałkowego (Magmatic and metamorphic exotic rocks from the Cretaceous and Palaeogene of the Pieniny Klippen Belt, Carpathians). *Biul. Inst. Geol.*, 135: 97 — 150.

Streszczenie

EGZOTYKI PELAGICZNYCH WAPIENI TRIASOWYCH Z GÓRNEJ KREDY PIENIŃSKIEGO PASA SKAŁKOWEGO POLSKI: ŚWIADECTWO WCZESNO-MEZOZOICZNEGO OTWARCIA BASENU OCEANICZNEGO W KARPATACH ZACHODNICH

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Otoczaki egzotycznych wapieni triasowych, pochodzących z górnokredowych zlepieńców pienińskiego pasa skałkowego Polski, dostarczyły mikrofauny (głównie konodontów i sklerytów strzykw) świadczącej o pelagicznych warunkach depozycji w basenie skałkowym w czasie późnego triasu, w czasie karniku i noryku, z późnym norykiem (najwyższy sewat) — poziom *Misikella hernsteini — Parvigondolella andrusovi* włącznie. Są to szare plamiste wapienie, litologicznie bardzo podobne do plamistych wapieni i margli liasu i doggeru skałkowego. Sugeruje to ciągłość depozycji pelagicznych szarych plamistych wapieni w basenie skałkowym od triasu po jurę środkową, bez wynurzenia na granicy triasu i jury. Uwzględniając dane z Polski i wcześniej opublikowane dane z pienińskiego pasa skałkowego Słowacji, autorzy przyjmują, że warunki pelagicznej sedymentacji w basenie skałkowym, który został otwarty pod wpływem ryftu odgałęziającego się z oceanicznego basenu Transylwanii, nastąpiły już na granicy triasu wczesnego (scytu) i środkowego (anizyku).

Pelagiczne wapienie triasu w pienińskim pasie skałkowym znane są wyłącznie z egzotyków w zlepieńcach górnokredowych. Pochodziły one prawdopodobnie z pryzmy akrecyjnej zbudowanej z pelagicznych osadów triasu i jury, która przyrosła od strony północnej do egzotycznego masywu Andrusova, ograniczającego basen skałkowy od południa, pod wpływem podsuwania się (subdukcji) ku południowi oceanicznej skorupy basenu skałkowego i jej osadowego nadkładu. Wydźwignięta (obdukowana) pryzma akrecyjna i sam grzbiet Andrusova (którego pokrywa osadowa utworzona była m.in. z platformowych osadów triasu i jury), ulegały erozji i denudacji w czasie późnej kredy, począwszy od aptu-albu, dostarczając materiału egzotykowego do basenu skałkowego (na północy) i basenu manińskiego *sensu lato* (na południu).

EXPLANATIONS OF PLATES

(Abbreviations: *CK* — Collection of Geological Institute, Innsbruck University, Austria; *KM* — Collection of Geological Institute, J.A. Comenius University, Bratislava, Czechoslovakia)

Plate I

Figs. 1 — 7: Microfossils from an exotic limestone pebble, Sromowce Formation. Bukowiny Gravelstone Member (Upper Santonian), Skalski Stream near Jaworki; Niedzica Nappe, Pieniny Klippen Belt of Poland. Figs. 8 — 11: Microfossils from an exotic limestone pebble, Jarmuta Formation conglomerate (Maastrichtian), Bialy Dunajec River at Szaflary, Pieniny Klippen Belt of Poland. Figs. 12 & 13: Microfossils from an exotic limestone pebble, Sromowce Formation, Gróbka Member (Lower Turonian), Gróbka Stream near Sromowce; Branisko Nappe, Pieniny Klippen Belt of Poland.

1 — *Budurovignathus hungaricus* (Kozur et Végh). Sample 71-22-9-86, Lower Longobardian (lower Upper Ladinian), ×100, Rep. No. CK/151188 II-100; *a* — lateral view; *b* — lower view.

2 — *Theelia immisorbicula* Mostler, upper view. Sample 65-22-9-86, pelagic uppermost Ladinian to Lower Carnian, ×200, Rep. No. CK/151188 II-104.

3 — *Theelia* cf. *liptovskaensis* Kozur et Mock, upper view. Sample 65-22-9-86, pelagic uppermost Ladinian to Lower Carnian, ×100, Rep. No. CK/151188 II-103.

4 — *Paragondolella foliata* Budurov, juvenile specimen, lateral view. Sample 65-22-8-86, pelagic uppermost Ladinian to Lower Carnian, ×100, Rep. No. CK/151188 II-101.

5 — Brachialia of roveacrinids (*Osteocrinus* sp.). Sample 65-22-8-88, pelagic uppermost Ladinian to Lower Carnian, ×100, Rep. No. CK/151188 II-106.

6 — Fish tooth. Sample 65-22-9-86, pelagic uppermost Ladinian to Lower Carnian, ×100, Rep. No. CK/151188 II-107.

7 — *Paragondolella inclinata* (Kovács), lower view. Sample 65-22-9-86, pelagic uppermost Ladinian to Lower Carnian, Rep. No. CK/151188 II-102; *a* — ×100; *b* — detail of posterior end of ‚keel”, ×400.

8 — *Enantiognathus petraeviridis* (Huckriede), enantiognathiform element of *Gladigondolella* Müller. Sample No. BD-1, pelagic Middle Carnian (Julian), Rep. No. CK/151188 II-110.

9 — *Gladigondolella malayensis* Nogami, juvenile specimen, oblique lateral view. Sample No. BD-1, pelagic Middle Carnian (Julian), ×100, Rep. No. CK/151188 II-99.

10 — *Metaprioniodus spengleri* (Huckriede), metaprioniodiniform (modified hindeodelliform) element of *Gladigondolella* Müller. Sample No. BD-1, pelagic Middle Carnian (Julian), ×100, Rep. No. CK/151188 II-109.

11 — Fish tooth. Sample No. BD-1, pelagic Middle Carnian (Julian), ×100, Rep. No. CK/151188 II-108.

12 — *Theelia* cf. *barkeyi* Kozur et Simon, upper view. Sample No. 55-21-9-86, Upper Ladinian to Cordevolian, ×200, Rep. No. CK/151188 II-112.

13 — Placoid scale. Sample No. 55-21-9-87, Upper Ladinian to Cordevolian, ×100, Rep. No. CK/151188 II-113.

Plate II

Figs. 1 — 6: Microfossils from exotic limestone pebbles, Sromowce Formation, Bukowiny Gravelstone Member (Upper Santonian), Skalski Stream near Jaworki; Niedzica Nappe, Pieniny Klippen Belt of Poland. Figs. 7 — 13: Microfossils from exotic limestone pebbles, Sromowce Formation, Gróbka Member (Lower Turonian), Gróbka Stream near Sromowce; Branisko Nappe, Pieniny Klippen Belt of Poland.

1 — *Paragondolella polygnathiformis noah* (Hayashi), juvenile specimen, lateral view. Sample No. 63-22-9-86, pelagic Middle Carnian (Julian), ×200, Rep. No. CK/151188 II-114.

2 — *Gladigondolella tethydis* (Huckriede), earliest juvenile stage of the platform element (= *Prioniodina kochi* Huckriede). Sample No. 63-22-9-86, pelagic Middle Carnian (Julian), ×100, Rep. No. CK/151188 II-117.

3 — Modified hindeodelliform (metaprioniodiniform) element of *Gladigondolella* Müller. Sample No. 63-22-9-86, pelagic Middle Carnian (Julian), ×50, Rep. No. CK/151188 II-116.

4 — *Tiborella* sp. (Radiolaria). Sample No. 63-22-9-86, pelagic Middle Carnian (Julian), ×200, Rep. No. CK/151188 II-118.

5 — *„Lonchodina" posterognathus* (Mosher), lonchodiniform element of *Gladigondolella* Müller. Sample No. 63-22-9-86, pelagic Middle Carnian (Julian), ×100, Rep. No. CK/151188 II-115.

6 — *Prioniodina (Cypridodella) venusta* (Huckriede), modified prioniodiniform (cypridelliform) element of *Gladigondolella* Müller. Sample No. 64-22-9-86, pelagic Middle Triassic to Julian, ×100, Rep. No. CK/151188 II-111.

7 — *Neohindeodella summesbergeri summerbergeri* Kozur et Mostler. Sample No. 49A-21-9-86, Norian, ×200, Rep. No. CK/151188 II-120.

8 — *Epigondolella abneptis* (Huckriede), juvenile specimen, oblique lateral view. Sample No. 58-22-9-86, Lower Norian, ×200, Rep. No. CK/151188 II-119.

9 — Ophiuroid hook. Sample No. 54-21-9-86, pelagic uppermost Norian *M. hernsteini — P. andrusovi* A.Z., ×200, Rep. No. CK/151188 II-126.

10 — Calcisponge spicule. Sample No. 54-21-9-86, pelagic uppermost Norian *M. hernsteini — P. andrusovi* A.Z., ×100, Rep. No. CK/151188 II-7.

11 — Ophiuroid dorsal plate. Sample No. 54-21-9-86, pelagic uppermost Norian *M. hernsteini — P. andrusovi* A.Z., ×100, Rep. No. CK/151188 II-124.

12 — Ophiuroid vertebra. Sample No. 54-21-9-86, pelagic uppermost Norian *M. hernsteini — P. andrusovi* A.Z., ×50, Rep. No. CK/151188 II-122.

13 — Ophiuroid vertebra. Sample No. 54-21-9-86, pelagic uppermost Norian *M. hernsteini — P. andrusovi* A.Z., ×100, Rep. No. CK/151188 II-123.

Plate III

All specimens figured are from Sample No. 54-21-9-86, exotic limestone pebble, pelagic uppermost Norian *M. hernsteini — P. andrusovi* A.Z.; Sromowce Formation, Gróbka Member (Lower Turonian), Gróbka Stream near Sromowce; Branisko Nappe, Pieniny Klippen Belt of Poland.

1 — 4 — *Misikella hernsteini* Mostler; *1* — lateral view, ×200, Rep. No. CK/151188 III-16; *2* — Rep. No. CK/151188 III-15 (*a* — somewhat oblique lateral view, ×200; *b* — lower view, ×370); *3* — upper view, ×200, Rep. No. CK/151188 III-17; *4* — lateral view, ×200, Rep. No. CK/151188 III-18

5, 8, 9 — *Norigondolella steinbergensis* (Mosher), juvenile specimens; *5* — lateral view, ×100, Rep. No. CK/151188 III-13; *8* — oblique lower view, ×80, Rep. No. KM 1989 I-4078; *9* — Rep. No. CK/151188 III-12 (*a* — oblique lateral view, ×100; *b* — lower view, ×83; *c* — detail of posterior half of lower surface, ×400)

6 — *Neohindeodella* cf. *triassica* (Müller), ×200; Rep. No. CK/151188 III-9

7 — *Oncodella paucidentata* (Mostler), ×100; Rep. No. CK/151188 III-11

10 — Echinoderm spine (?ophiuroid spine) ×100; Rep. No. CK/151188 III-125

Plate IV

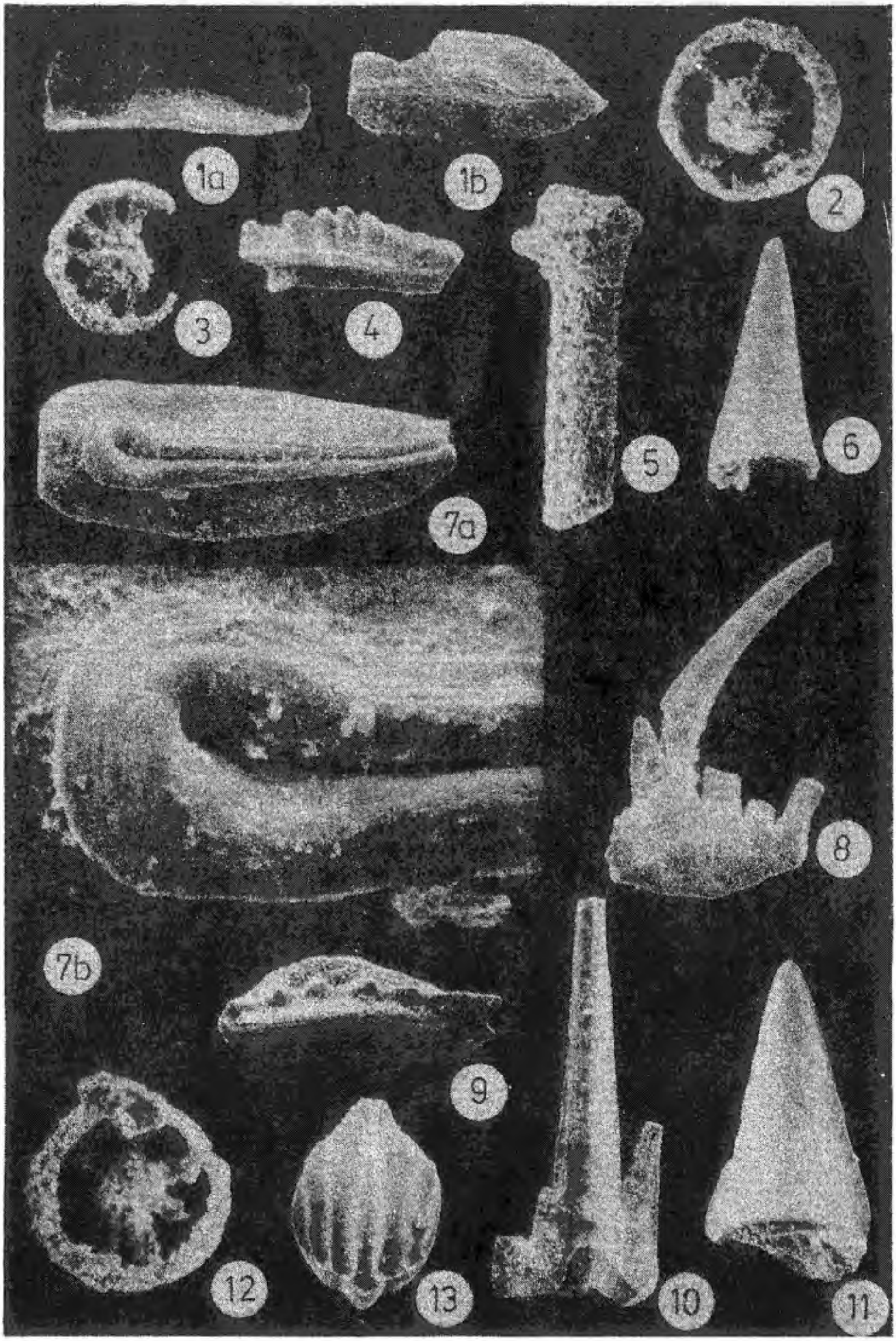
All specimens figured are from Sample No. 54-21-9-86, exotic limestone pebble of pelagic uppermost Norian *M. hernsteini — P. andrusovi* A.Z.; Sromowce Formation, Gróbka Member (Lower Turonian), Gróbka Stream near Sromowce; Branisko Nappe, Pieniny Klippen Belt of Poland.

1 — *Kuehnites andrusovi* Kozur et Mock, upper view, ×200; Rep. No. CK/151188 III-35
2 — *Semperites* cf. *ungersteinensis* Mostler, ×100; Rep. No. CK/151188 III-3
3 — Problematic echinoderm remain (holothurian sclerite?), ×100; Rep. No. CK/151188 III-19
4 — *Tetravirga* n.sp. ×200; Rep. No. CK/151188 III-20
5, 6 — *Biacumina multiperforata* Kozur et Mock, n.sp. ×100; *5* — Rep. No. CK/151188 III-2; *6* — holotype, Rep. No. CK/151188 III-1
7 — *Punctatites triangularis* (Mostler), ×50; Rep. No. CK/151188 III-8
8 — *„Eocaudina"* cf. *longa* Kozur et Mock, ×200; Rep. No. CK/151188 III-36
9 — *Canisia mostleri* Kozur et Mock n.sp., holotype, ×200; Rep. No. CK/151188 III-34
10 — *Fissobractites subsymmetricus* Kristan-Tollmann, ×100; Rep. No. CK/151188 III-5
11, 12 — *Acanthotheelia* cf. *minima* Kozur et Mock n.sp., upper views, ×200; *11* — Rep. No. CK/151188 III-41; *12* — Rep. No. CK/151188 III-26
13 — *Acanthotheelia minima* Kozur et Mock n.sp., upper view, holotype, ×200; Rep. No. CK/151188 III-25
14 — *Theelia pseudoplanata* Kozur et Mock, upper view, ×200, Rep. No. CK/151188 III-37
15 — *Theelia stellifera bistellata* Kozur et Mock, upper view, ×200; Rep. No. CK/151188 III-22

Plate V

All specimens figured are from Sample No. 54-21-9-86, exotic limestone pebble, pelagic uppermost Norian *M. hernsteini* — *P. andrusovi* A.Z.; Sromowce Formation, Gróbka Member (Lower Turonian), Gróbka Stream; Branisko Nappe, Pieniny Klippen Belt of Poland.

1 — 3 — *Theelia immisorbicula* Mostler, ×200; *1* — oblique upper view, Rep. No. CK/151188 III-27; *2* — oblique upper view, Rep. No. CK/151188 III-24; *3* — lower side, Rep. No. CK/151188 III-28
4 — *Theelia variabilis variabilis* Zankl, upper view, ×200; Rep. No. CK/151188 III-31
5, 6 — *Theelia stellifera bistellata* Kozur et Mock, lower view, ×200; *5* — Rep. No. CK/151188 III-21; *6* — Rep. No. CK/151188 III-23
7 — *Theelia* cf. *simoni* Kozur et Mock, upper view, ×200; Rep. No. CK/151188 III-38
8, 9 — *Theelia planorbicula* Mostler, upper view, ×200; *8* — Rep. No. CK/151188 III-32; *9* — Rep. No. CK/151188 III-30
10 — *Theelia patinaformis* Mostler, somewhat oblique view, ×200; Rep. No. CK/151188 III-33
11 — Crinoid ossicle, ×50, Rep. No. CK/151188 III-121
12 — *Argonevis nuda* Kozur et Mostler (microproblematicum), ×200; Rep. No. CK/151188 III-6
13, 14 — *Theelia simoni* Kozur et Mock, ×200; *13* — upper view, Rep. No. CK/151188 III-29; *14* — lower view, Rep. No. CK/151188 III-40
15 — *Theelia* cf. *planorbicula* Mostler, oblique upper view, ×200; Rep. No. CK/151188 III-39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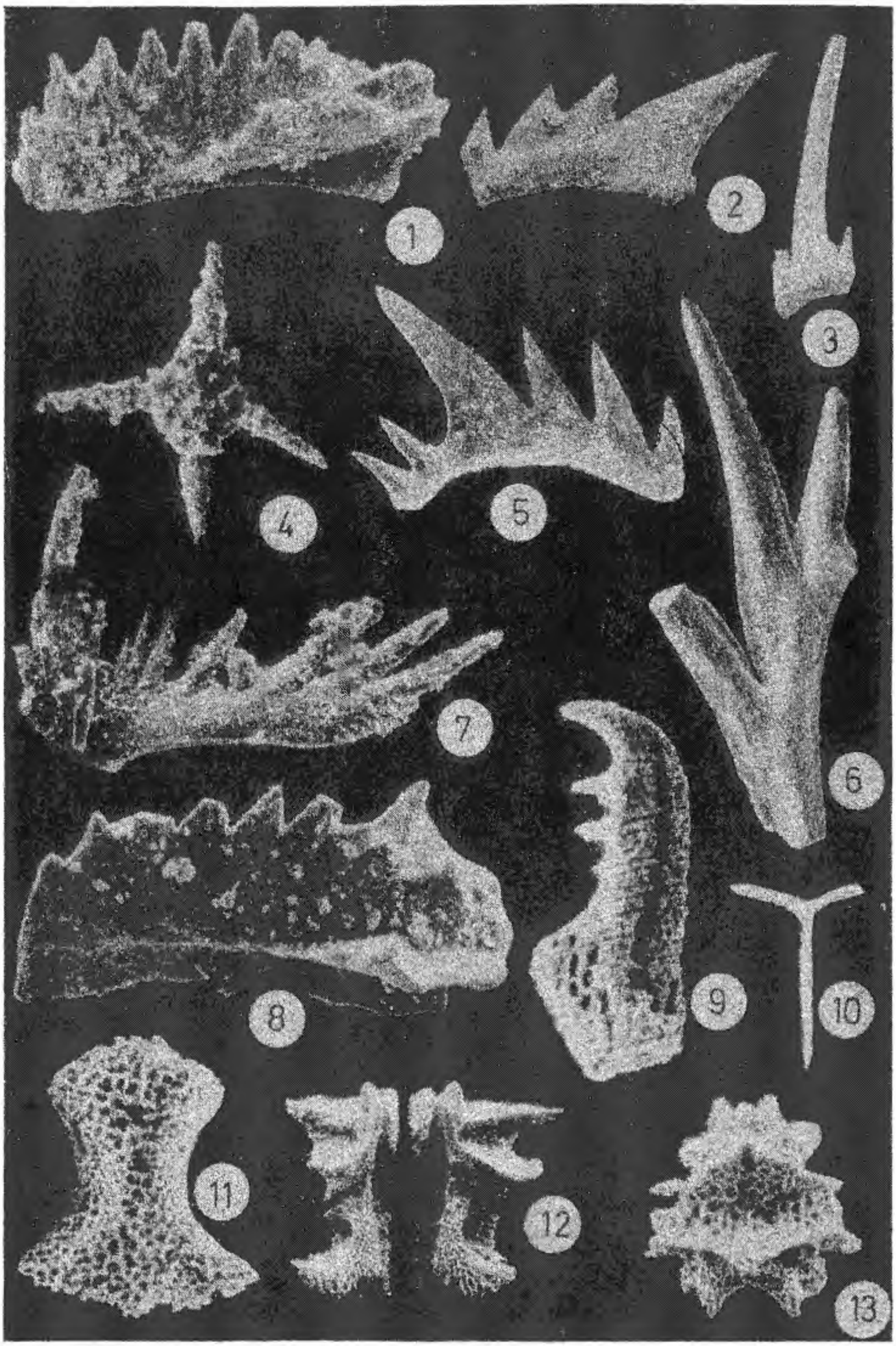
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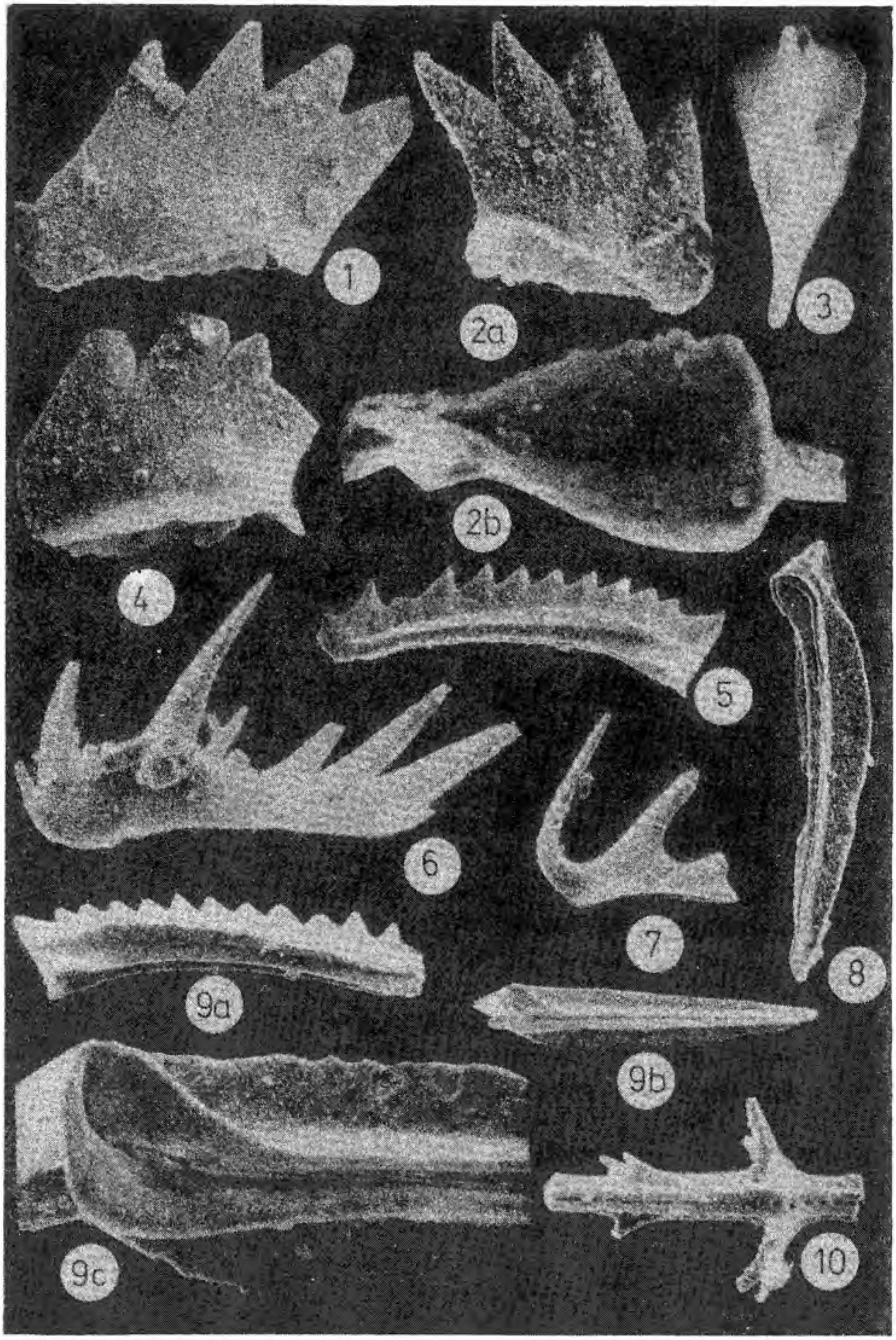
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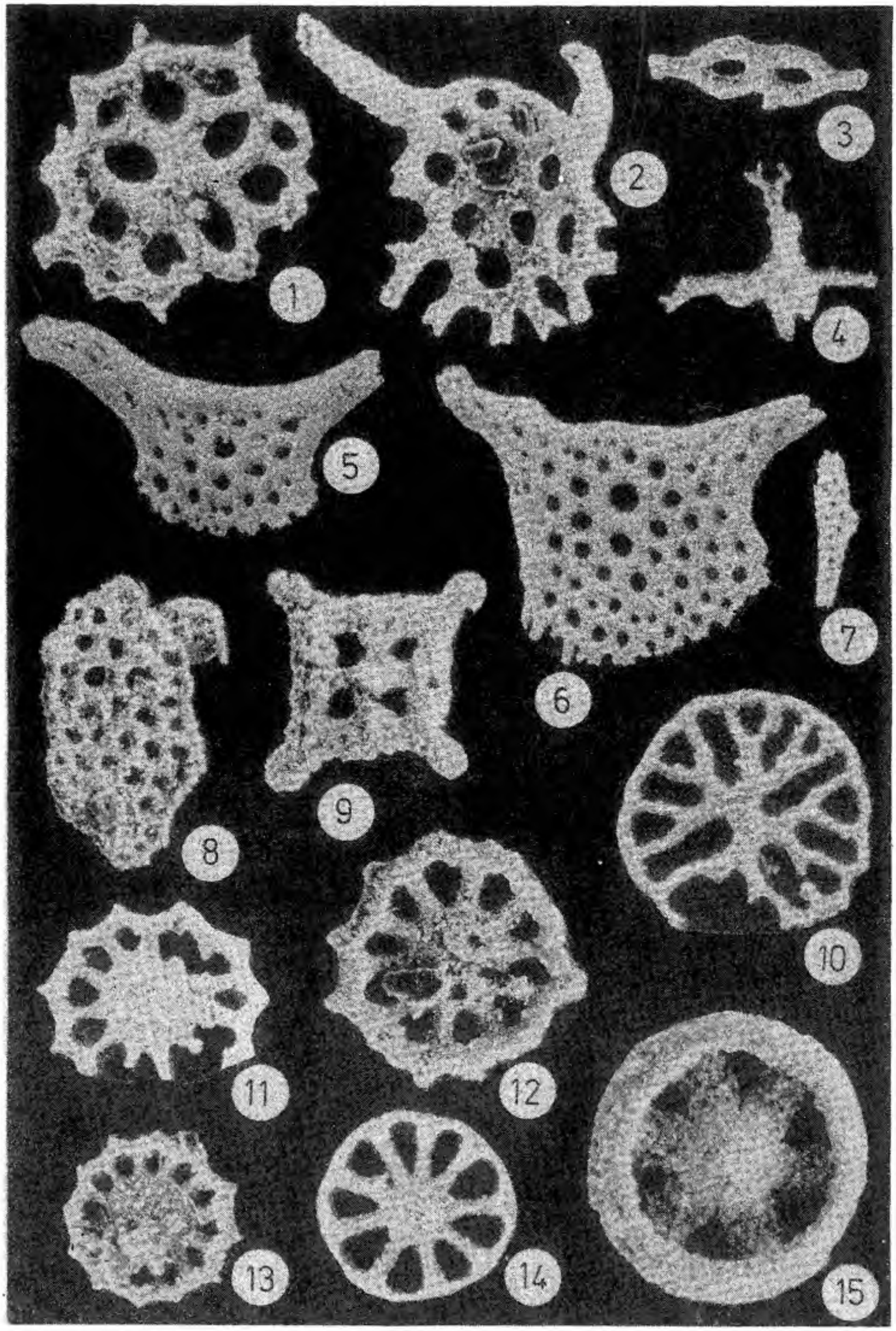
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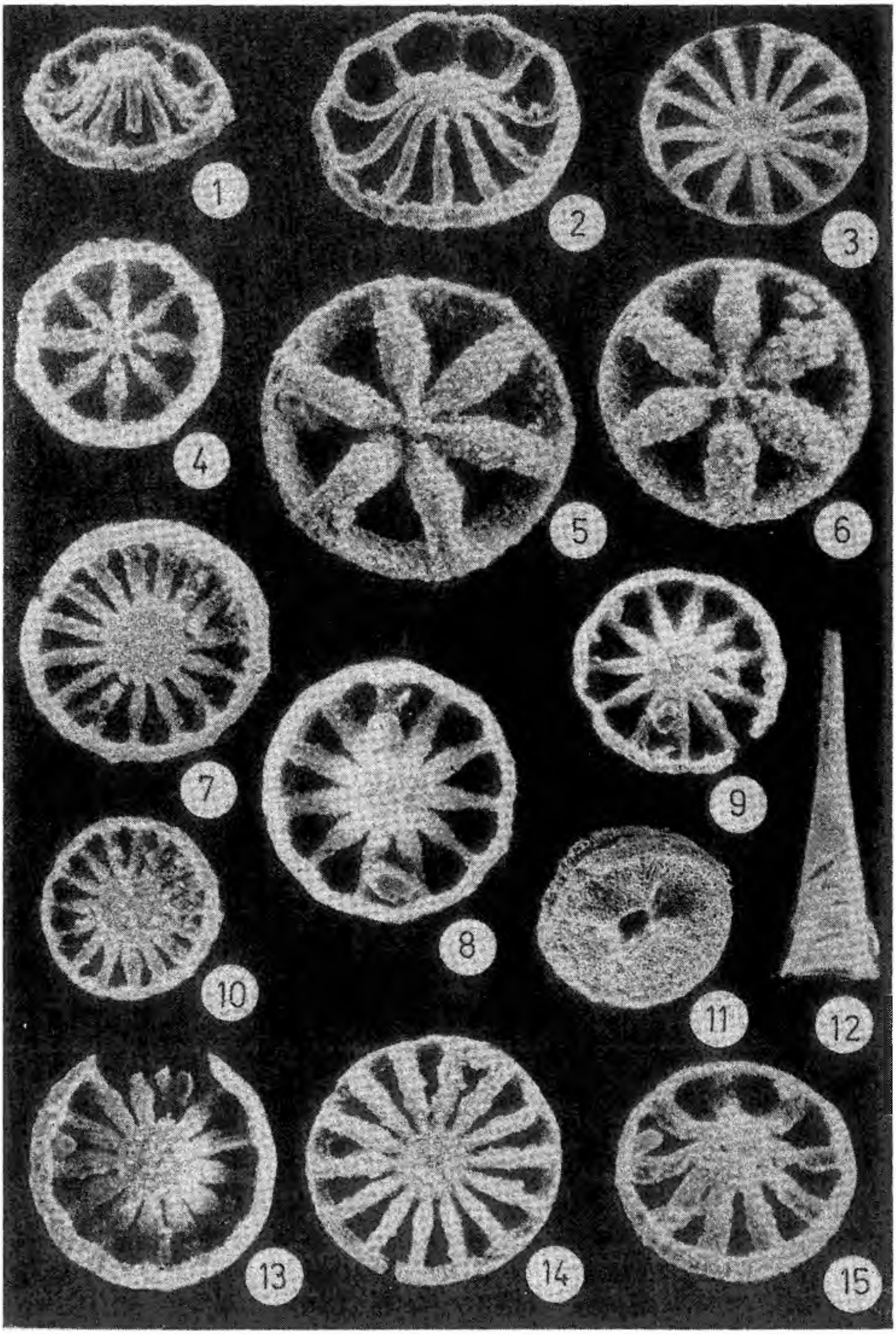
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