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Conodont stratigraphy and sedimentary environment of the Muschelkalk in Upper Silesia

ABSTRACT: The conodont stratigraphy of the Muschelkalk in the Opole area, Upper Silesia, Southern Poland, is the subject of the present paper. Seven conodont zones, three of them containing conodont fauna almost identical with that of corresponding assemblages in the Tethyan Middle Triassic, are recognizable here. The *Neospathodus germanicus, N. kockeli* and *Gondolella excelsa* zones comprise the Gogolin, Górażdże and *Terebratula* beds, as well as part of the Karchowice Beds (Lower Muschelkalk), which corespond to the Lower Anisian, Pelsonian and the lowermost Illyrian. Conodont zones *"1"*, *"2"*, *"3"* and *"4"* with a conodont fauna typical of the German province are characteristic of the remaining part of the Muschelkalk sequence. These zones include the Tarnowice, Wilkowice and Boruszowice beds (Illyrian through Fassanian). The Muschelkalk/Keuper boundary in Silesia runs in the lowermost Langobardian and, therefore, the *"Lettenkohle"* series is precisely of this age. A conodont assemblage from the Muschelkalk of Opole Silesia departs from all others known so far in its considerable content of eccentric and bifurcated gondolellids. The presence of some lithological and microfacies types, the formation of which was connected with environments similar to those of the Great Bahama Bank and of the Persian Gulf, occurring throughout the Muschelkalk of Opole Silesia, is also shown. An analysis of the conodont assemblage allowed to find paleobiogeographical relationships between Silesia and other sedimentary areas of the marine Triassic.

INTRODUCTION

The present paper is a result of the writer's studies on the microfauna of the Silesian Muschelkalk. For the stratigraphic purposes, the conodonts have been used, the material of which (about 8,000 specimens) has been obtained from about 800 samples taken from various exposures and boreholes (Figs 1 and 2). In addition to the conodonts, associated microfossils such as polychaete remains, arm hooks of cephalopods, sclerites of holothurians as well as foraminifers and algal spores were reported in previous papers (Zawidzka 1970a, b, 1971a, 1972a, 1974b, 1975; Głazek, Trammer & Zawidzka 1973) and their importance considered in detail. Of these groups, the polychaetes and holothurians, which have recently been assigned to the most important Alpine Triassic microfossil groups (*cf.* Salaj 1969; Koehn-Zaninetti 1969; Urošević 1971; Zaninetti & al. 1972; Gaździcki 1974), are only shortly discussed here, while the foraminifers from the area under study are the subject of a separate paper (Gaździcki, Trammer & Zawidzka 1975).

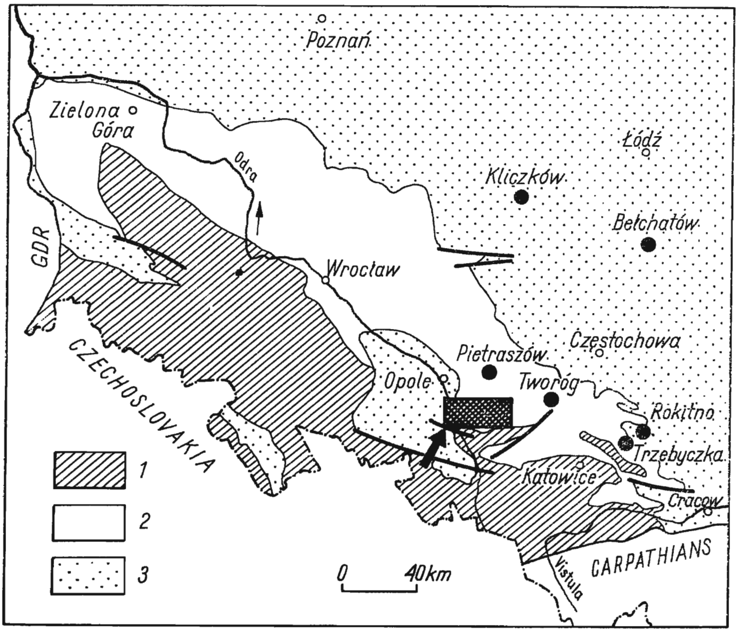

Fig. 1. Geological sketch-map of the Fore-Sudetic and Silesia-Cracow monoclines; rectangled is the Opole Silesia area with Triassic exposures (*cf.* Text-fig. 2); investigated boreholes are marked with black spots

1 pre-Triassic formations, *2* Triassic deposits, *3* post-Triassic formations

The sclerites of the holothurians are fairly numerous in the Alpine Triassic (*cf.* Mostler 1968a—c, 1969, 1970, 1971; Kozur & Mostler 1970b, 1971b; Kozur & Mock 1972). In Poland, they are known from the Middle Triassic of the Tatra Mountains (Zawidzka 1971b) and from the Muschelkalk Basin (Kozur & Mostler 1970b, Senkowiczowa 1972). The occurrence of various sclerites in particular lithological members of the Muschelkalk in the German Basin, constituted a basis for distinguishing by Kozur & Mostler (1970b), several assemblages characteristic of a few chronostratigraphic units (Scythian, Lower Anisian, Lower and Middle Pelsonian). No special search after holothurian sclerites has been conducted during studies on the Muschelkalk of Opole Silesia. Their collection is not very abundant and their state of preservation is rather poor. Forms of the genera *Theelia, Priscopedatus* and *Tetravirga* have been found in the Gogolin, Górażdże and *Terebratula* Beds.

Acknowledgements. The present writer feels greatly indebted to Docent J. Kutek for guiding her work, many discussions, valuable remarks and advice.

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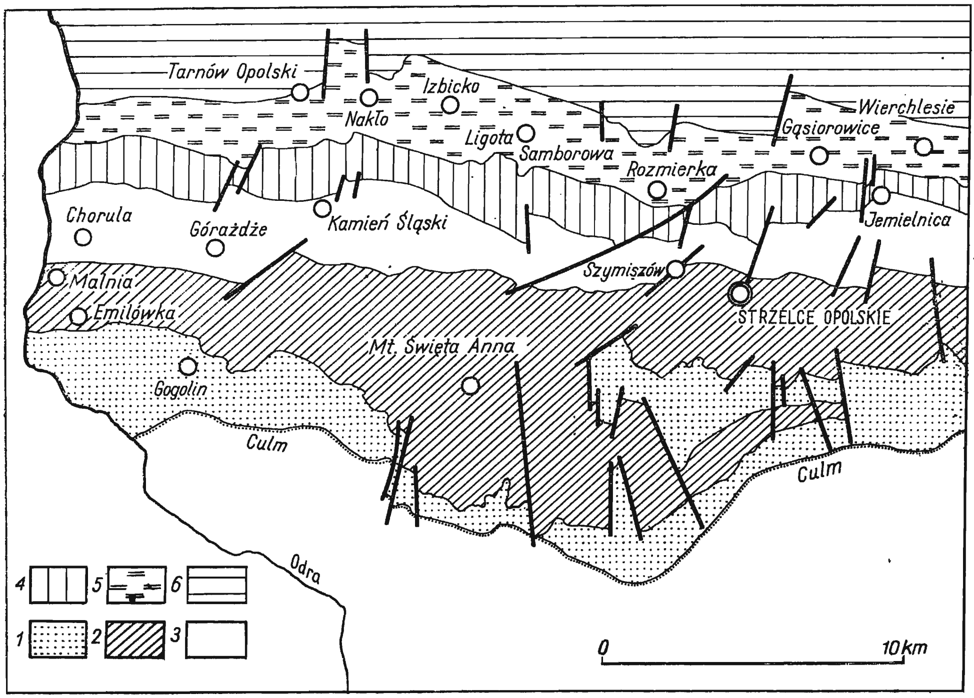


Fig. 2. Geological sketch map of Opole Silesia (*after* Assmann 1944; simplified)
1 Bunter Sandstone, *2* lower part of the Lower Muschelkalk, *3* upper part of the Lower Muschelkalk, *4* Middle Muschelkalk, *5* Upper Muschelkalk, *6* Keuper

sions of the subject; to Professor Z. Kielan-Jaworowska of the Polish Academy of Sciences for making available indispensable apparatus; to Dr. J. Pawlak and colleagues from the Institute of Geology of the Warsaw University for their aid in preparing the paper and, finally, to Dr. S. Kotlicki for making available materials from the boreholes.

REMARKS ON THE SEDIMENTARY ENVIRONMENT

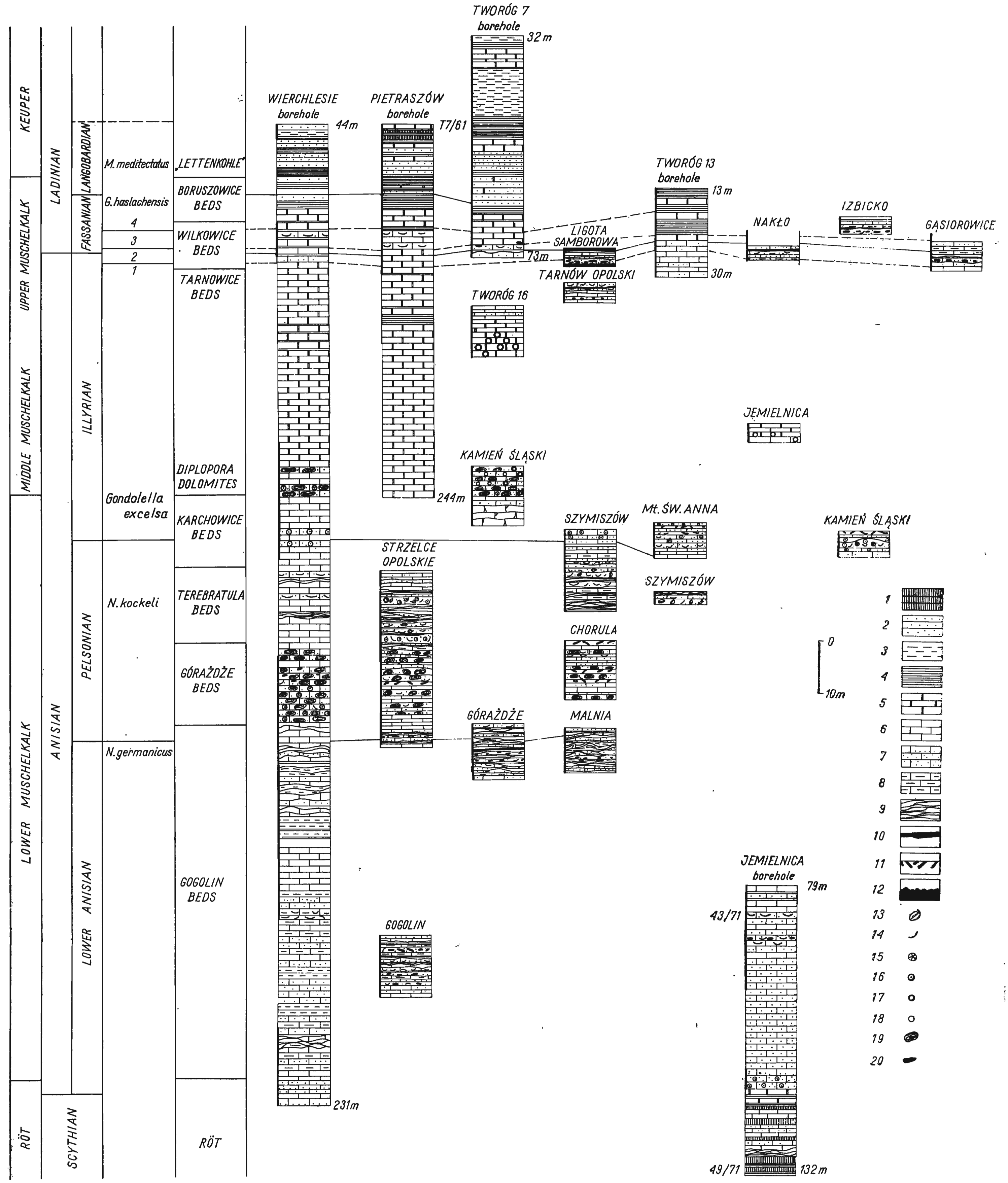
The shallow-water deposits and the salinity, which is normal in the greatest part of the sequence are, generally, characteristic features of the sedimentary environment of the Muschelkalk deposits in Opole Silesia. The lithological and microfacies types, as well as sedimentary structures, occurring in the Gogolin Beds, allow one to compare their sedimentary environment with that of the Lower Muschelkalk of SW Germany (*cf.* Schwarz 1970; Backhaus & Flügel 1971). In these beds there occur various types of crumpled limestones (Siedlecki 1964; Popiel 1967; Bogacz & al. 1968; Anketell & al. 1969; Anketell & Dżułyński 1969; Kubicz 1970a; Bialik, Trammer & Zapaśnik 1972), lenticular and *"Flaser"* type stratification, delicate horizontal lamination, small-scale diagonal stratification (observed, among other places, in ripples formed by pseudoooids), slump structures, "ball-and-pillow" structures (*cf.* Dunbar & McCall 1971), multiple alternation of marly pelitic limestones and calcarenites, erosional furrows, ripplemarks, bioturbation horizons, surfaces rich in glauconite and, finally, phosphate lumps (*cf.* Pls 1—6). Important is also the occurrence of many horizons of intraformational breccias in the Gogolin Beds, in which mostly the unconsolidated substrate was eroded (*cf.* Pl. 6, Figs 2—3). The main granular components of various microfacies types such as intrasparudites, intrabiomicrites, biocalcirudites, biocalcarenites (encrinites and coquina-encrinites) also include echinoid spines, ophiuroid arm vertebrae, holothurian sclerites, small gastropods, pelecypods, brachiopods, ostracodes, foraminifers (*Glomospira* and Nodosaridae), as well as *Girvanella* coatings and balls, pseudoooids, lumps, glauconite, quartz and mica (*cf.* Pls 19, 20 and Pl. 34, Figs 2, 4). The deposits of the Gogolin Beds were thus formed in a shallow-water marine basin, frequently influenced by faint bottom currents. An abundant occurrence of the ostracodes (*cf.* Pl. 19, Figs 1—2) in some lithological members, in the absence of eu- and brachyhaline fauna to which the conodonts should undoubtedly be assigned, is indicative of a salinity periodically slightly increased as compared with the normal one.

The transportation of the terrigenic material abundant in the Gogolin Beds was stopped during the period corresponding to the deposition of the uppermost members of the Gogolin and the lowermost members of the Górażdże Beds. Various new faunal groups appeared in this period which is more likely to correspond to the occurrence of stronger open-sea conditions than the earlier and later period, the latter corresponds to the sedimentation of the predominant part of the Górażdże Beds.

The Górażdże Beds are mostly represented by onkolitic limestones (Pls 7—12; Pl. 34, Fig. 3) formed as a result of the activities of algae (*cf.* literature cited *in* Radwański 1968; Szulczewski 1968; Kutek 1969), as well as by fine-grained calcarenites and calcilutites. The stratification of calcilutites is frequently turbulent and resembles textures connected with convolute bedding (*cf.* references *in* Dunbar & McCall 1971). Granular components are mostly lumps, accompanied by onkolites, foraminifers, small gastropods and various bioclasts with onkolitic crusts and coatings (*cf.* Wood 1941; Radwański 1968), as well as recrystallized grains with micritic envelopes (Friedmann 1964).

Onkolites and onkolitic-lumpy limestones (Pls 21—22), locally containing a considerable amount of benthic foraminifers, display many analogies to the deposits of grapestone facies of the Bahamas. The sedimentary environment of the Bahamian deposits is well-known as markedly shallow water (Purdy 1963, *cf.* also Kutek 1969). Thus, on the basis of these analogies we may determine the onkolitic-lumpy limestones of the Górażdże Beds as sediments deposited in a basin not deeper than 20 m and in which the turbulence of environment was probably on the whole moderate or low. The horizons of pelitic limestones with enteropneustan burrows, occurring a few times in the Górażdże Beds, confirm the conclusion on the shallow-water environment. Parts of the bottom settled by the enteropneustans occur in the intertidal zones (*cf.* Kaźmierczak & Pszczółkowski 1969). The systems of the enteropneustan burrows, observed in the Górażdże Beds, are as a rule eroded and covered with a granular material of the overlying beds (Pl. 11, Fig. 1). The thickness of the beds penetrated by the enteropneustans reaches from a few to 40 cm (Pl. 8; Pl. 11, Figs 1—2; Pl. 12, Figs 1—2). Canals of the *Arenicolites* type (*cf.* Mägdefrau 1932; Kaźmierczak & Pszczółkowski 1968, 1969) are another, much rarer type of burrows. These canals are developed in onkomicrites, having the structure of calcarenites, or in pelitic limestones with a certain part of granular components (Pl. 10, Fig. 1; Pl. 22,

Lithological profiles of the Muschelkalk deposits in Opole Silesia (taken from exposures and boreholes); sections sampled in intervals smaller than 1 m are marked with a heavy line at leftside of the profiles



1 gypsum, 2 sandstones, 3 siltstones, 4 silty or clayey shales, 5 dolomites, 6 pelitic limestones, 7 calcarenites, 8 marly limestones, 9 crumpled limestones, 10 bioturbated layers, 11 horizons with enteropneustan burrows, 12 hardground, 13 Terebratula shells, 14 shell detritus, 15 corals, 16 trochites, 17 dasycladaceans (*Diplopora*), 18 ooids. 19 onkolites. 20 intraclasts

Fig. 3). Similar multiple sequences of canal systems of burrowers are known from the Persian Gulf under the conditions of a relatively normal salinity and temperature and a depth reaching 30 m, where the material, forming layers to 1 m thick, deposited during storms, covers the subaquatically cemented, previously furrowed parts of the bottom (Shinn 1969). The diagonal stratifications are relatively frequent in the granular limestones of the Górażdże Beds. They may be related with the activity of currents which redeposited onkolitic-lumpy deposits formed in the zones with a faint turbulence of water. A change in the type of deposits occurred with the beginning of the sedimentation of the *Terebratula* Beds. Limestones are then formed of the character of lumachelles (*cf.* Pl. 23, Figs 2—3; Pl. 34, Fig. 6), consisting mostly of shells of the species *Coenothyris vulgaris* (Schlotheim), predominant in these beds (*cf.* Assmann 1944; Nowakowski 1972) and of marly limestones with calcarenite intercalations, displaying features typical of crumpled limestones of the Gogolin Beds, along with an entire set of similar sedimentary structures (Pls 13—14). Characteristic layers of encrinites or coquina-encrinites (Pl. 23, Fig. 1) occur in both the bottom and top of the *Terebratula* Beds. Encrustings, supposedly attributable to the sessile foraminifers *Tolypammina* are usually developed on the bioclasts.

The change in character of deposit, which occurs on the boundary between the Górażdże and *Terebratula* beds, does not seem to be caused by considerable changes in the depth of the basin. Various lumachelles are formed at depths reaching a maximum of only several scores of meters (*cf.* references *in* Kutek 1969).

The deposition of the lower parts of the Karchowice Beds probably took place in calmer and deeper parts of the basin. Predominant are pelmicrites with biomicrite intercalations composed of the crinoid-brachiopod detritus, echinoid spines, small gastropods, sponge spicules, foraminifers, spores *Globochaete alpina* Lombard and some "filaments" (Pl. 24, Fig. 3; Pl. 25, Fig. 2). The silification occurs rather generally in the lowermost part of the Karchowice Beds, which contain, in addition, several horizons of flints (Pl. 17, Fig. 2). Characteristic cavernous limestones (Pl. 16, Fig. 1) of the Upper Karchowice Beds resulted from recrystallization and dissolution (Dżułyński & Kubicz 1971). It seems, however, that these factors exerted a larger influence due to an earlier disturbing of relatively large parts of limestones by the burrowers that several times settled the sea floor.

After the sedimentation of the lower part of the Karchowice Beds, a distinct tendency is recorded to a more shallow-water environment with a high energy of water reflected in the formation of many diagonally stratified detrital, mostly crinoid (Pl. 15) limestones. Also formed are biohermal structures containing corals and other organisms (Pl. 16, Figs 2—3).

Markedly shallow-water deposits are once again formed on the boundary of the Lower and Middle Muschelkalk. Limestones with diplopores and onkolites seem to be replaced sometimes by oolitic limestones (*cf.* Bilan & Golonka 1972). Microfacies types, distinguishable in these deposits are relatively variable, and their granular components (diplopores, solenopores, foraminifers, gastropods, trochites, brachiopod debris, onkolites, lumps, ooids, intraclasts) form various numerical proportions and many structural varieties (Pl. 24, Figs 1—2; Pl. 25—29; Pl. 34, Figs 1, 5, 7—10).

The dolomitic character of the Middle Muschelkalk is indicative of a small increase in the salinity of the basin, since most dolomites are here syngenetic. Contrary to Germany and western and northern regions of Poland, the Opole Silesia area lacks hypersalinary facies. Breccia-like, locally oolitic dolomites, displaying characteristic structures which strongly resemble the Ladinian Wetterstein Dolomites, occur within the range of the Middle Muschelkalk of Silesia (*cf.* Pl. 28, Fig. 1; Pl. 29, Fig. 1). The sequences of deposits in the Wettersteinkalk Formation are similar, that is, they contain dolointramicrudites with dolomite intercalations and limestones of various types (including onkolitic ones). The formation of breccia-like structures is connected (German 1969) with the destruction of dolomite layers, formed as a result of an early lithification and dolomitization occurring in the supratidal zone. The appearance of calcareous deposits, containing fauna, in the lowermost members of the Upper Muschelkalk (*i.e.* the Tarnowice Beds — *cf.* Pl. 33, Fig. 2) is indicative of more open-sea conditions.

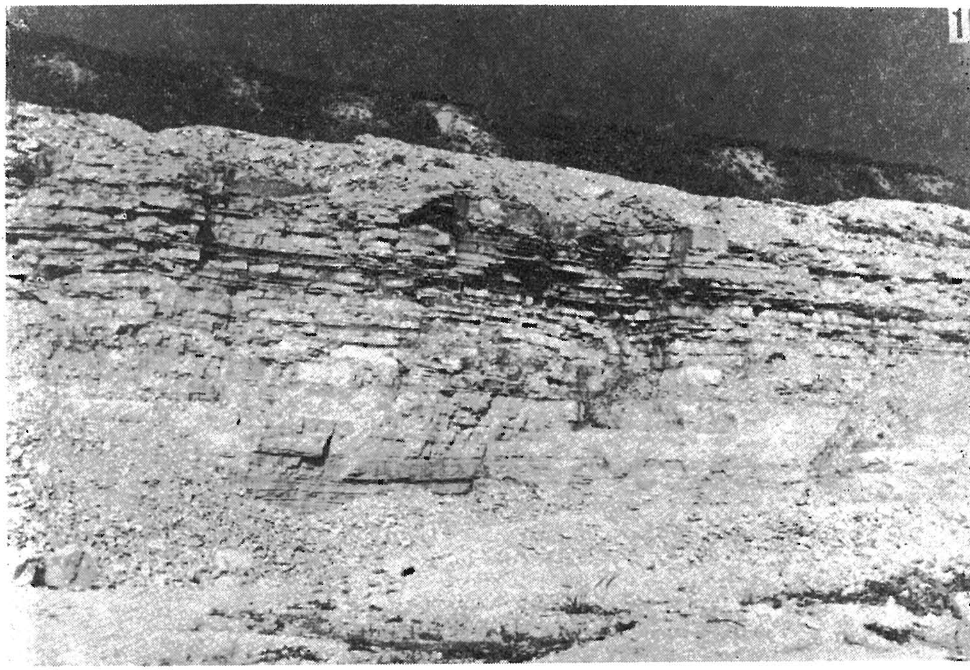
The Wilkowice Beds, the richest in macrofauna of all Muschelkalk members, contain horizons, in which structures are observed resulting from an early subaqueous lithification of deposits (*cf.* Friedmann 1964; Shinn 1969) resulting in the formation of a hardground. It is also likely that here occurs a considerable slowing-down of sedimentation rate and, consequently, the formation of deposits which display the characters of condensation (*cf.* Pls 29—32, Pl. 33, Fig. 3). Some microfacies types related with these horizons are identical with those found in a band of bone-breccia occurring in Germany at the boundary of the Muschelkalk and Keuper (Reif 1971, *cf.* also Pl. 29, Figs 2—3). The tendency to condensation seems to persist during the sedimentation of the whole Wilkowice Beds, the biochronostratigraphic units of which (*e.g.* conodont zone "*3*") are considerably thinner than the isochronous units in Germany. Particularly distinct characters of a condensed deposits are displayed by a conglomerate horizon of the Wilkowice Beds (Assmann 1944; Kubicz 1970b), having an extensive regional importance and known in a similar stratigraphic position in the Holy Cross Mts (Rek 1970; Trammer 1975).

The Boruszowice Beds make up deposits undoubtedly shallow-water in character, formed in a basin with a slightly raised salinity and to which relatively large amounts of terrigenic material were transported (*cf.* Pl. 33, Figs 1, 4). This material is decidedly predominant in the overlying "*Lettenkohle*" series of the Keuper. The enrichment in fish remains and flora detritus is characteristic of the Boruszowice Beds and lower parts of the "*Lettenkohle*". In addition, there occur sponge spicules, conodonts, scolecodonts and numerous arm hooks of cephalopods (*cf.* Zawidzka 1974b).

The "*Lettenkohle*" deposits were formed, therefore, still in a marine basin near shoreline (*cf.* Kozur 1972d). Considering the environmental requirements of marine organisms (polychaetes), occurring in the "*Lettenkohle*", the salinity of the basin may be termed as brachy- or pliohaline (*cf.* Hiltermann 1963, Kozur 1972d).

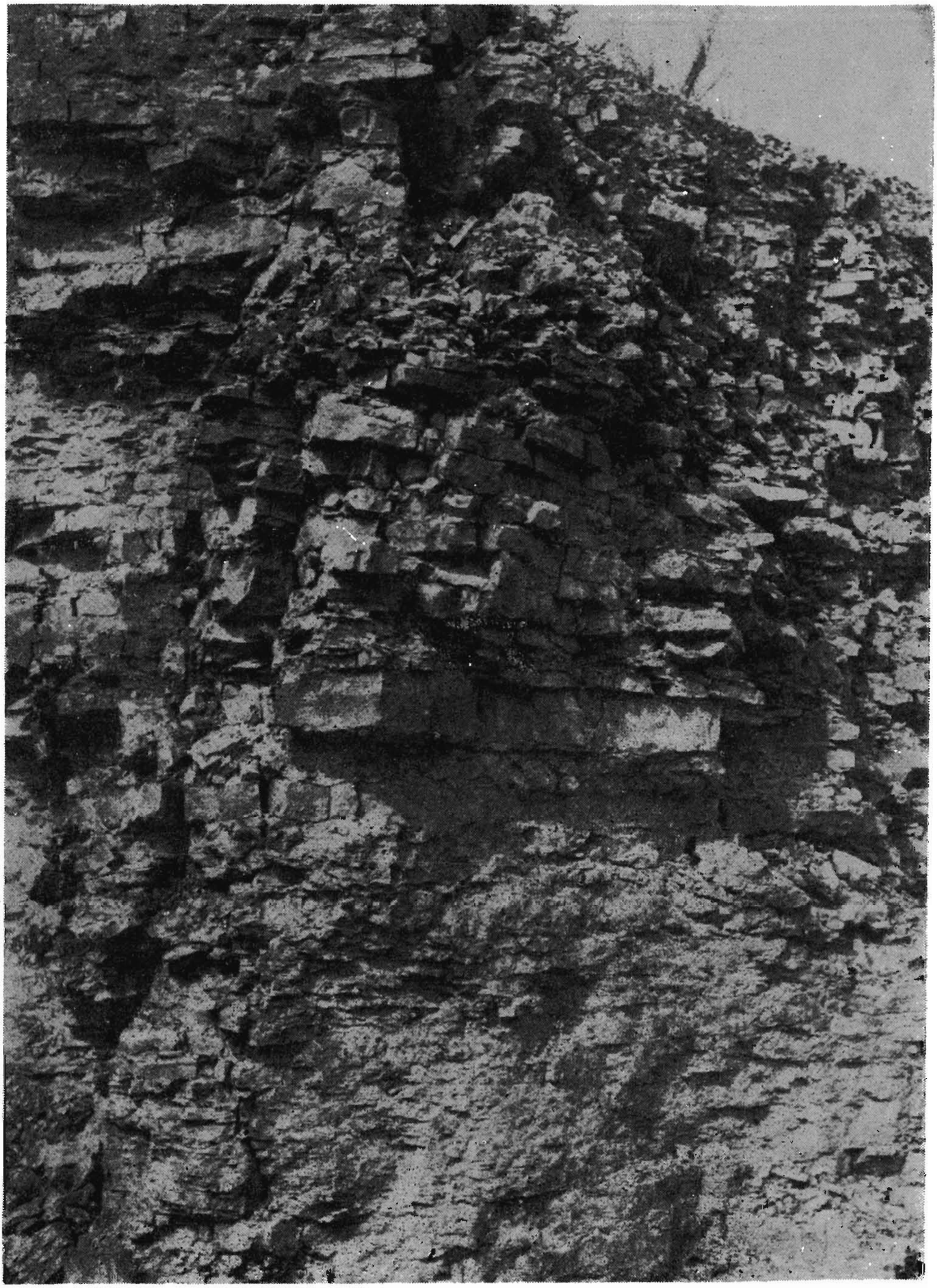
STRATIGRAPHY

The first works on the stratigraphy of the Silesian Triassic were published in the 1860's (Eck 1865; Romer 1870). The Muschelkalk was then divided into the following three lithostratigraphic units: the Lower, Middle and Upper Muschelkalk, all of which were also subdivided into smaller lithostratigraphic units. As studies became more and more extensive, the lithostratigraphic schema of the Muschelkalk was a subject to modifications (Michael 1904; Ahlburg 1906; Wysogórski 1904; Bohdanowicz 1907; Różycki 1924). At present, the lithostratigraphic schema is used which was founded in 1944 by Assmann (*cf.* Siedlecki 1949, 1951, 1953, 1964; Bojkowski 1955; Gruszczyk 1956; Senkowiczowa 1959, 1962; Kłapciński 1959; Pastwa-Leszczyńska & Śliwiński 1960; Senkowiczowa & Szyperko-Śliwczyńska 1961; Śliwiński 1964; Gajewska 1964; Tokarski 1965, 1969; Alexandrowicz 1966; Popiel 1967; Kotlicki 1973, 1975).

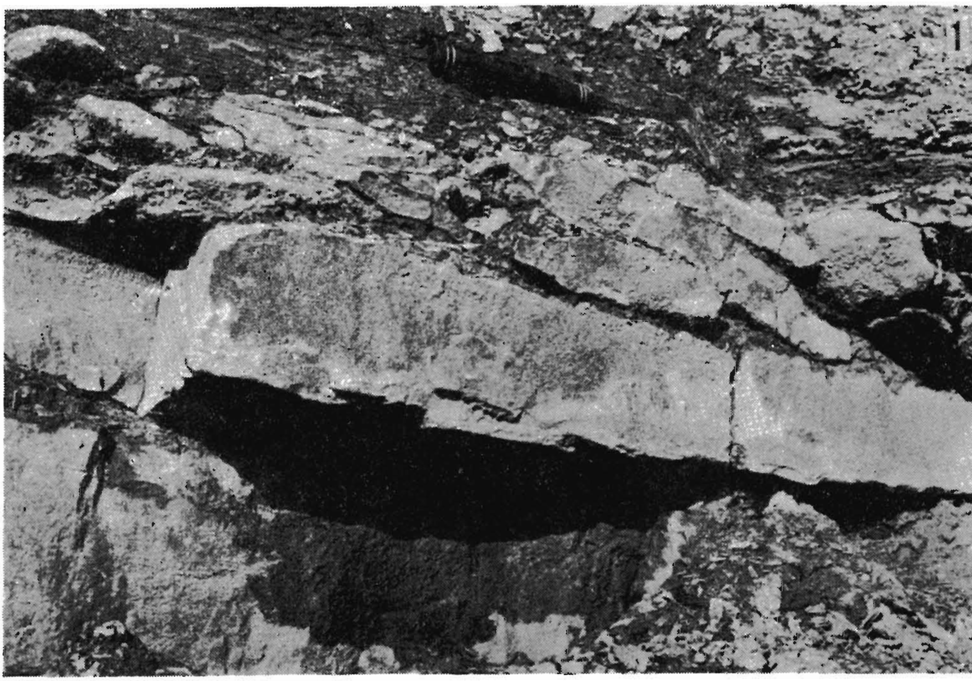


1 — Typical sequence of the Gogolin Beds at Gogolin (Lower Anisian): intrasparudites, pelitic and marly limestones, biocalcarenites with trochites, pelecypod and ostracode detritus.

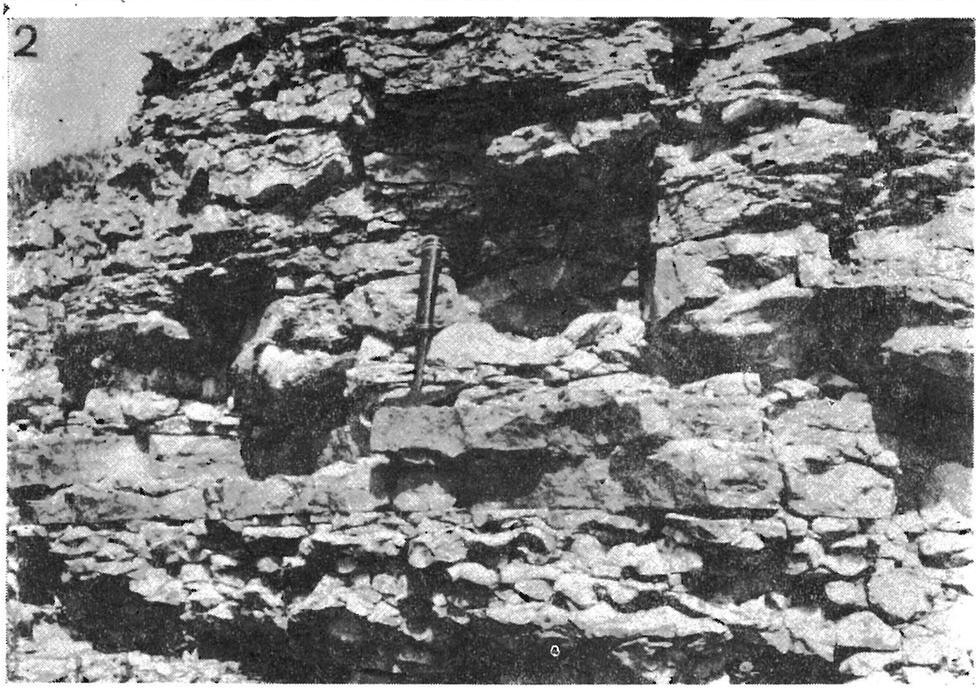
2 — Upper part of the Gogolin Beds at Górażdże (Lower Anisian/Pelsonian junction), with abundant conodonts and scolecodonts: biosparites (thicker layers) and intrabiosparites, pelitic and marly limestones.



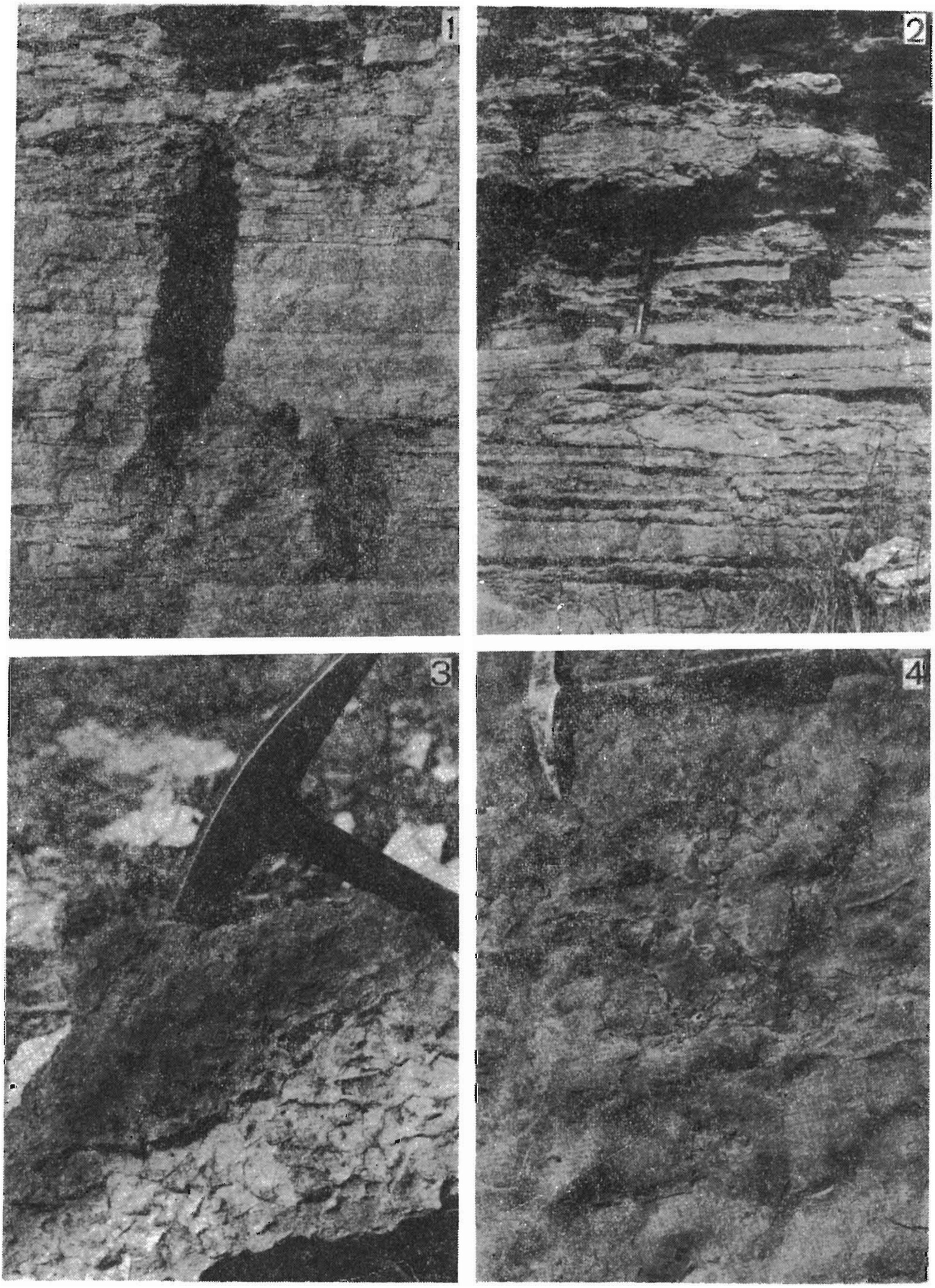
The Gogolin Beds at Malnia (Lower Anisian): development the same as that presented in Pl. 1, Fig. 2



1-2 — Horizon with conglomerates (intrasparudites) and marls in the lower part of the Gogolin Beds at Gogolin (Lower Anisian)



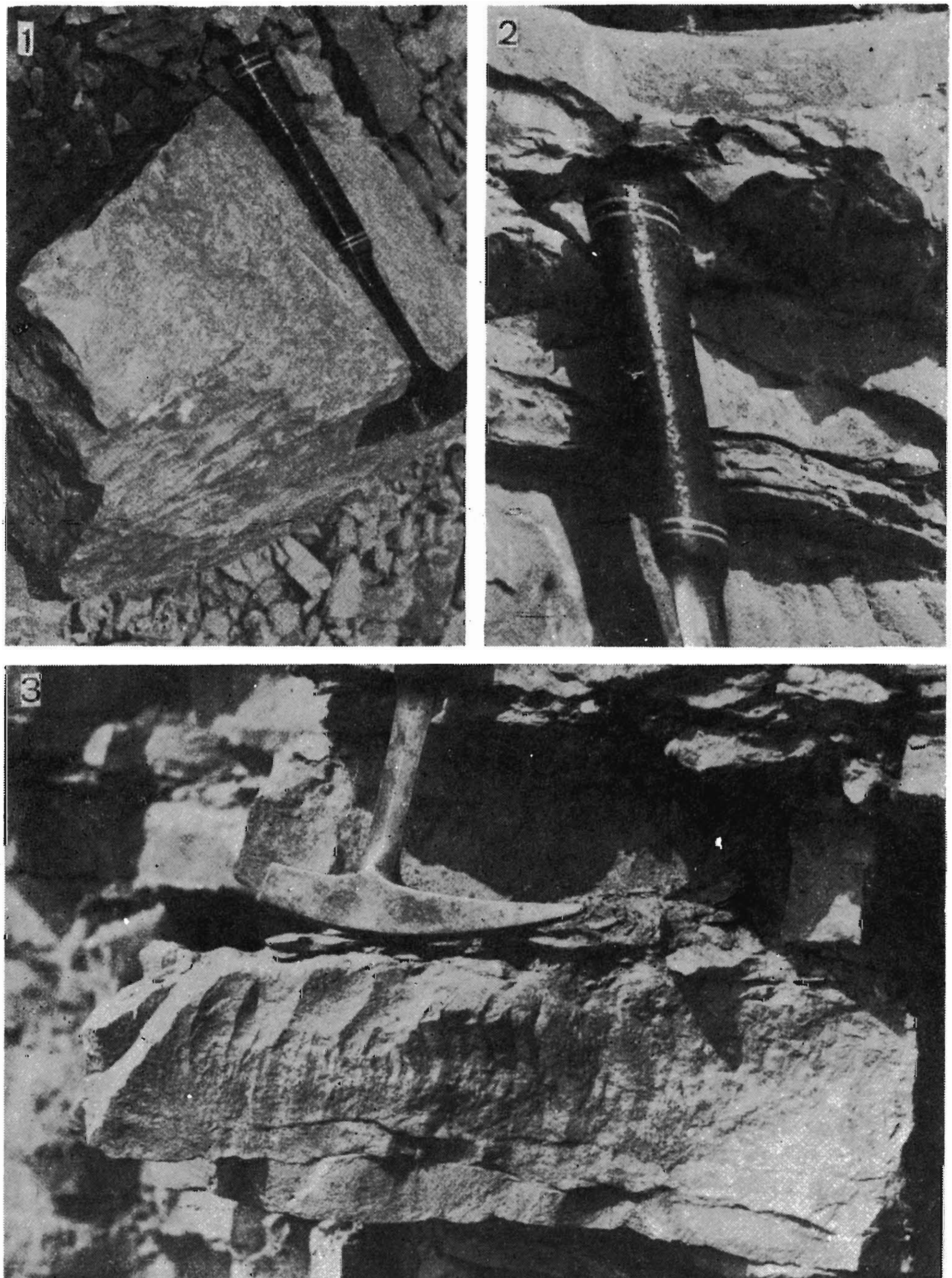
1-2 — Crumpled limestones and the *Flaser*-type bedding in biocalcarenites and marly limestones in the upper part of the Gogolin Beds at Malnia (Lower Anisian)



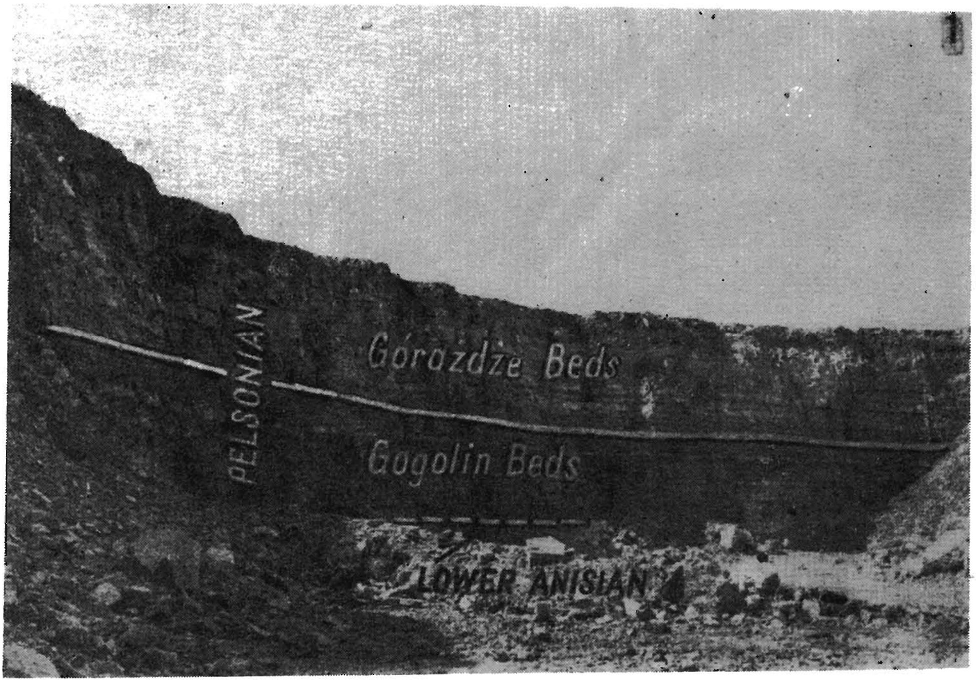
1-2 — Platy limestones (biocalcarenites, pelitic and marly limestones) with bedding of the *Flaser* and lenticular type; conglomerate horizon at the top; Gogolin Beds at Gogolin (Lower Anisian).

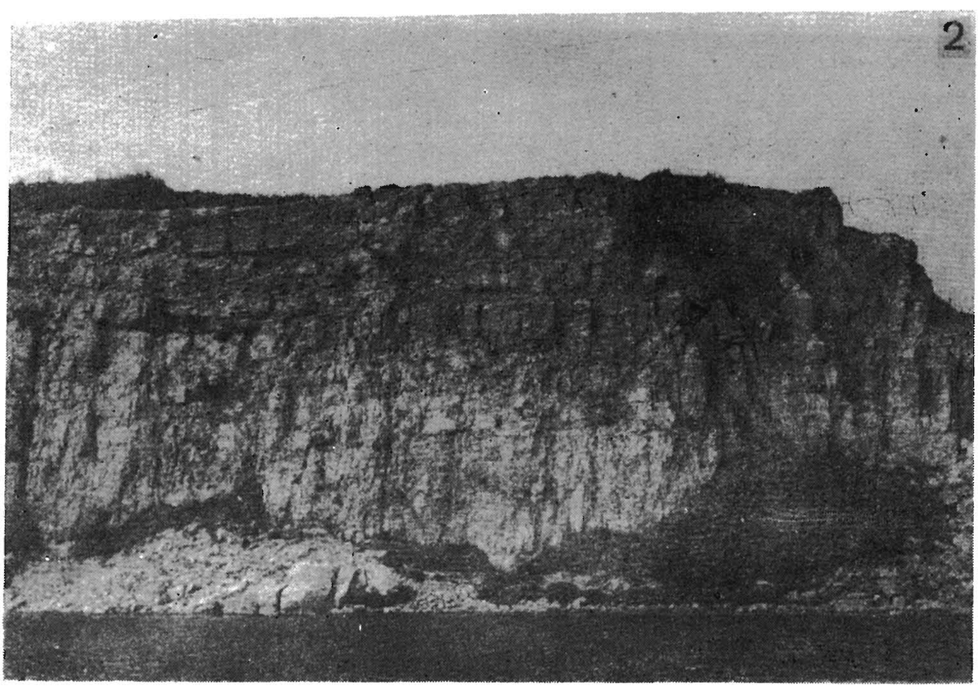
3 — "Cellular" limestone in the lower part of the Gogolin Beds at Emilówka (Lower Anisian).

4 — Top surface of marly limestone with organic burrows; upper part of the Gogolin Beds at Górażdże (Lower Anisian).



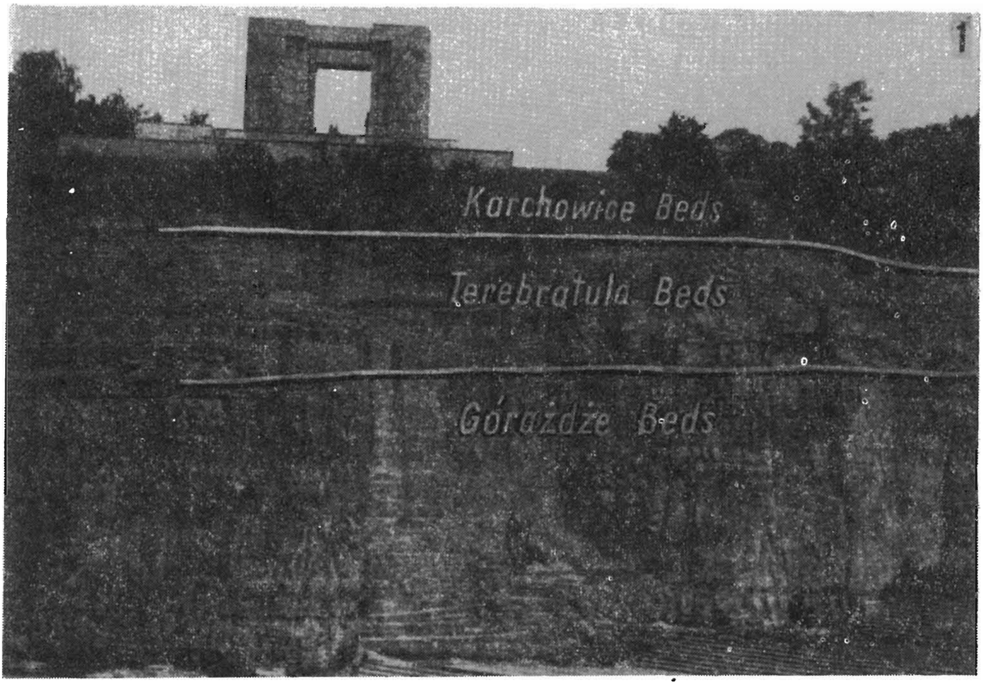
Intraformational breccias (intrabiosparudites) in the lower part of the Gogolin Beds (Lower Anisian) at Emilówka (Figs 2 and 3) and Górażdże (Fig. 1)

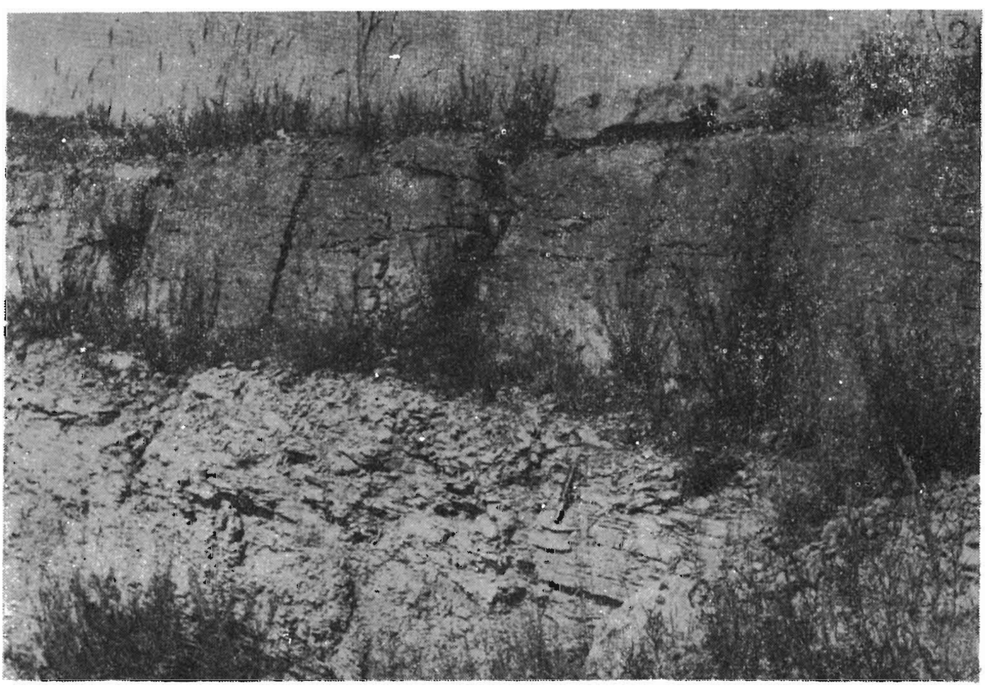




1 — Junction of the Gogolin and Górażdże Beds at Górażdże (Lower Anisian/ /Pelsonian).
2 — Górażdże Beds at Strzelce Opolskie.

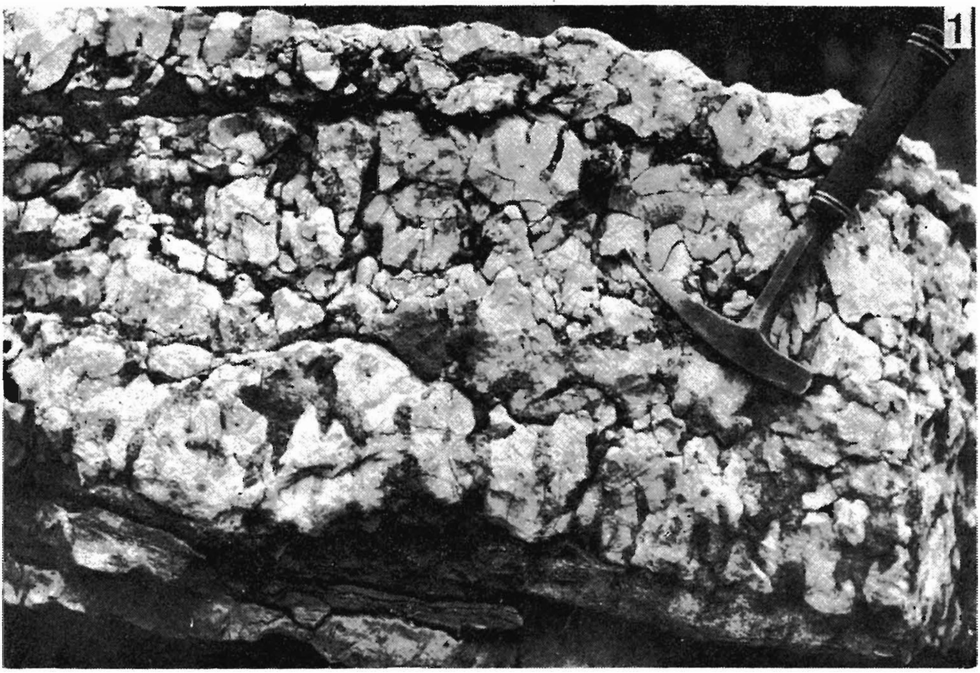
Pelitic limestones with enteropneustan burrows (corrugated surfaces), and onko-biosparites of the Górażdże Beds at Strzelce Opolskie (Pelsonian)



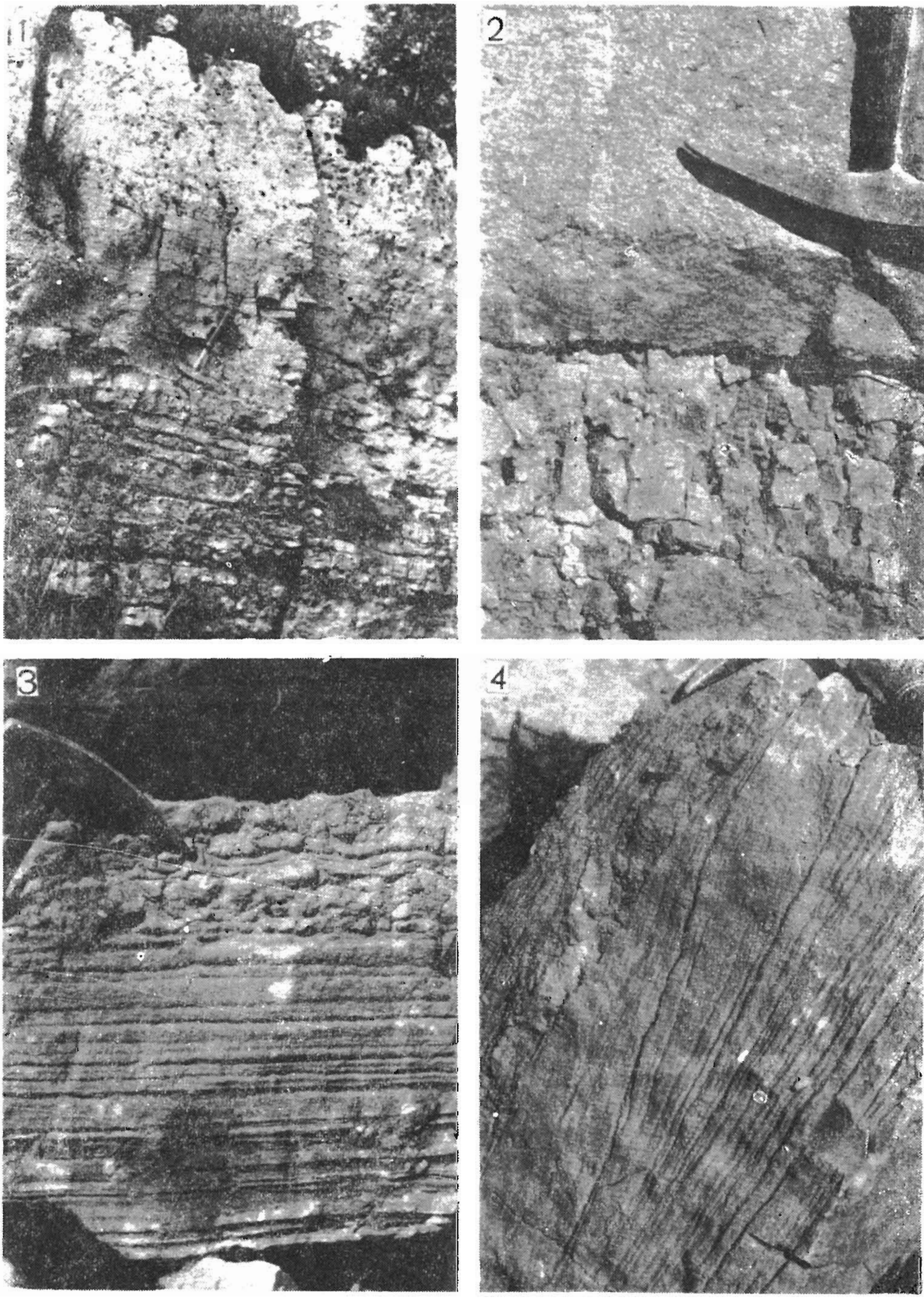


1 — Sequence of the Górażdże, *Terebratula* and Karchowice beds at Mt. Święta Anna (Pelsonian/Illyrian).
2 — Encrinites of the *Terebratula* Beds at Strzelce Opolskie (Pelsonian).

1 — *Arenicolites*-type burrows in calcarenites of the Górażdże Beds at Chorula (Pelsonian).
2 — Structures resulting from instability in density stratification; Górażdże Beds at Chorula (Pelsonian).



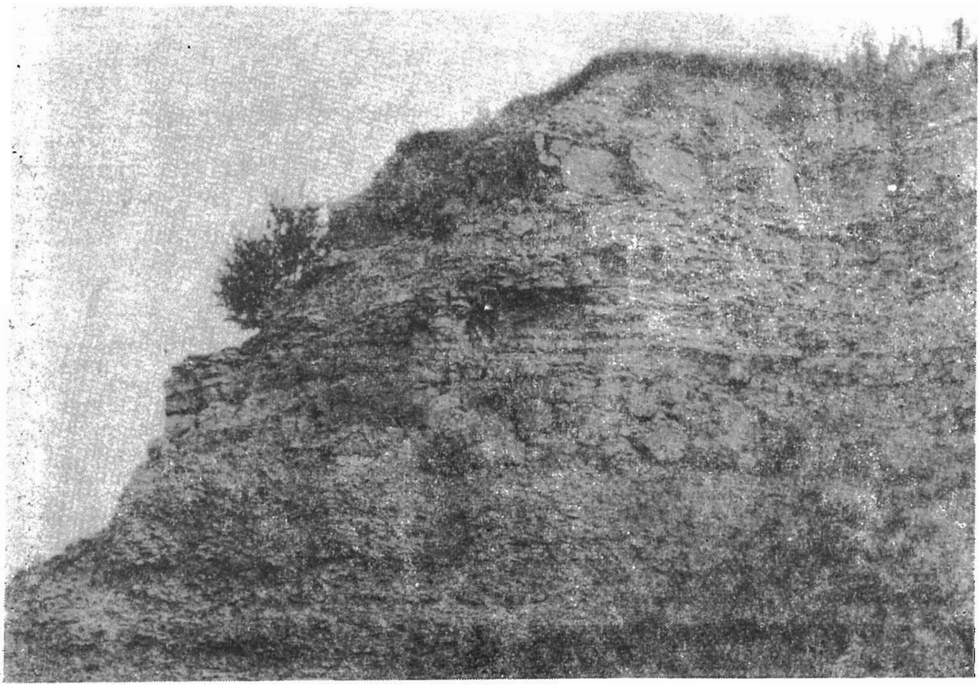
1 — Layer of pelitic limestones with enteropneustan burrows; at topside (bottom in the figure) the burrows are truncated and filled with calcarenite of the overlying layer.
2 — Bottomside of the same layer; Górażdże Beds at Strzelce Opolskie (Pelsonian).

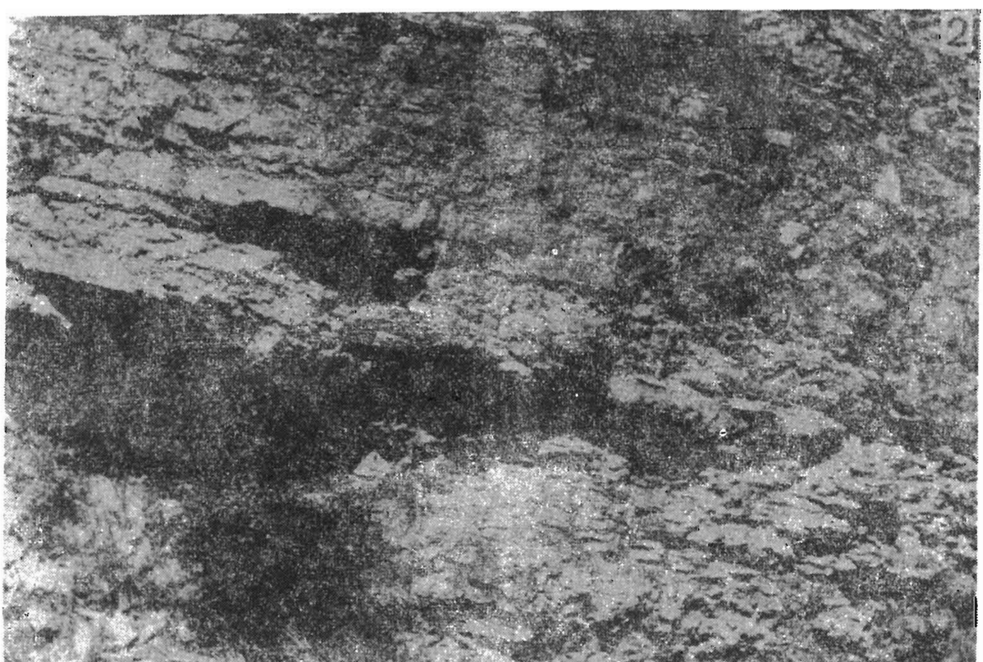


1 — *Terebratula* Beds at Szymiszów (Pelsonian): pelitic limestones and onkobiosparites with enteropneustan burrows.

2 — Pelitic limestones with enteropneustan burrows overlaid by pelletal-onkolitic limestone (enteropneustan burrows deformed by stylolites); Górażdże Beds at Chorula (Pelsonian).

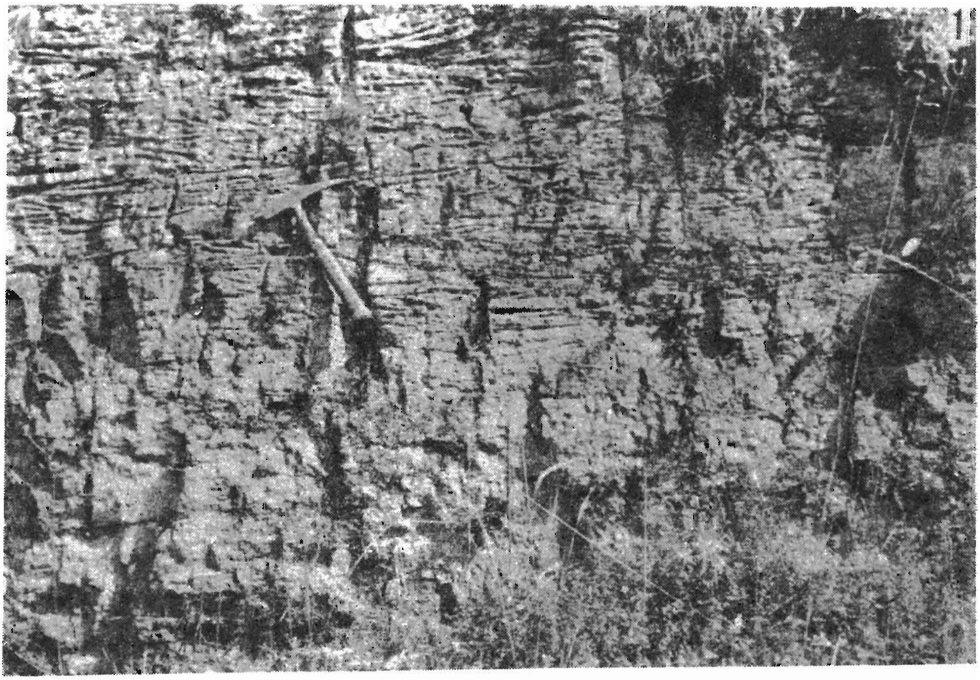
3-4 — Laminated and crumpled pelitic limestones and calcarenites of the Górażdże Beds at Górażdże (Pelsonian).

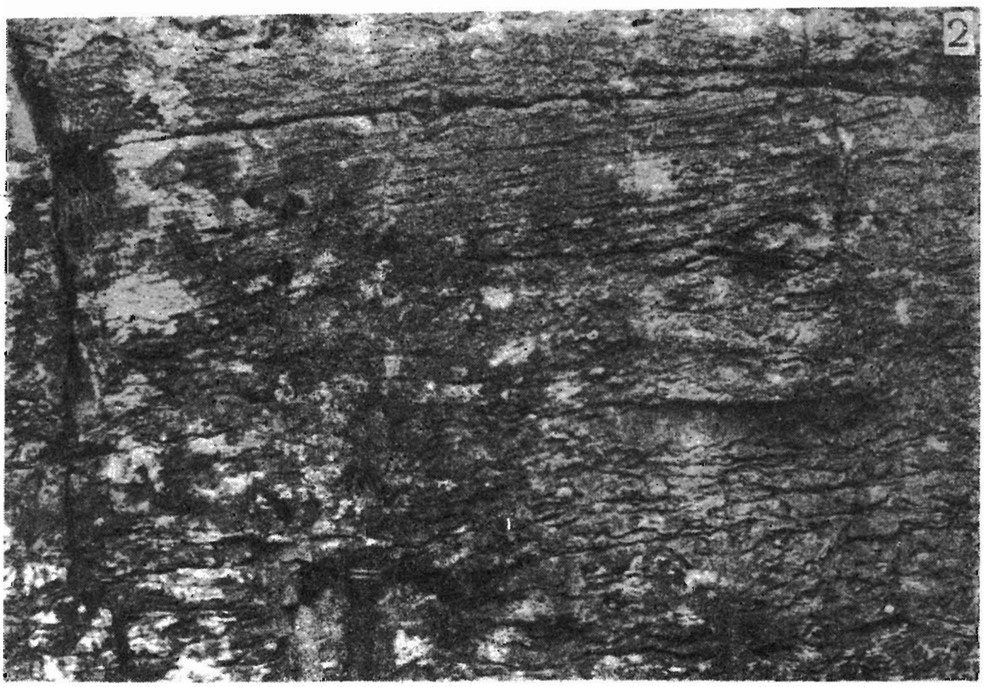




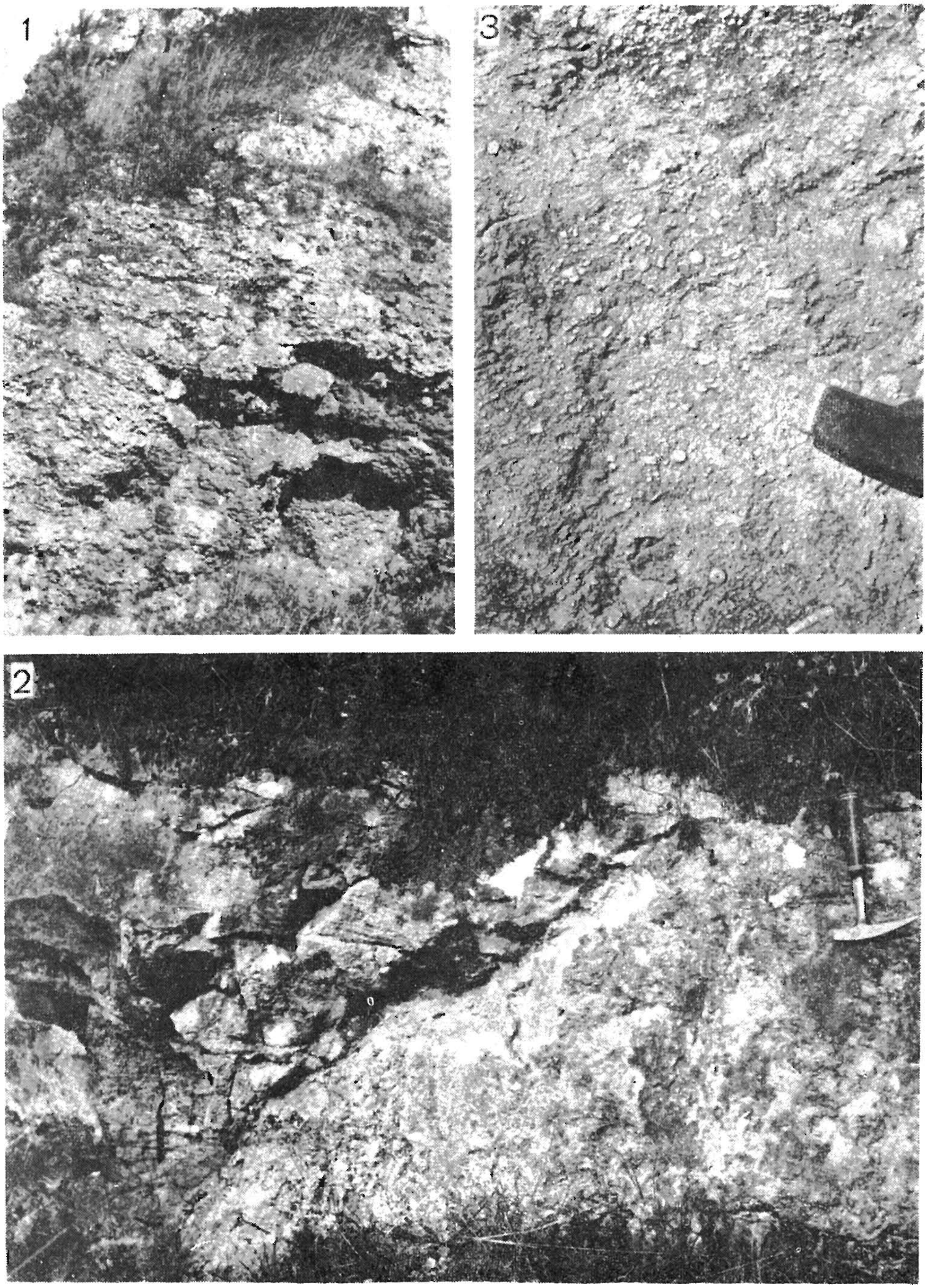
1 — *Terebratula* Beds at Strzelce Opolskie (Pelsonian): lumachelles, biocalcarenites and marly limestones.
2 — Load-casted layers of lumachelles in slightly wavy-bedded limestones of the *Terebratula* Beds at Szymiszów (Pelsonian).

Structures resulting from instability in density stratification; *Terebratula* Beds at Szymiszów (Pelsonian).

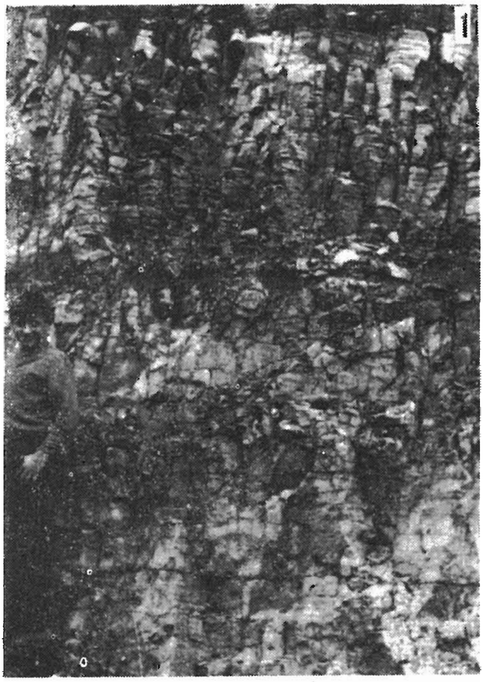


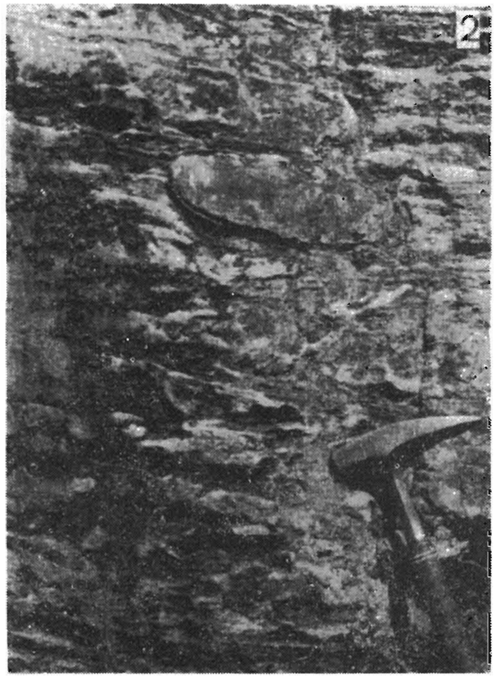


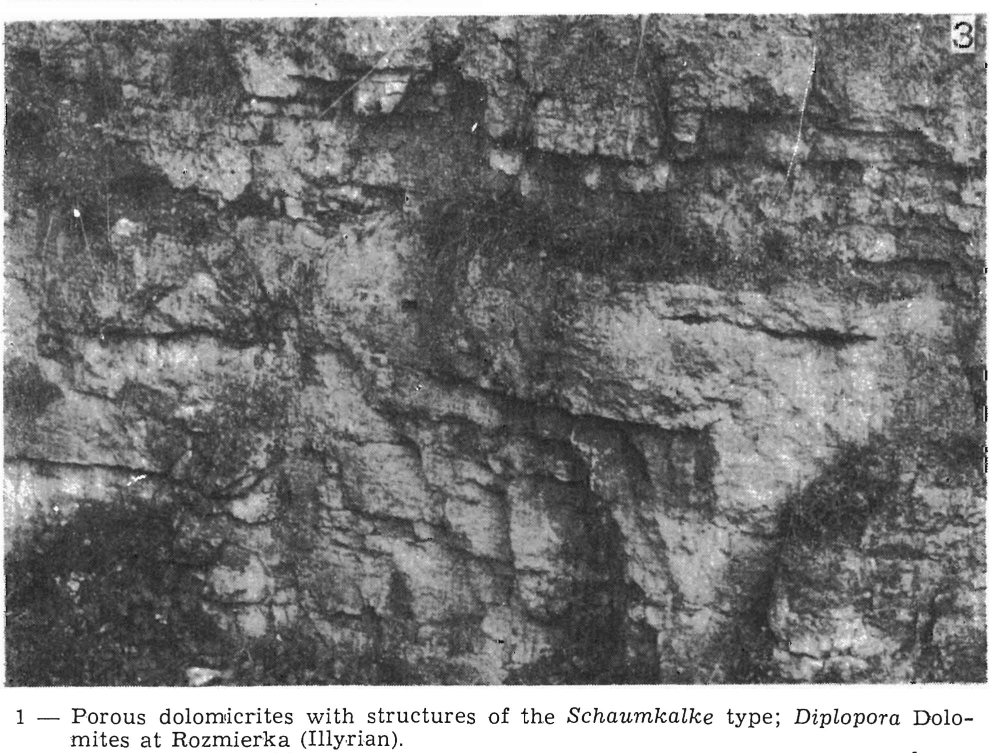
Cross bedding in encrinites of the Karchowice Beds at Kamień Śląski (Illyrian)



1 — Cavernous limestones (recrystallized micritic-sparry limestones or calcarenites) of the Karchowice Beds at Kamień Śląski (Illyrian).
2 — Biohermal structure in the Karchowice Beds at the same locality.
3 — Close-up view of the bioherm: crinoid detritus and corals are visible.





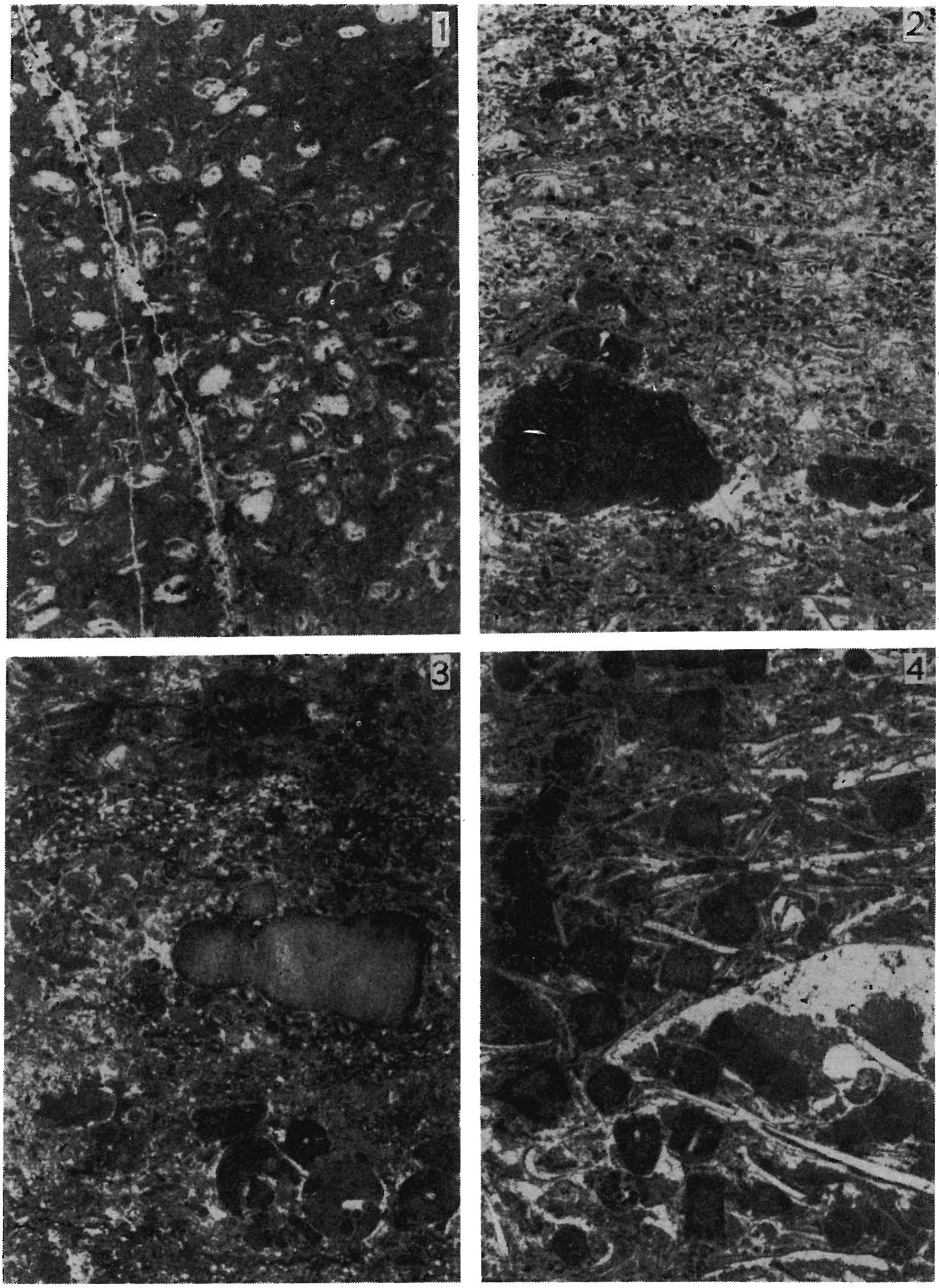


1 — Porous dolomicrites with structures of the *Schaumkalke* type; *Diplopora* Dolomites at Rozmierka (Illyrian).

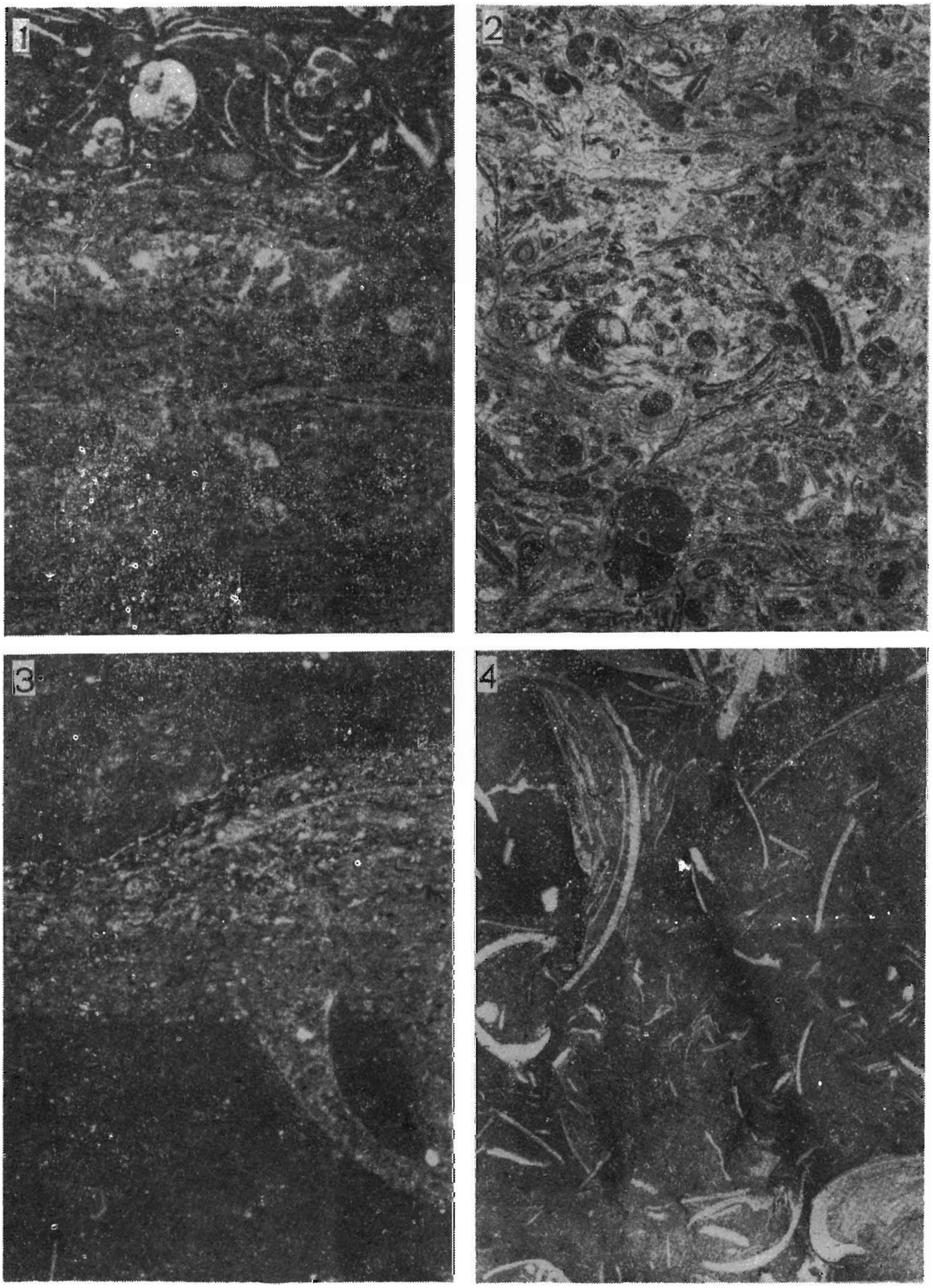
2 — Flint in cross-bedded calcarenites of the Karchowice Beds at Kamień Śląski (Illyrian).

3 — *Diplopora*, oolitic and brecciated dolomites of the stratotype section of the Middle Muschelkalk at Jemielnica (Illyrian).

Tarnowice and Wilkowice beds with hardground and conglomerate horizon (at bottom) at Ligota Samborowa (Illyrian/Fassanian junction)

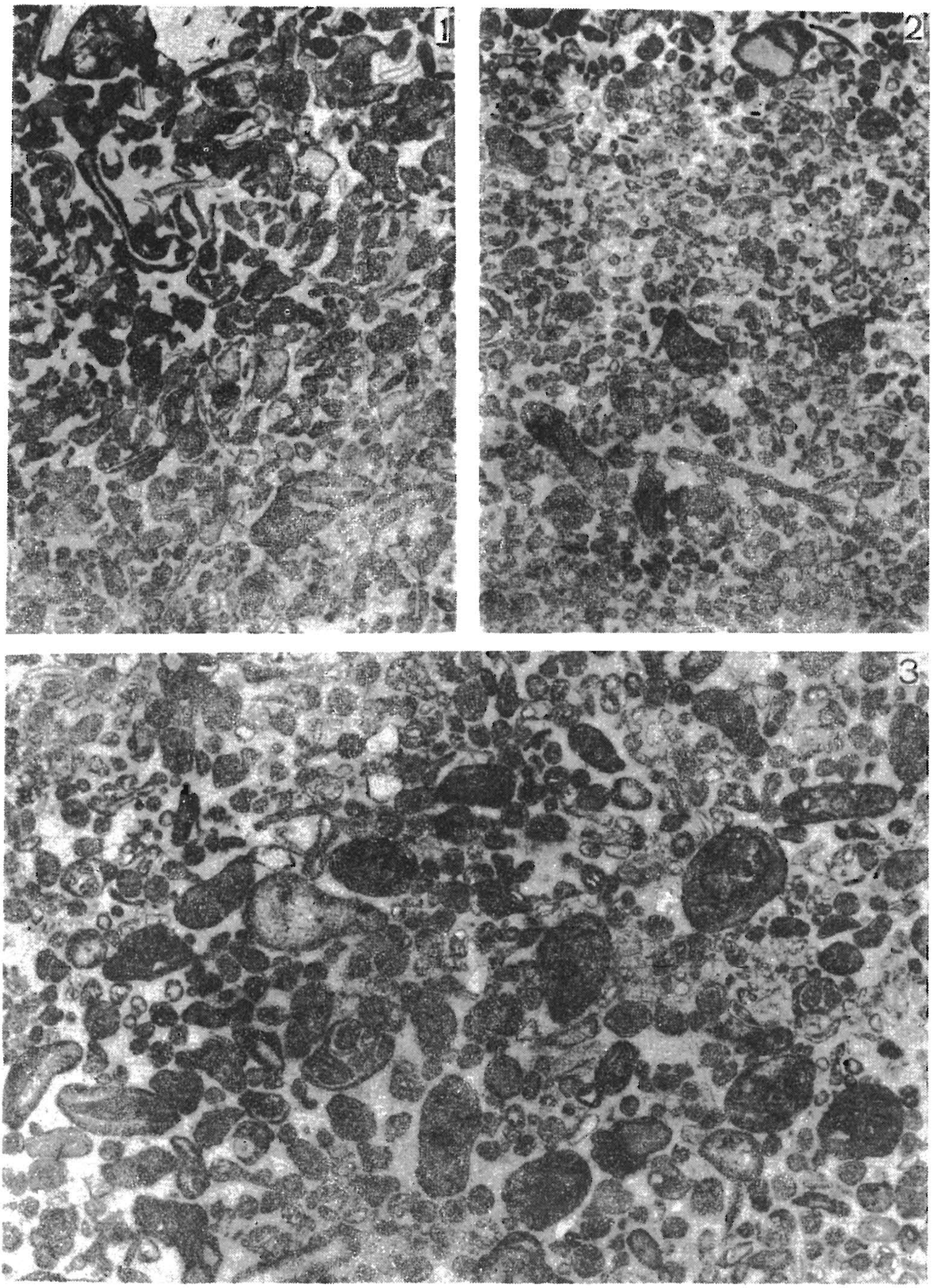


1 — Biomicrite with ostracodes; × 10.
2 — Intrabiomicrite with numerous ostracodes and small gastropods; × 6.
3 — Biomicrite with trochites and small gastropods; × 6.
4 — Biomicrite with trochites and pelecypod detritus; × 10.
All samples from Gogolin Beds at Gogolin (Lower Anisian)

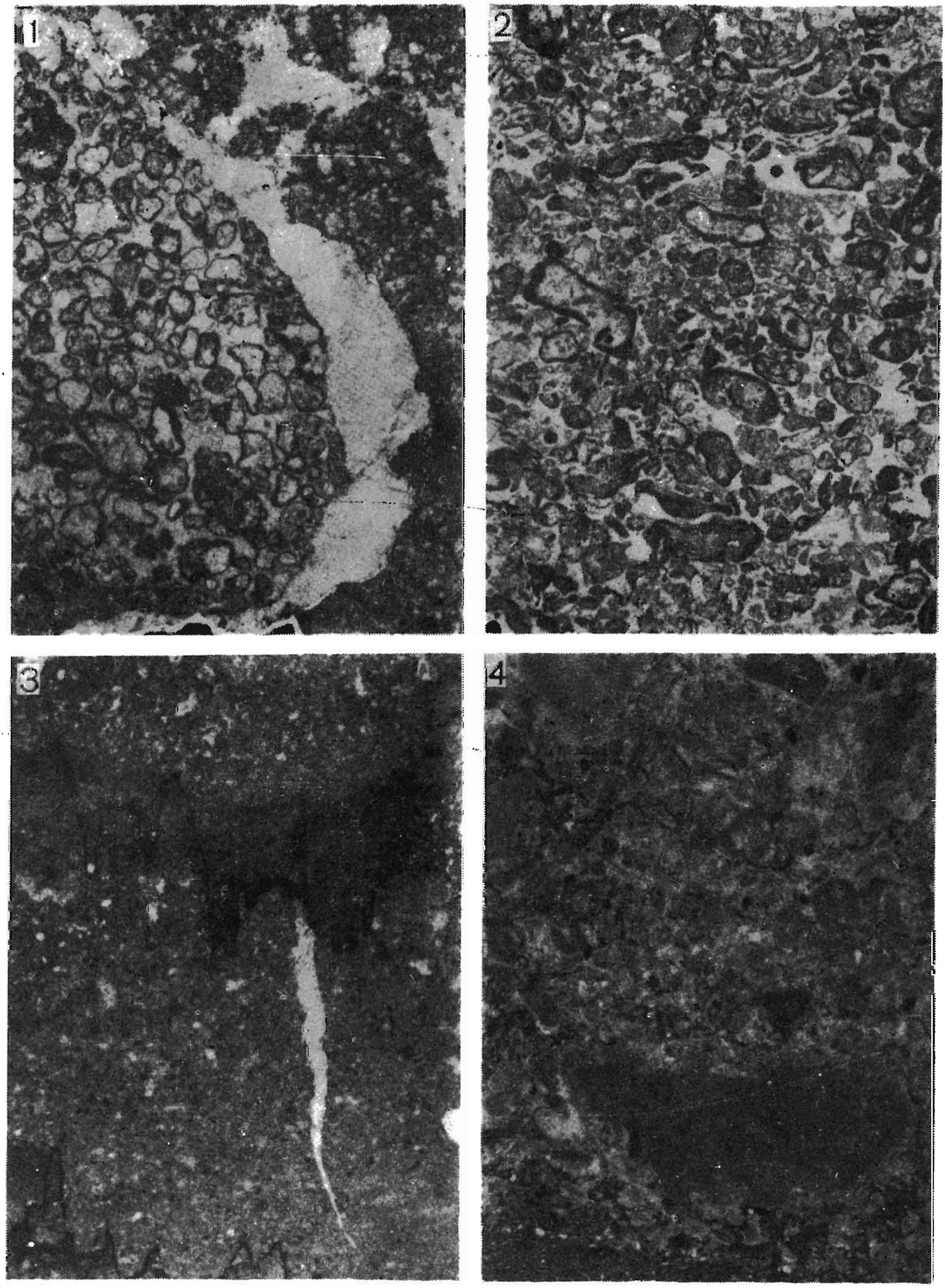


1 — Biomicrite with gastropods and ostracodes; × 10.
2 — Biosparite with gastropods; some bioclasts are coated by *Girvanella* envelopes; × 5.
3 — Biomicrite with ostracodes, cut by an organic burrow; × 10.
4 — Biomicrite with pelecypod detritus; × 5.

All samples from Gogolin Beds at Gogolin (Lower Anisian)

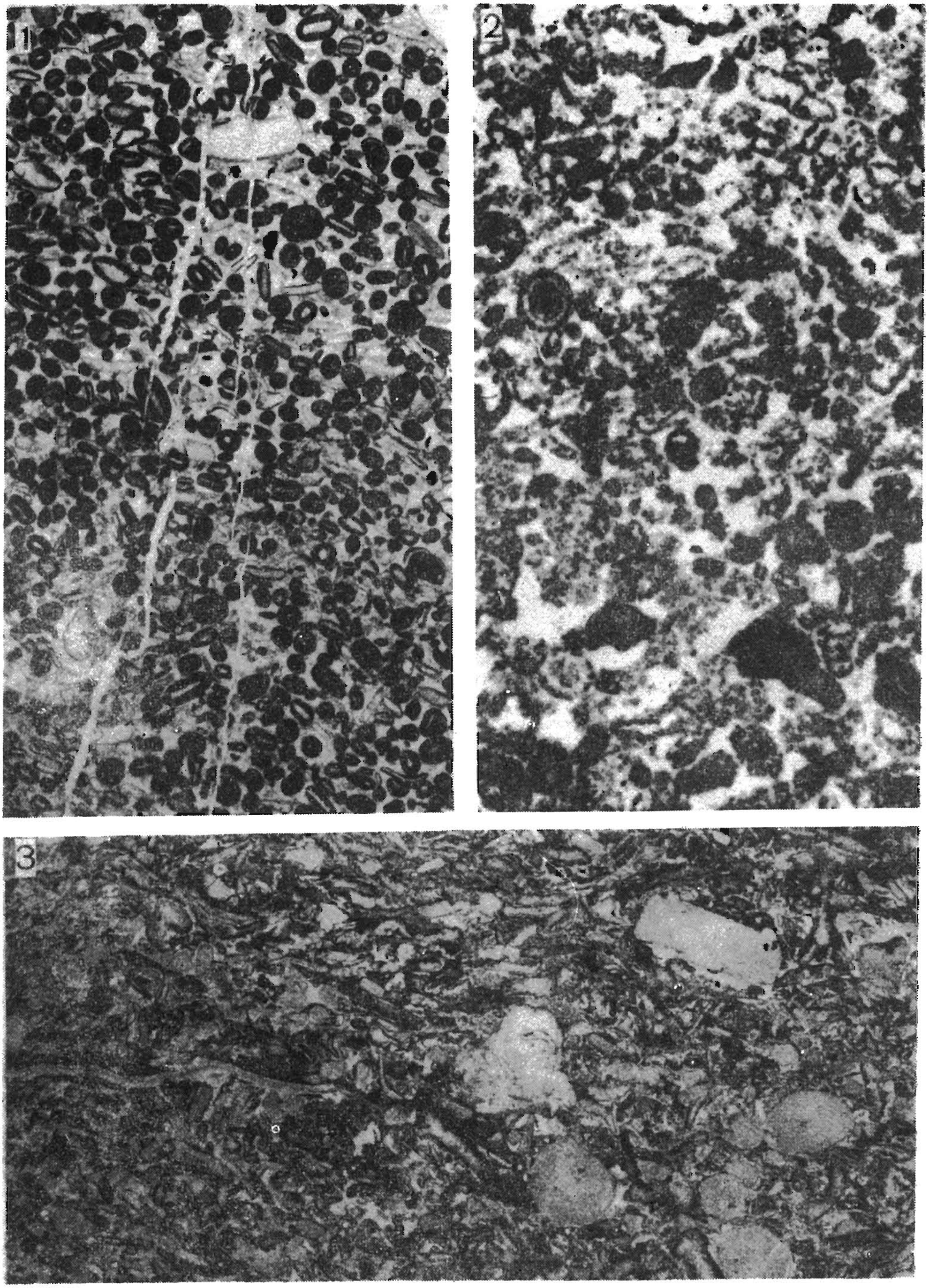


1 — Sparry, lumpy limestone with bioclasts (coated by onkolitic envelopes); × 6.
2 — Onkobiosparite with lumps and foraminifers; × 10.
3 — Sparry, lumpy limestone with numerous foraminifers and bioclasts coated by onkolitic envelopes; × 10.
All samples from Górażdże Beds at Strzelce Opolskie (Pelsonian)

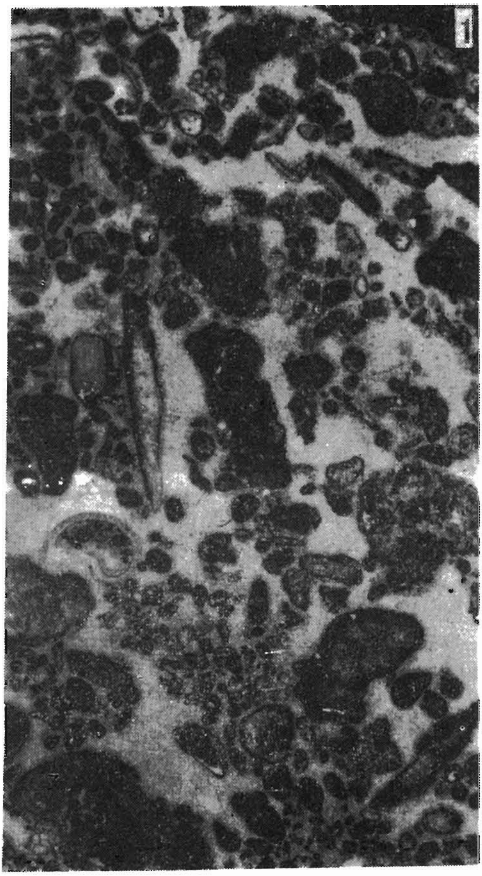


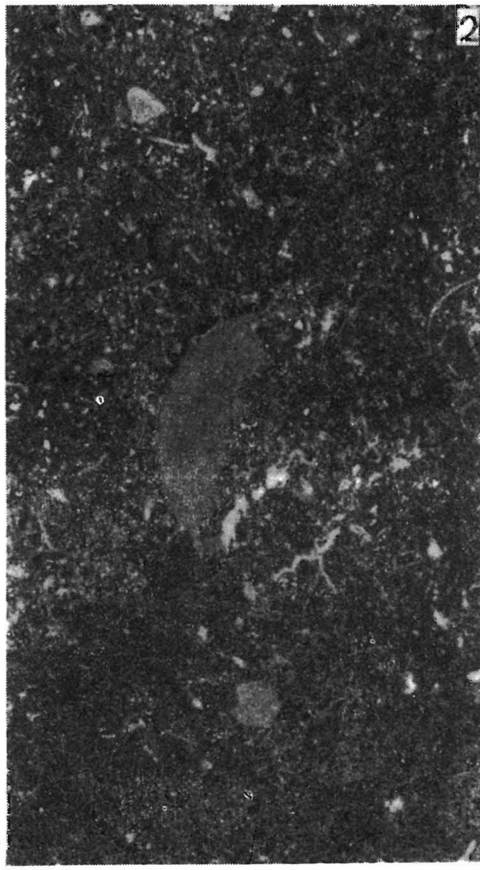
1 — Micritic, partly sparry lumpy limestone of the Góraždže Beds at Strzelce Opolskie (Pelsonian); × 8.
2 — Sparry, lumpy limestone with onkolites (the lumps are also recrystallized) of the Góraždže Beds at Strzelce Opolskie (Pelsonian); × 5.
3 — Micritic limestone with few bioclasts; stylolitic seams enriched in iron compounds are visible; Góraždže Beds at Strzelce Opolskie (Pelsonian); × 8.
4 — Intrabiomicrite with numerous ostracodes and trochites; quartz and muscovite flakes subordinate; Góraždže Beds at Góraždže (Pelsonian); × 10.

1 — Biosparite with *Terebratula* detritus and trochites; most of the bioclasts are coated by onkolitic envelopes; Strzelce Opolskie, × 8.
2 — Biomicrite with *Terebratula* detritus; Strzelce Opolskie, × 6.
3 — Biosparite with *Terebratula* detritus; most of the bioclasts are bored, and coated by onkolitic envelopes and sessile foraminifers *Tolypammina;* Szymiszów, × 8.
All samples from *Terebratula* Beds (Pelsonian)



1 — Oobiosparite; Middle Muschelkalk (Illyrian) at Kamień Śląski, × 8.
2 — Recrystallized, sparry limestone with relics of ooids and lumps; Middle Muschelkalk at Wierchlesie (Illyrian), × 8.
3 — Biomicrite with numerous trochites and *Terebratula* detritus; Karchowice Beds at Wierchlesie (Pelsonian), × 6.

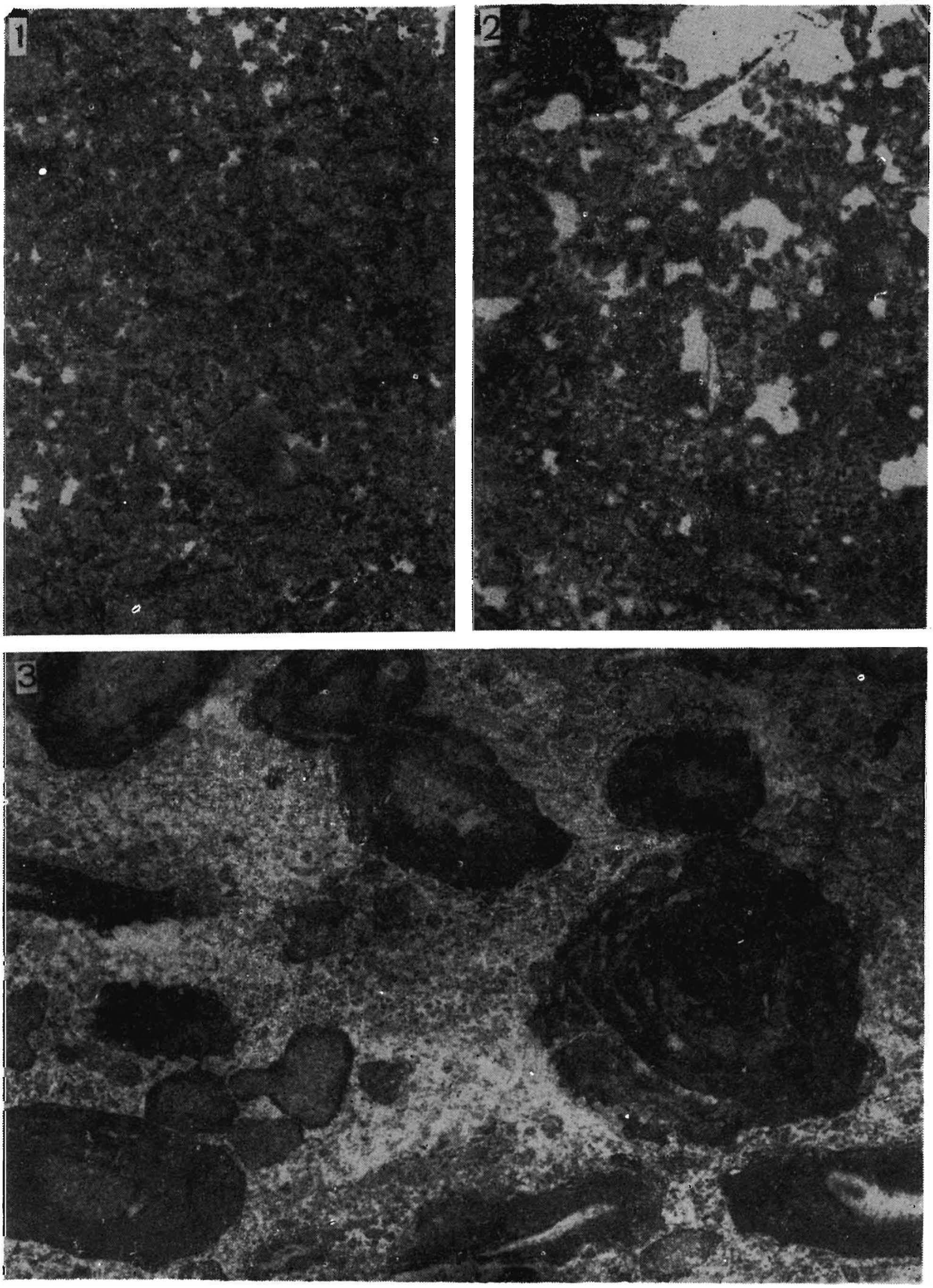




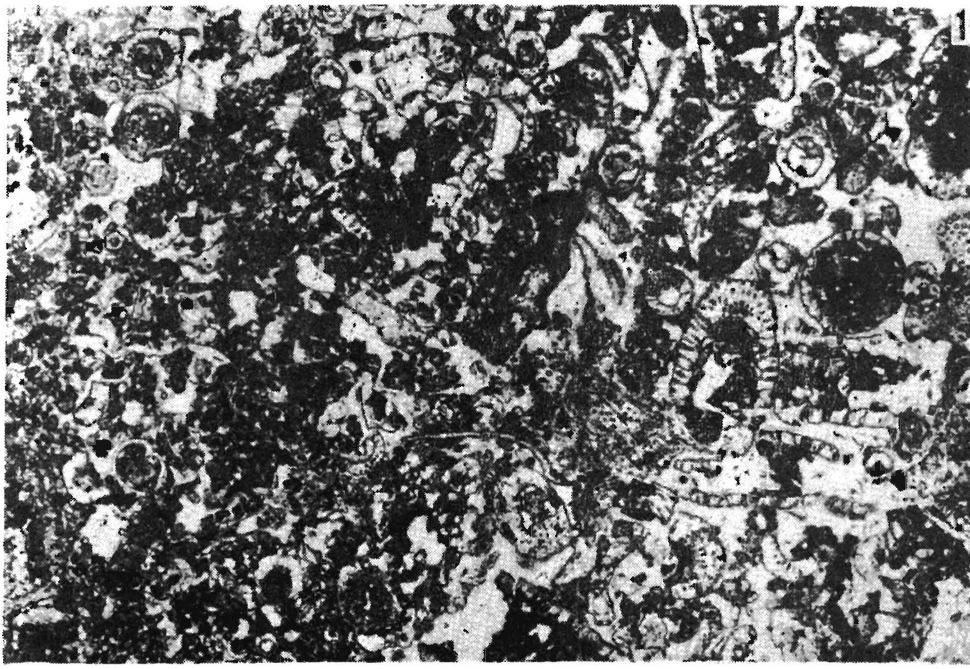
1 — Sparry, lump-onkolitic limestone with numerous bioclasts (i.e. *Solenopora* and *Diplopora*); Middle Muschelkalk at Kamień Śląski (Illyrian), × 5.

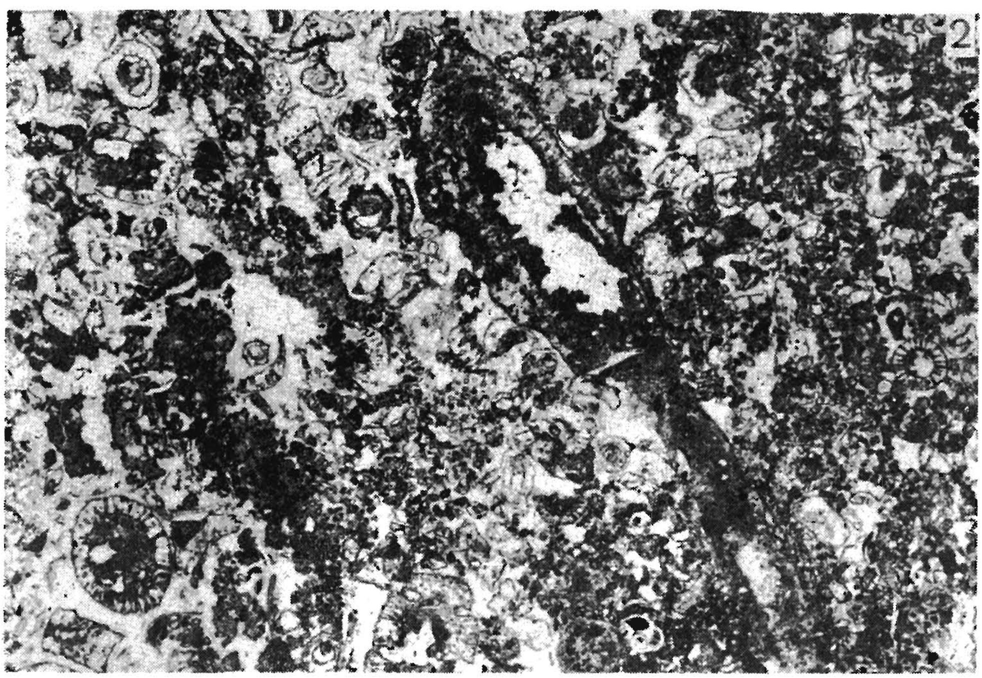
2 — Biomicrite with fine detritus of mollusks, brachiopods, and with trochites and spores *Globochaete alpina* Lombard; Karchowice Beds at Szymiszów (Pelsonian), × 10.

3 — Sparry-micritic skeletal limestone with numerous trochites and *Terebratula* detritus coated by onkolitic envelopes; Karchowice Beds at Wierchlesie, × 7.

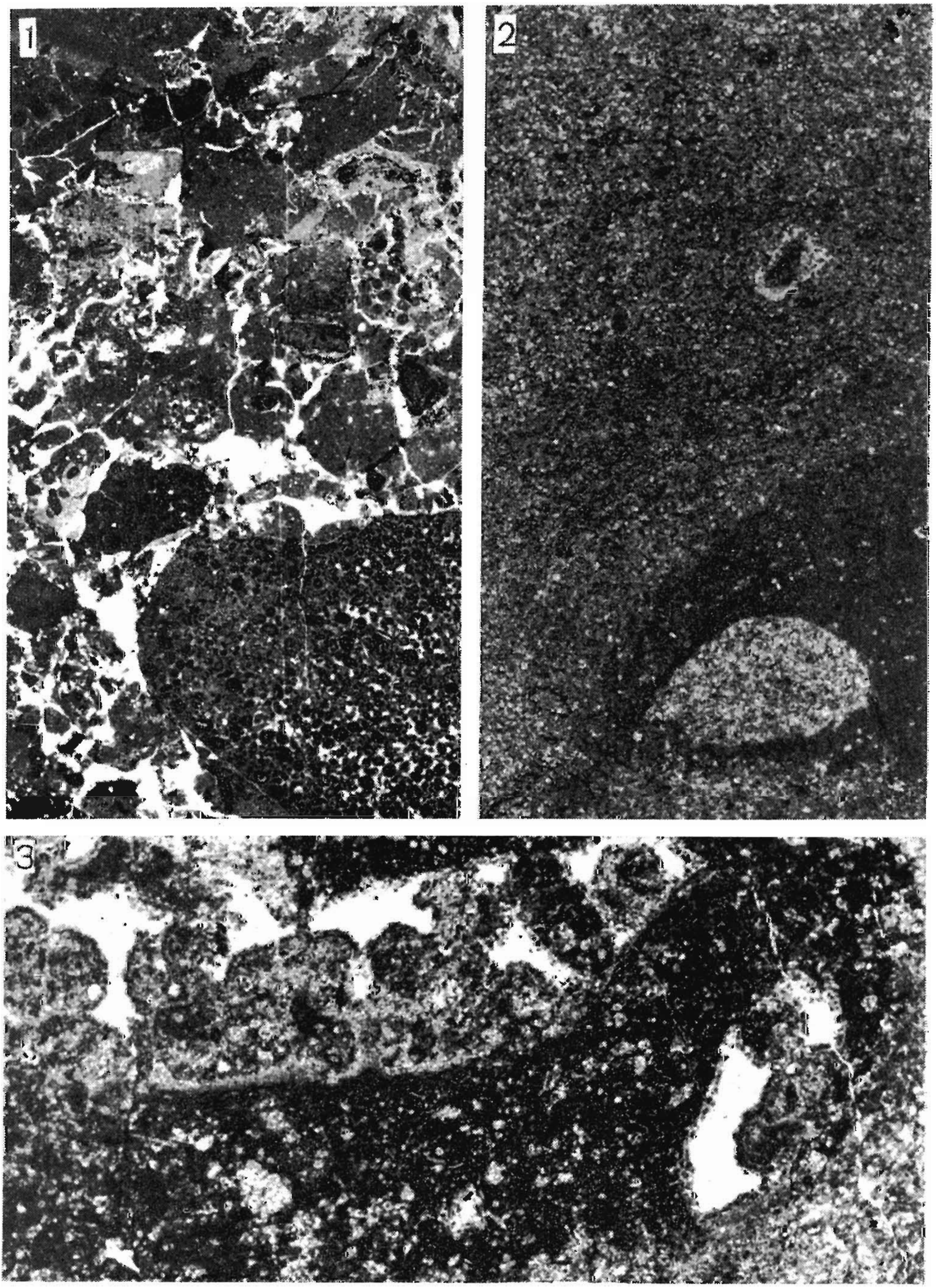


1 — Porous dolomicrite; Middle Muschelkalk at Pietraszów (Illyrian), × 8.
2 — Porous, micritic pelletal limestone, partly recrystallized; Karchowice Beds at Kamień Śląski (Illyrian), × 5.
3 — Sparry, onkolitic-pelletal limestone; pellets occur both in matrix and in onkolites and lumps; Middle Muschelkalk at Wierchlesie (Illyrian) × 7.

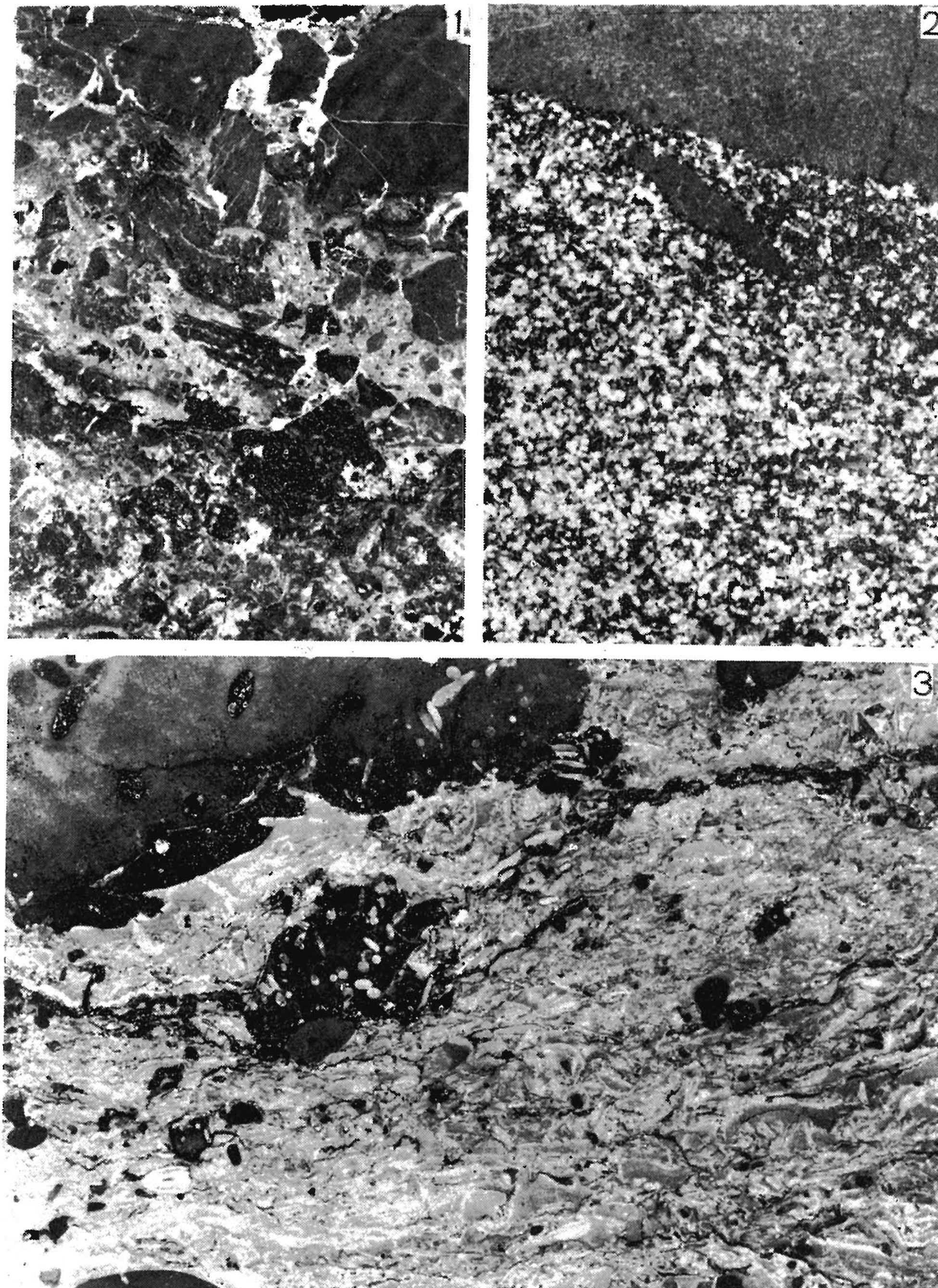




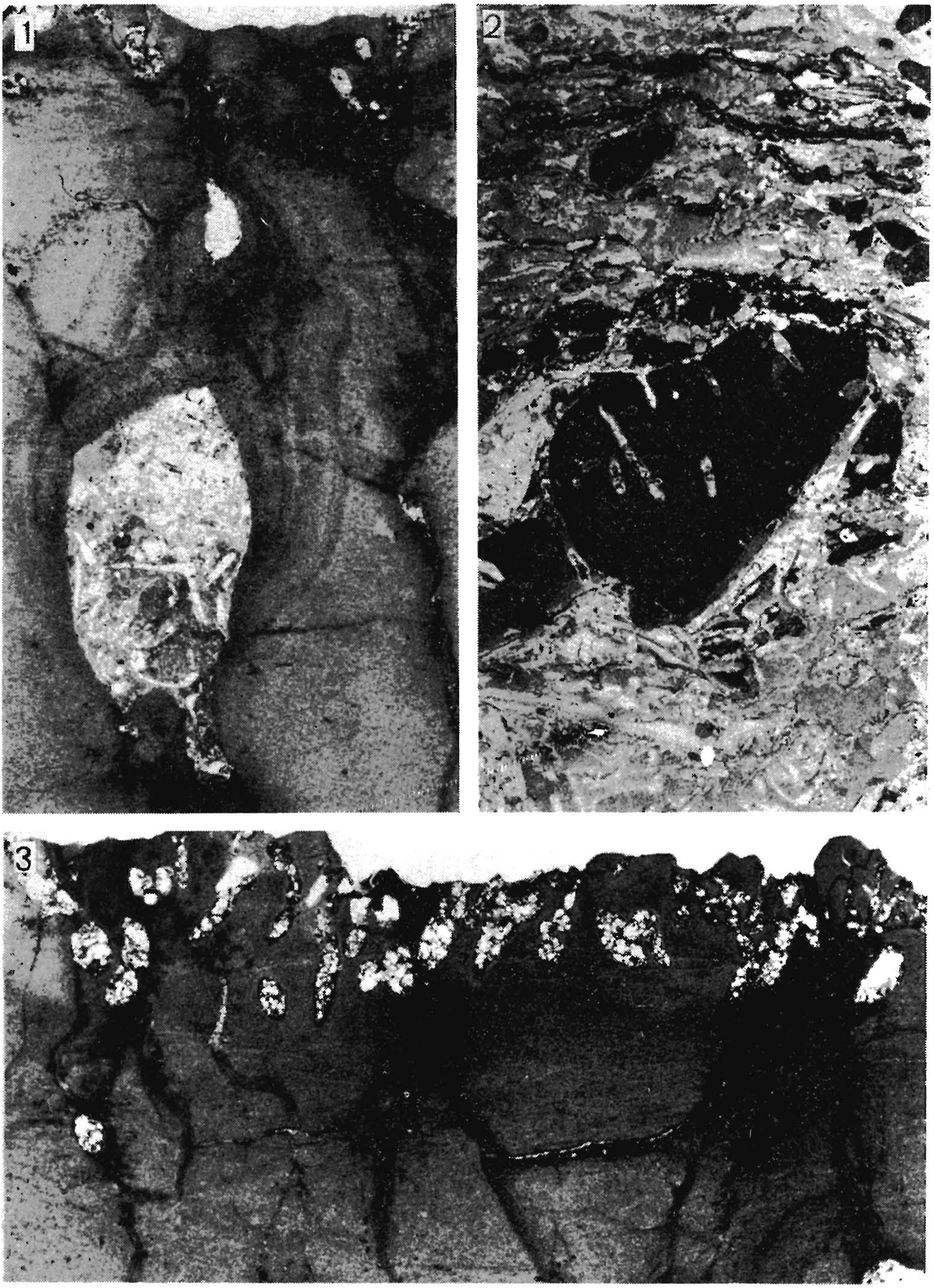
1-2 — Biosparites with *Diplopora* detritus; Middle Muschelkalk at Kamień Śląski (Illyrian), × 7.



1 — Dolointrasparudite (intraclasts composed of oodolomicrite) with ooids; Jemielnica, × 7.
2 — Dolomicrite with a relic of onkolite; Wierchlesie, × 10.
3 — Epigenetic structures in dolomicrite; Wierchlesie, × 10.
All samples from Middle Muschelkalk (Illyrian)

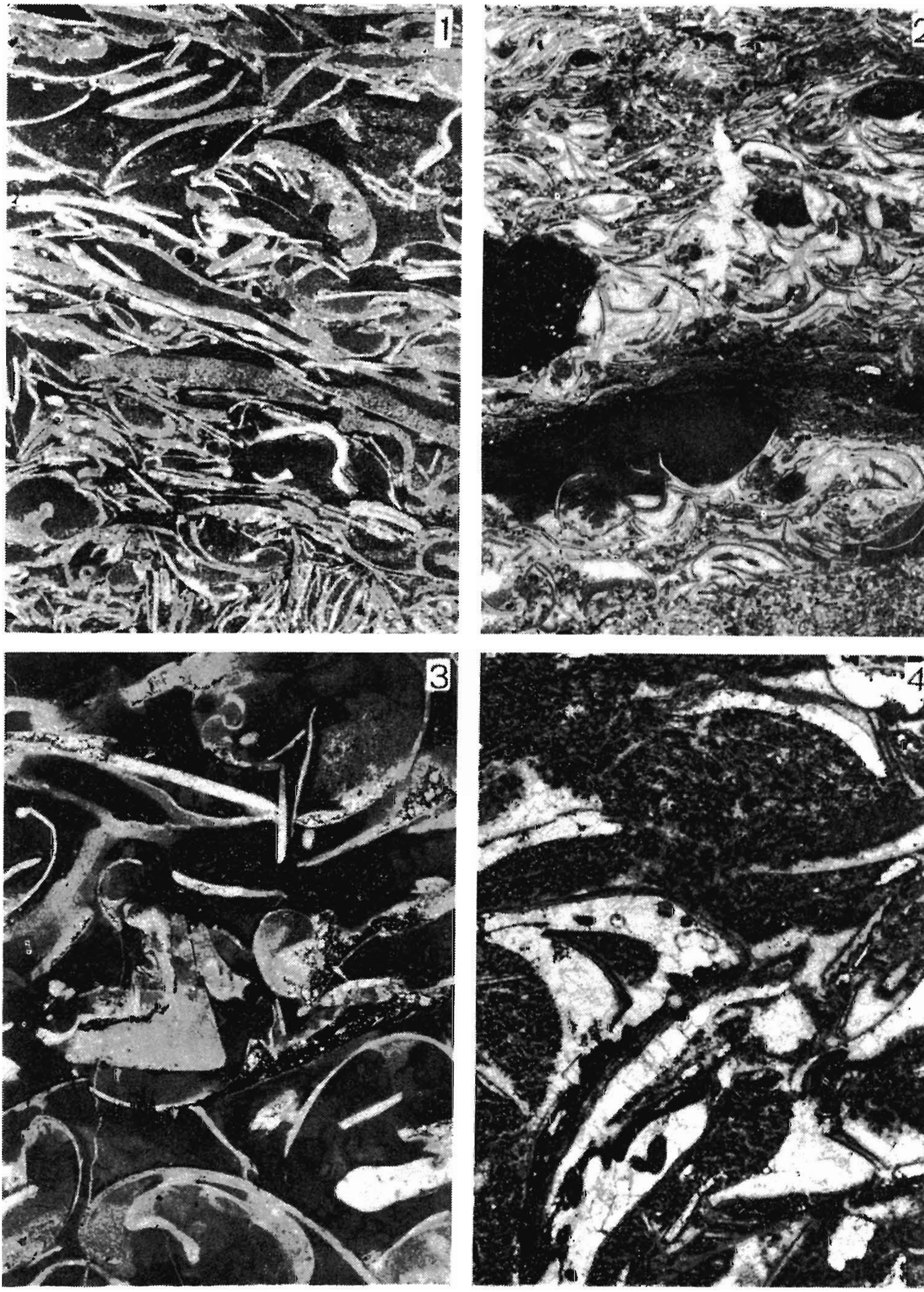


1 — Dolointrasparudite; Middle Muschelkalk at Wierchlesie (Illyrian), × 5.
2 — Contact of calcilutite and (underlying) calcareous, quartz sandstone with numerous fish remains; Wilkowice Beds at Ligota Samborowa (Illyrian), × 12.
3 — Intrabiosparudite: intraclasts of pelitic limestone are bored at the surface; associated are fish remains, shell detritus, quartz, glauconite and phosphatic lumps; Conglomerate horizon of the Wilkowice Beds at Ligota Samborowa (Illyrian), × 3.

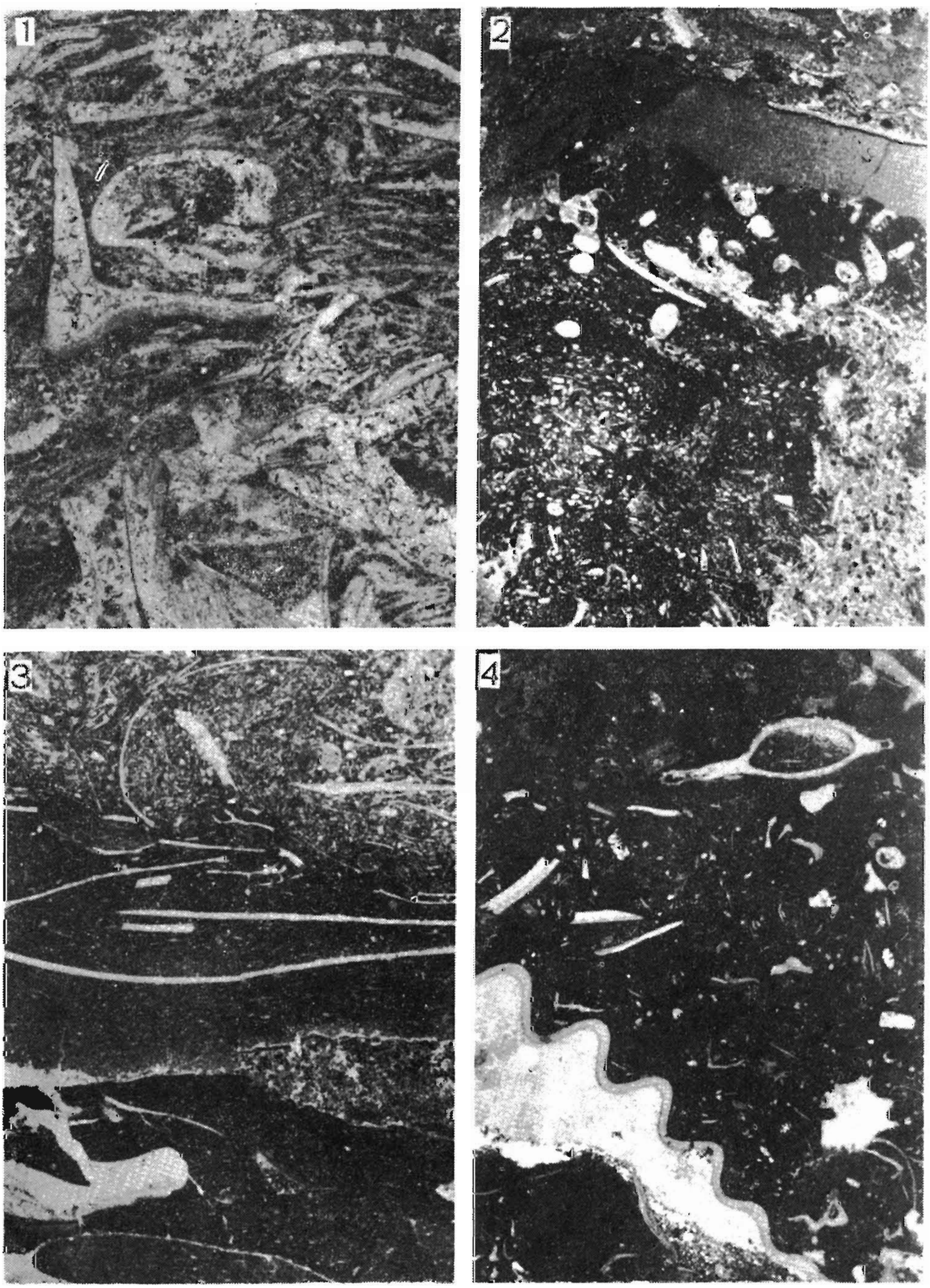


1 — Fragment of a hardground in pelitic limestone (the burow is filled with organo-detrital material); × 7.
2 — Intrabiosparudite: pieces of pelitic limestone with *Trypanites* borings, phosphatic lumps and concentrations of iron compounds; × 7.
3 — Hardground with *Trypanites* borings filled with detrital material (quartz, shell detritus, fish remains); × 5.

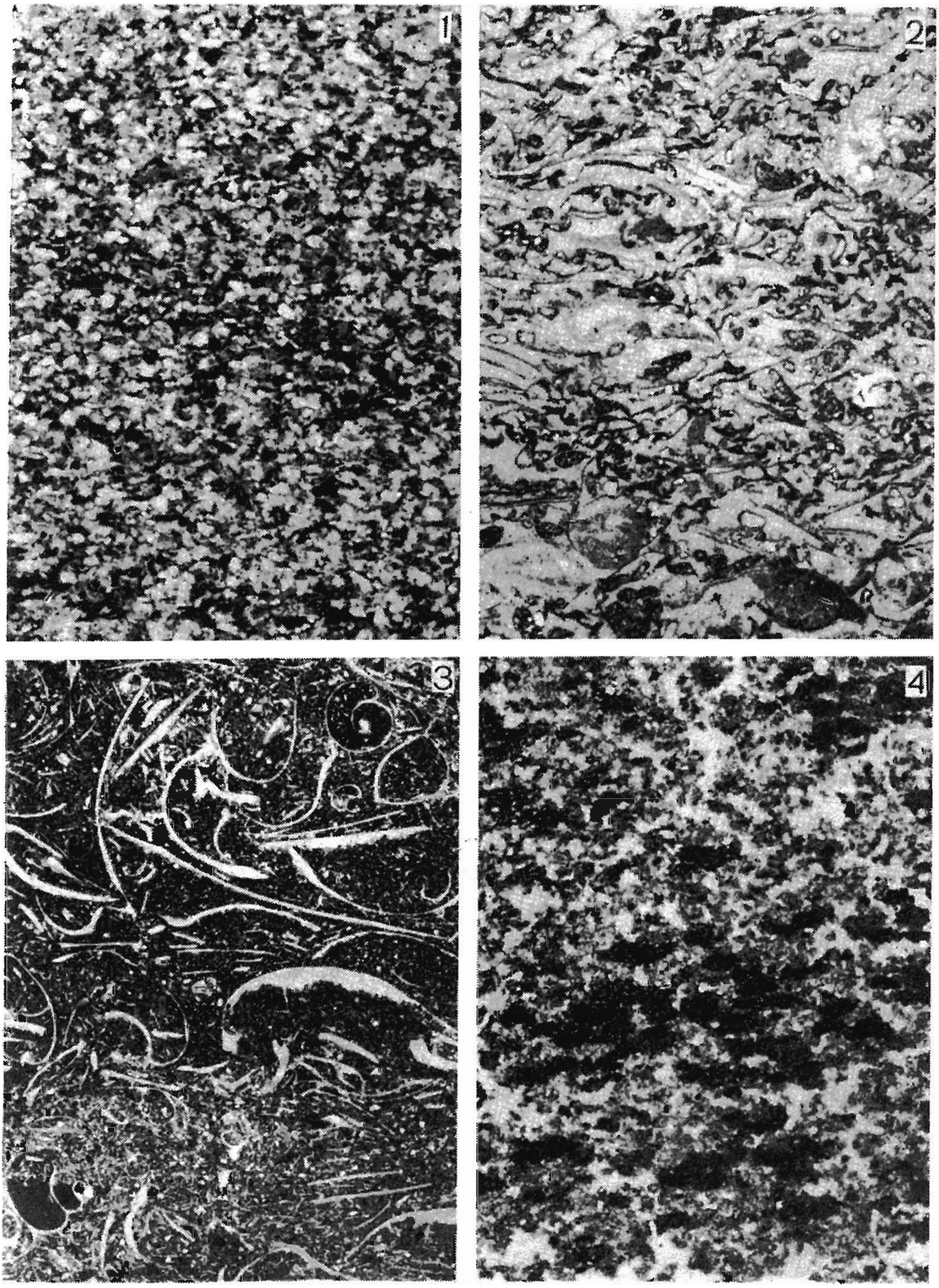
All samples from Wilkowice Beds at Ligota Samborowa (Illyrian)



1 — Biomicrite with pelecypod detritus; Wilkowice Beds at Wierchlesie (Fassanian), × 5.
2 — Biointramicrite (matrix partly recrystallized); Wilkowice Beds at Tworóg *13* (Illyrian), × 5.
3 — Biomicrite; Wilkowice Beds at Ligota Samborowa (Fassanian), × 5.
4 — Biomicrite with pellets (pelecypod detritus with *Trypanites* borings); Wilkowice Beds at Tworóg *13* (Fassanian), × 5.



1 — Biopelmicrite; Ligota Samborowa, × 7.
2 — Intrasparudite: pebbles of micritic limestones with *Trypanites* borings; Tworóg 7, × 7.
3-4 — Biomicrites; Ligota Samborowa, × 7.
All samples from Wilkowice Beds (Fassanian)



1 — Calcareous, glauconitic quartz sandstone; Lower Keuper ("*Lettenkohle*") at Wierchlesie (Langobardian), × 8.
2 — Biosparite with pelecypod detritus; Tarnowice Beds at Tarnów Opolski (Illyrian), × 12.
3 — Biopelmicrite; Wilkowice Beds at Wierchlesie (Fassanian), × 5.
4 — Porous dolosparite with patches of dolomicrite; Boruszowice Beds at Wierchlesie (Fassanian), × 8.

COMPARISON WITH THE ALPINE MIDDLE TRIASSIC

The part of Alpine forms in the rich assemblage of the Muschelkalk fauna and flora of southern Poland is considerable, and some of the lithostratigraphic units are particularly abounding in them, for example in the Hauptwellenkalk (*cf.* Senkowiczowa 1962).

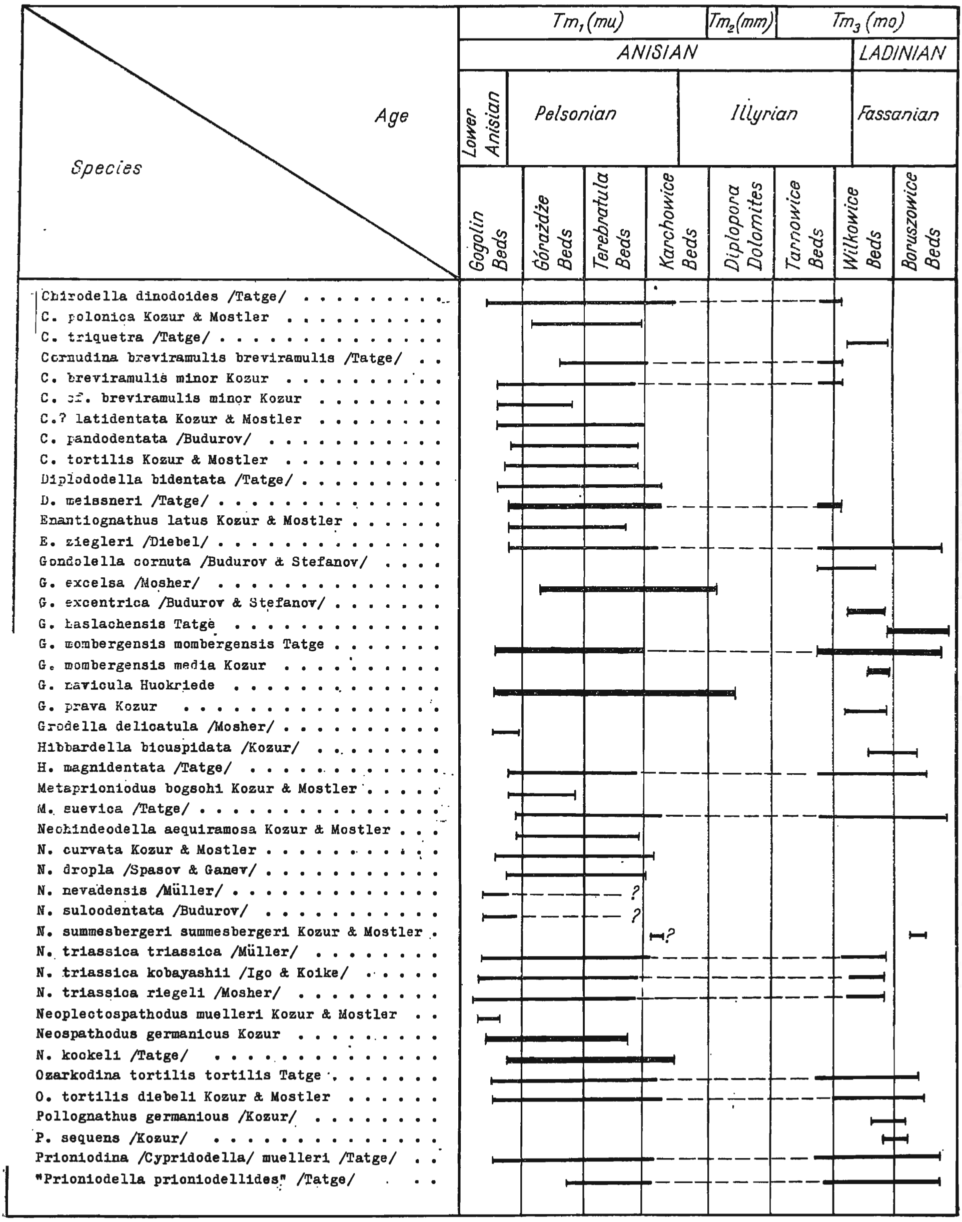


Fig. 4. Stratigraphic range of Muschelkalk conodonts in the Silesia region (range of stratigraphically important forms is marked with a heavy line)

On the basis of diplopores and cephalopods, Pia conducted in the 1930's a comparison between the Muschelkalk and the Alpine Middle Triassic. As follows from this comparison, the Gogolin Beds are Lower Anisian and Pelsonian, while the Górażdże, *Terebratula* and Karchowice Beds and *Diplopora* Dolomites include the Upper Pelsonian and the entire Illyrian. The Upper Muschelkalk would correspond to the Fassanian and the lower part of the Langobardian (Ladinian). In this presentation, the Lower Keuper would be of Upper Langobardian and Cordevolian (Upper Ladinian, Lower Carnian) age.

On the basis of the presence of *Diplopora annulata* (Schafhäutl) in the *Diplopora* Dolomites (*cf.* Pastwa-Leszczyńska & Śliwiński 1960), of *Ceratites trinodosus* Mojsisovics in the Górażdże and Karchowice Beds (Assmann 1937, 1944) and of *Dadocrinus gracilis gracilis* (Buch) and *D. gracilis kunischi* Wachsmuth & Springer in the Gogolin Beds (Lefeld 1958), the Lower Anisian/Pelsonian boundary was placed by Senkowiczowa (1959, 1962) at the base of the Górażdże Beds, the Pelsonian/Illyrian boundary within the range of the Górażdże Beds and the Illyrian/Fassanian boundary at the base of the *Diplopora* Dolomites (*cf.* Fig. 5).

Revised identifications of the most important index forms (*cf.* Kozur 1968a, b, 1971, 1972a, b; Kozur & Mostler 1971a, 1972a, b; Kotlicki 1975, oral communication) have primarily shown that the Silesian *Diplopora* Dolomites do not contain *Diplopora annulata* (Schafhäutl), but *D. annulatis-*

<table>
<tr><th colspan="4">Senkowiczowa & Szyperko-Śliwczyńska 1961
Senkowiczowa 1962</th><th colspan="2">Kozur 1972a,b, 1974
Kozur & Mostler 1972a</th><th colspan="2">Zawidzka 1974, 1975 /this paper/</th></tr>
<tr><th colspan="2">Lithostratigraphical units</th><th colspan="2">Chrono-stratigraphical units</th><th>Chrono-stratigraphical units</th><th>Conodonts zones</th><th>Chrono-stratigraphical units</th><th>Conodonts and megaspore zones</th></tr>
<tr><td>Keuper</td><td>"Lettenkohle"</td><td>Carnian</td><td>Cordevolian</td><td>Langobardian</td><td rowspan="2">G. haslachensis Zone</td><td>Langobardian</td><td rowspan="2">M. meditectatus subzone
G. haslachensis Zone</td></tr>
<tr><td rowspan="4">Upper Muschelkalk</td><td>Boruszowice Beds</td><td rowspan="6">Ladinian</td><td rowspan="4">Langobardian</td><td rowspan="3">Fassanian</td><td rowspan="3">Fassanian</td></tr>
<tr><td>Wilkowice Beds</td><td>3</td><td>3</td></tr>
<tr><td>Conglomerates of the Wilkowice Beds</td><td rowspan="2">2</td><td>2</td></tr>
<tr><td>Upper Tarnowice Beds</td><td rowspan="4">Illyrian</td><td rowspan="4">Illyrian</td><td rowspan="4">1
G. excelsa assemblage Zone</td></tr>
<tr><td rowspan="2">Middle Muschelkalk</td><td>Platy dolomites</td><td rowspan="2">Fassanian</td><td rowspan="3">1</td></tr>
<tr><td>Dolomites and limestones with Diplopora</td></tr>
<tr><td rowspan="4">Lower Muschelkalk</td><td>Karchowice Beds</td><td rowspan="4">Anisian</td><td rowspan="2">Illyrian</td></tr>
<tr><td>Terebratula Beds</td><td rowspan="2">Pelsonian</td><td rowspan="2">N. kockeli Zone</td><td rowspan="2">Pelsonian</td><td rowspan="2">N. kockeli Zone</td></tr>
<tr><td>Górażdże Beds</td><td>Pelsonian</td></tr>
<tr><td>Gogolin Beds</td><td>Lower Anisian</td><td>Lower Anisian</td><td>N. germanicus Subzone</td><td>Lower Anisian</td><td>N. germanicus Subzone</td></tr>
</table>

Fig. 5. Correlation of the investigated Muschelkalk units with the chronostratigraphic column

sima Pia, a species which is the index of the Carpathian-Alpine Illyrian (Andrusov 1959, Ott 1972). Then, the species *Paraceratites trinodosus* Mojsisovics from the Gorażdże Beds, illustrated by Assmann (1937), represents, according to Schmidt (*in* Kozur 1974), a juvenile form, whose assignment to the genus *Paraceratites* is rather doubtful. The *Diplopora* Dolomites of the Middle Muschelkalk of southern Poland should, therefore, in the light of the facts presented above, be assigned to the Illyrian.

Studies on the Triassic microfauna and microflora of the Polish part of the epicontinental basin, combined with similar studies conducted on the sequences of Tethys and the Pacific zone, supplied several new data enabling a comparison of the Polish Muschelkalk and the Middle Triassic of all the discussed regions.

The Alpine conodonts, spores *Globochaete alpina*, and foraminifers *Meandrospira dinarica* and *Glomospira densa* (*cf.* Popiel 1967; Zawidzka 1970b, 1972a, 1973, 1974a; Trammer 1971, 1972; Głazek, Trammer & Zawidzka 1973) have recently been found also in the epicontinental part of the Triassic basin.

Of the group of organisms mentioned above, the conodonts, due to their general and abundant occurrence in the Triassic deposits, may be used as index fossils, in particular in all localities, which, much the same as in the Muschelkalk of Poland, are nearly devoid of important stratigraphically macrofauna.

CONODONT STRATIGRAPHY OF THE TRIASSIC

A work of Bender (1967), who erected in the Campilan and Lower Anisian (Hydaspian) of Greece two new conodont zones, viz. *Spathognathodus homeri* and *Neogondolella aegaea* zones, was one of the first attempts at applying conodonts to the Triassic stratigraphy.

On the basis of materials, coming mostly from North America, the Alps and German Basin, Mosher (1968) formed several assemblage zones and indicated assemblages of conodont fauna which might be of a stratigraphic importance in the Middle Triassic. The assemblage with *Gondolella mombergensis* is characteristic of the Ladinian of the German Basin, that with *Gladigonodolella tethydis* — of the Upper Anisian and Lower Ladinian of the Alps and that with *Neospathodus microdus* — of the Upper Ladinian of the last-named area.

In the German part of the epicontinental Triassic basin, Kozur (1968a, b) subdivided the Upper Muschelkalk sequence into seven conodont zones correlatable with the ceratitid zones.

A detailed recognition of the Upper Permian and Lower Triassic of Salt Range and Trans-Indus Range (*cf.* Kummel & Teichert 1970) enabled an establishment of nine conodont zones, with the Permian/Triassic boundary traced within the oldest, that is, *Anchinognathus typicalis* zone (Sweet 1970a, b).

A division of the Triassic into twenty-two conodont zones, correlated with ammonite zones of North America, was presented by Sweet & al. (1971).

Kozur & Mostler (1972a) suggested a new schema, containing fourteen conodont zones, in which several American zones have been maintained after certain modifications, but several new ones, universally important, introduced. At the same time, Budurov & Stefanov (1972), divided, using the conodonts, the Middle Triassic of Bulgaria (Upper Pelsonian through Fassanian) into six zones.

The original stratigraphic schema was subject to several changes in later papers of Kozur (1972a, b) and Kozur & Mostler (1972a). After certain modifications, this schema have also been used in the present paper (*cf.* Fig. 5).

In Poland, the Triassic conodonts have first been found in the Middle Triassic of the Tatra Mountains (Choč nappe, Zawidzka 1970b, 1972b). They were also found in the Muschelkalk of the here discussed Opole Silesia region (Zawidzka 1970b), as well as in the Holy Cross Mts (Prejbisz 1970; Trammer 1971).

The lack of index taxons of higher conodont zones ("*5*", "*6*" and "*7*") in the Upper Muschelkalk of Opole Silesia enabled a confirmation of earlier authors' view (*cf.* Brinkmann 1954, 1969) that the Keuper facies became prevalent in the Polish part of the Triassic epicontinental basin earlier than in the German part (Zawidzka 1970a, b, 1973, 1974a, b; Trammer 1972, 1974a).

The index species *Gondolella regale* and *Neospathodus kockeli*, as well as an assemblage characteristic of zones "*1*", "*2*", "*3*" and "*4*" of the Upper Muschelkalk, were found, among other species, by Trammer (1972) in the Lower Muschelkalk of the Holy Cross Mts. At the same time, this author introduced certain modifications concerning the boundaries of zones and indicated relationships between the Holy Cross region and particular conodont provinces of the Triassic established by Kozur (1971). The Triassic conodonts are also known from several boreholes (Pacholec 1972; Głazek, Trammer & Zawidzka 1973).

CONODONTS FROM SILESIA

Two variable groups may be distinguished among the conodont fauna of the Silesian Muschelkalk. They are: the Lower and Middle Muschelkalk assemblages and the Upper Muschelkalk assemblage (*cf.* Fig. 4 and Pls 35—44).

The Lower Muschelkalk conodont fauna is decidedly richer than that of the Upper Muschelkalk. The former contains both the platform and compound conodonts, represented by a relatively large number of specimens. Two species, *Chirodella polonica* and *Cornudina tortilis* (*cf.* Pl. 35, Figs 2 and 5) were described by Kozur & Mostler (1970a) from the Lower Muschelkalk of Opole Silesia.

The presence of Alpine platform conodonts, *Gondolella navicula* and *G. excelsa*, the latter lacking fully adult forms, is a characteristic feature of the conodont assemblage under study. These species in the German Basin have first been found in Opole Silesia, and their presence is indicative of a separate paleogeographic position of the western (the lack of the platform conodonts) and the eastern part of the Basin (Zawidzka 1970b, 1973, 1974a; Trammer 1971, 1972, 1973).

The presence of the following conodont species has been stated in the Gogolin, Górażdże, *Terebratula* and Karchowice beds (*cf.* Fig. 4):

Chirodella dinodoides (Tatge, 1956)
Chirodella polonica Kozur & Mostler, 1970

Cornudina breviramulis breviramulis (Tatge, 1956)
Cornudina breviramulis minor Kozur, 1968
Cornudina cf. *breviramulis minor* Kozur, 1968
Cornudina? latidentata Kozur & Mostler, 1970
Cornudina pandodentata (Budurov, 1962)
Cornudina tortilis Kozur & Mostler, 1970
Diplododella bidentata (Tatge, 1956)
Diplododella meissneri (Tatge, 1956)
Enantiognathus latus Kozur & Mostler, 1970
Enantiognathus ziegleri (Diebel, 1956)
Gondolella excelsa (Mosher, 1968)
Gondolella mombergensis mombergensis Tatge, 1956
Gondolella navicula Huckriede, 1958
Grodella delicatula (Mosher, 1968)
Hibbardella magnidentata (Tatge, 1956)
Metaprioniodus bogschi Kozur & Mostler, 1970
Metaprioniodus suevica (Tatge, 1956)
Neohindeodella aequiramosa Kozur & Mostler, 1970
Neohindeodella curvata Kozur & Mostler, 1970
Neohindeodella dropla (Spasov & Ganev, 1960)
Neohindeodella nevadensis (Müller, 1956)
Neohindeodella sulcodentata (Budurov, 1962)
Neohindeodella summesbergeri summesbergeri? Kozur & Mostler, 1970
Neohindeodella triassica triassica (Müller, 1956)
Neohindeodella triassica kobayashii (Igo & Koike, 1965)
Neohindeodella triassica riegeli (Mosher, 1968)
Neoplectospathodus muelleri Kozur & Mostler, 1970
Neospathodus germanicus Kozur, 1972
Neospathodus kockeli (Tatge, 1956)
Ozarkodina tortilis tortilis Tatge, 1956
Ozarkodina tortilis diebeli Kozur & Mostler, 1972
Prioniodina (Cypridodella) muelleri (Tatge, 1956)
"*Prioniodella prioniodellides*" (Tatge, 1956)

In the Upper Muschelkalk, the gondolellids, primarily *Gondolella mombergensis mombergensis* Tatge, are a predominant (95 per cent) element in the conodont assemblage. The percentage of compound conodonts is insignificant. In regard to the number of taxa and specimens, a marked impoverishment as compared with the conodont assemblage from the Upper Muschelkalk of Germany is evident (*cf.* Kozur 1968a, b; Kozur & Mostler 1972a, b). The Alpine forms, known in the Middle Triassic of the Tethys from the Pelsonian through Cordevolian (*Cornudina breviramulis breviramulis, C. pandodentata, Chirodella dinodoides, Diplododella meissneri),* occur only in the lowermost Upper Muschelkalk (the uppermost part of Tarnowice and the lowermost part of the Wilkowice Beds). The lack of Alpine platform conodonts is recorded throughout the Upper Muschelkalk of Opole Silesia.

The presence of the following conodont species has been stated in the Tarnowice, Wilkowice and Boruszowice beds (*cf.* Fig. 4):

Chirodella dinodoides (Tatge, 1956)
Chirodella triquetra (Tatge, 1956)
Cornudina breviramulis breviramulis (Tatge, 1956)
Cornudina breviramulis minor Kozur, 1968
Diplododella meissneri (Tatge, 1956)
Enantiognathus ziegleri (Diebel, 1956)

Gondolella cornuta (Budurov & Stefanov, 1972)
Gondolella excentrica (Budurov & Stefanov, 1972)
Gondolella haslachensis Tatge, 1956
Gondolella mombergensis mombergensis Tatge, 1956
Gondolella mombergensis media Kozur, 1968
Gondolella prava (Kozur, 1968)
Hibbardella bicuspidata (Kozur, 1968)
Hibbardella magnidentata (Tatge, 1956)
Metaprioniodus suevica (Tatge, 1956)
Neohindeodella summesbergeri summesbergeri Kozur & Mostler, 1970
Ozarkodina tortilis tortilis Tatge, 1956
Ozarkodina tortilis diebeli Kozur & Mostler, 1972
Pollognathus germanicus (Kozur, 1968)
Pollognathus sequens (Kozur, 1968)
Prioniodina (Cypridodella) muelleri (Tatge, 1956)
"*Prioniodella prioniodellides*" (Tatge, 1956)

An asymmetry, visible mostly in the posterior part of particular specimens is a characteristic feature of the platform conodonts from the Upper Muschelkalk in Opole Silesia. It is expressed in the constriction of platform, eccentric course of carina, bifurcation of basal area, frequently combined with a division of platform into two lobes, presence of a characteristic secondary rib on the aboral surface of platform (usually being a continuation of a deformed basal area) and, finally, the appearance of accessory denticles growing out of the margin of platform (Pl. 40, Figs 4 and 7). Forms of *Gondolella navicula*, marked by a distinct crenulation of platform (Pl. 44, Fig. 2), occur, in addition, in the gondolellid assemblage of the *Terebratula* Beds. In the Lower Muschelkalk, predominant are "asymmetric" gondolellids, except for *Gondolella excelsa*, which does not display asymmetry, although several of its individuals have a distinct, symmetric constriction in the rear part of platform.

The constriction of the posterior part of platform is the most important feature of the species *Gondolella constricta* Mosher & Clark, 1965. Such a constriction may be also observed in other Triassic gondolellids (Clark 1959; Hirschmann 1959; Budurov & Vrablijanski 1964; Budurov & Stefanov 1965, 1973; Mosher & Clark 1965; Mosher 1968, 1970; Sweet 1970a, b; Kozur 1972b). A set of specific features characteristic of *Gondolella constricta* may be observed only in the Upper Muschelkalk gondolellids from Opole Silesia (Pl. 42, Figs 1, 3).

Bifurcated keel and carina occur in many Triassic gondolellids (*cf.* Pls 40—44), assigned to various genera and species. However, this concerns mostly the platform conodonts of the Upper Triassic. In the Middle Triassic of Bulgaria, the appearance of this character among unidentified forms with *Gondolella navicula* Huckriede leads to the formation of the species *Gondolella bifurcata* (Budurov & Stefanov), to which a stratigraphic importance is ascribed (an index of the Lower Illyrian *G. bifurcata* zone).

In Opole Silesia, the forms of the genus *Gondolella*, tending to bifurcate their keels, appear much earlier than in Bulgaria, that is, in the Lower Anisian (*cf.* Pls 40 and 42—44) and are recorded in the Gogolin, Górażdże and *Terebratula* Beds. Striking is the fact that gondolellids with the keel and carina bifurcated almost identically as in the forms transitional between *G. navicula* and *G. bifurcata* Budurov & Stefanov (*cf.* Pl. 40, Fig. 8 and Budurov & Stefanov 1972, Pl. 2, Figs 7—9) occur also in the Upper Muschelkalk of Opole Silesia. Consequently, the species *Gondolella bifurcata* (Budurov & Stefanov) in Opole Silesia seems to be of no stratigraphic importance.

The eccentricity of keel and carina is a morphological character fairly common also among the Triassic gondolellids. According to Budurov & Stefanov (1972), this character is distinctly manifested in the Lower Fassanian forms related to *Gondolella mombergensis* and served as a basis for erecting the species *Gondolella excentrica* (Budurov & Stefanov), an index of the Lower Fassanian.

In Opole Silesia, forms related to *Gondolella excentrica* occur as early as the Lower Muschelkalk and appear in the Gogolin Beds (Lower Anisian) simultaneously with *G. navicula* and *G. mombergensis*. Such forms were also found in the Górażdże and *Terebratula* Beds. The lack of eccentric or bifurcating forms (except for *Gondolella prava*) was recorded in the Upper Muschelkalk, in the Tarnowice Beds and in the lower part of the Wilkowice Beds. An undoubtful *Gondolella excentrica* occurs somewhat higher-up, accompanying, in the Wilkowice Beds, conodonts which are index forms of zone "2". On the basis of data from Bulgaria (Budurov & Stefanov 1972), the place of its appearance was accepted as the Anisian/Ladinian boundary.

Forms of the genus *Neospathodus,* which display a set of morphological characters not fully comparable with those of so far known species of this genus occur in the Lower Anisian of the Wierchlesie borehole (*cf.* Fig. 3 and Pl. 37, Fig. 2b).

Most species of the genus *Neospathodus* are known from the Lower Triassic of the Tethys and from the Pacific area, where they are of stratigraphic importance (Mosher 1968, 1973; Bender 1967; Sweet 1970a, b; McTavish 1973). Thus far, only four species have been described (Tatge 1956; Bender 1967; Kozur 1972b; Zawidzka 1972b) from the Middle Triassic. Two of them (*N. germanicus* and *N. kockeli*) are known from the German Basin, and *N. homeri* (Bender 1967) occurs in many Triassic areas (*cf.* Sweet 1970a, b). The form called here *Neospathodus* sp. displays characters, which are contained within the range of the characters of *N. homeri* (Bender 1967), both *sensu* Bender and *sensu* Sweet. Among them, we may mention the general proportions, number, shape and position of denticles, the presence of medial convexity and the route of lower margin. Only the proportions of the basal furrow and basal cavity are similar to the corresponding morphological elements in *N. germanicus* (Kozur 1972b). In addition, the basal cavity is relatively narrow.

According to Kozur (1972b), *Neospathodus homeri* and *N. germanicus,* make up two links of one and the same evolutionary line; in his previous opinion (Kozur 1971), only one species, *N. homeri*, was distinguished, along with its two subspecies, *N. homeri homeri* (Bender) and *N. homeri newpassenis* Kozur, the latter subsequently (Kozur 1972b) called as *N. germanicus* Kozur.

CONODONT STRATIGRAPHY IN OPOLE SILESIA

GENERAL REMARKS

No direct interdependence has been found between the presence and number of conodonts, on the one hand, and the lithological type of rock, on the other. The conodonts occur in many lithological varieties of limestones, from marly calcilutites, through calcarenites varying in structure, up to biocalcirudites. They may be also found in onkosparites (*cf.* Zawidzka 1970b), in which, as compared with the rocks of the types mentioned above, they are not very abundant (up to twenty conodonts per one-kilogram sample).

At present, the view is predominant that a large number of conodonts in a rock is mostly connected with a slower deposition, and condensation, or with a secondary enrichment in elevated parts of the bottom, from which lighter mineral particles were swept away (*cf.* Lindström 1964, Szulczewski 1973).

The greatest frequency is recorded in the Wilkowice Beds, where distinct symptoms of condensation may be observed. A very similar number of conodonts occurs in the Upper Muschelkalk of Germany, where four conodont maxima were recorded by Hieke (1967) and used for regional correlations.

Four maxima of the frequency of conodonts, all of them situated on the boundary of particular lithological units, may be determined in the whole sequency of the Muschelkalk in Opole Silesia. No conodonts are recorded in the lowermost part of the Gogolin Beds (limestones with *Pecten* and *Dadocrinus*) and higher-up, to the Hauptwellenkalk. At Gogolin, with lower members of the Muschelkalk exposed (Pl. 1), the material was sampled with each lithological change (on the average one sample per fifteen centimeters) and yet no conodonts were found. They appear about thirty meters over the Röt/Muschelkalk boundary (*cf.* Wierchlesie and Jemielnica boreholes, Fig. 3) where they are represented by conodonts of the hindeodellid group, *Neohindeodella triassica triassica* (Tatge) and *N. triassica riegeli* (Mosher). The first, rich assemblage, containing conodonts of all morphological types, comes from members situated between a dozen or so to twenty meters below the boundary of the Gogolin and Górażdże Beds. Higher-up, conodonts are recorded with a variable frequency up to the Middle Muschelkalk inclusively, where such forms as *Gondolella navicula* occur in calcareous intercalations within the dolomites above the uppermost onkosparites. Subsequently, they occur in the Tarnowice Beds, reaching a maximum frequency in the Wilkowice Beds (about 1,000 per one kilogram of rock). The youngest conodonts of the Muschelkalk were found in the Boruszowice Beds close below a complex of dark clayey shales, which upwards turn in sandy-marly shales and calcareous quartz--glauconite sandstones ("*Lettenkohle*").

CHARACTERISTICS OF CONODONT ZONES

Conodonts characteristic of the following zones, recognized in various regions of the sedimentation of the Triassic deposits (North America, Tethys and German Basin) were found in the Middle Triassic of Opole Silesia (*cf.* Fig. 5):

Lower Anisian — ***Neospathodus germanicus*** Subzone;
Pelsonian — ***Neospathodus kockeli*** Zone;
Lowermost Illyrian — *Gondolella excelsa* assemblage zone;
Upper Illyrian — zone "*1*", including an assemblage of the conodonts *Gondolella mombergensis, Chirodella dinodoides, Cornudina breviramulis breviramulis* and the lower part of zone "2" with *Gondolella mombergensis mombergensis;*
Fassanian — upper part of zone "2" with *G. mombergensis* media and zone 4 — *G. haslachensis.*

STRATIGRAPHY OF THE LOWER MUSCHELKALK

Gondolella aegaea Zone

Classical sections of *G. aegaea* zone occur in Nevada, British Columbia, Canada and Greece (*cf.* Bender 1967, Sweet & al. 1971; Kozur 1972a, b; Kozur & Mostler 1972a, b). In North America, it corresponds to the Lower Anisian zone *14* (with *Lenotropites causurus* and *Agymnotoceras varium*) and is characterized by the range of *Gondolella aegaea* Bender = *Gondolella regale* Mosher. In Greece, *G. aegaea* occurs in the upper part of the Lower Anisian (Bender 1967).

In Poland, the zone under study was found in the Lower Muschelkalk of the Holy Cross Mts, where the occurrence of *Gondolella aegaea* (Trammer 1972) was noted in the Wellenkalk and Łukowa Beds.

No index taxa of this zone occurs in Opole Silesia, but the Gogolin Beds, except for their uppermost part in which *Neospathodus kockeli,* an index species of the Pelsonian zone, appears, may be assigned to the *G. aegaea* Zone. The species *Neospathodus germanicus,* the index of the *N. germanicus* Subzone, *i.e.* the upper subzone of the *G. aegaea* Zone, occurs in the upper, but not uppermost parts of the Gogolin Beds. More detailed data on the species *N. germanicus,* found at Wierchlesie, Jemielnica, Malnia, Strzelce Opolskie and Górażdże and on its position in particular sections are given below.

The species *Neospathodus germanicus* appears in the Wierchlesie borehole 54 m above the Röt/Muschelkalk boundary (Fig. 3), along with a rich assemblage of accompanying forms. The form *Neospathodus* sp., displaying common characters of *Neospathodus homeri* (Bender) and *N. germanicus* Kozur also occurs in the borehole.

The first conodonts appear in samples from the Jemielnica borehole *c.* 30 m above the Röt/Muschelkalk boundary. These are forms characteristic of *Neospathodus germanicus* Subzone.

Lower parts of the Hauptwellenkalk exposed at Malnia contain *N. germanicus*, marking the lower boundary of the Pelsonian within the range of Hauptwellenkalk (the Upper Gogolin Beds).

The lowermost member, 5 m thick, exposed in the southern part of the quarry at Strzelce Opolskie, contains *N. germanicus* without *N. kockeli.* Overlaying members (the uppermost part of the Gogolin Beds, the Górażdże Beds and the *Terebratula* Beds) correspond to *N. kockeli* Zone.

The lower parts of the section exposed at Górażdże (Pl. 7, Fig. 1) contain *N. germanicus,* while *N. kockeli,* indicating *N. kockeli* Zone (Pelsonian), appears higher-up. The lower boundary of the last-named zone runs about 5 m below the top of the Gogolin Beds. The lower parts of the rock complex 14 m thick contain *N. germanicus* and characteristic accompanying forms, which include *Neohindeodella nevadensis* (Müller) and *N. curvata* Kozur & Mostler.

Neospathodus kockeli Zone

This zone was defined simultaneously in Bulgaria (Budurov & Stefanov 1972) and in the Middle Triassic of the epicontinental basin and in the Anisian of the Alps (Kozur 1972a, b; Kozur & Mostler 1972a, b). In Bulgaria, this zone was correlated with the Upper Pelsonian, marked by the presence of *Paraceratites binodosus* (*cf.* Budurov & Stefanov 1972).

The stratigraphic range of *Neospathodus kockeli* was established on the basis of the orthostratigraphy of ammonites in the Muschelkalk of the German Basin and in the classical Anisian profiles of the Tethys (Giudicariense Alps, Dolomites, Gross-Reifling, Balaton), which enabled the conclusion that the range of this species, as well as that of the *N. kockeli* Zone, correspond to the range of the entire Pelsonian (Assereto 1971; Kozur 1972a, b; Kozur & Mostler 1972a, b).

In Opole Silesia, like in the entire Europe, the Lower Anisian/Pelsonian boundary corresponds, therefore, with the appearance of *Neospathodus kockeli,* an index species of the Pelsonian and it runs in the upper part of the Gogolin Beds. Thus, these parts of the Gogolin Beds, the Górażdże and *Terebratula* beds and part of the Karchowice Beds should be paralleled with the Pelsonian. The Pelsonian conodonts represent the richest Muschelkalk conodont assemblage in Silesia, both in the variability of species and the number of specimens. Only one species, *N. kockeli,* is here in principle of a stratigraphic importance. Except for it, a stratigraphic range limited to the Pelsonian only has so far been displayed in Europe by three other species, *Chirodella polonica, Neohindeodella aequi-*

ramosa and *Hibbardella jenensis* (Kozur & Mostler 1970a). The first two of them are also known in Silesia, *N. aequiramosa* occurring in this region also in the Lower Anisian (Gogolin Beds). With the assumption that the entire range of *Neospathodus kockeli* is represented in Opole Silesia, the lower boundary of *N. kockeli* Zone has been characterized above. The upper boundary of this zone corresponds to the Pelsonian/Illyrian boundary. In the Alpine Triassic, it is adequate to the lower boundary of the *Gondolella excelsa* assemblage zone, to which the lower boundary of zone "*1*" corresponds in the German Triassic (Kozur 1968a, b, 1972a, b; Kozur & Mostler 1972a).

In Opole Silesia, the Pelsonian/Illyrian boundary runs within the Karchowice Beds. The place of this boundary may be explained on the basis of more abundant biostratigraphic data than those for Germany, since there is a possibility of recognition not only zone "*1*", but also the alpine *Gondolella excelsa* assemblage zone.

The position of the upper boundary of the zone under study is not, however, quite certain, since, although *Gondolella excelsa* occurs above the presumed boundary without *Neospathodus kockeli*, but it is found in few samples and together with only few accompanying forms. Thus, we cannot absolutely preclude the possibility of the occurrence of the last--named species in a somewhat higher part of the Karchowice Beds.

Gondolella excelsa assemblage zone

The lower boundary of the zone (with *Gondolella excelsa* as an index species) is tantamount to the upper boundary of the *N. kockeli* zone, determined by the disappearance of *N. kockeli*, while its upper boundary corresponds to the appearance of *Gondolella haslachensis*.

In the German Basin and in the western part of the Tethys, zone "*1*" corresponds to the *G. excelsa* assemblage zone, which is essential stratigraphically primarily in the Alps. The lower boundaries of the two zones under study run through the place of the disappearance of *Neospathodus kockeli* and, therefore, they are completely adequate. Conodonts characteristic of the lower part of the *G. excelsa* Zone (in addition to the index taxon, it also contains *G. navicula*) occur in the Karchowice Beds and in the lower part of the Middle Muschelkalk dolomites. The majority of the *Diplopora* Dolomites and the lower part of the Tarnowice Beds do not contain conodonts, which appear in the uppermost parts of the Tarnowice Beds, where they form an assemblage characteristic of zone "*1*", the oldest of the seven conodont zones of the Upper Muschelkalk of the German Basin and the western part of the Tethys. The uppermost Illyrian and Ladinian Alpine deposits, corresponding to these zones, have a different conodont assemblage and, consequently, a different stratigraphic schema.

STRATIGRAPHY OF THE UPPER MUSCHELKALK

This schema was developed on the basis of phylogenetic changes in the morphology of conodonts of the genus *Gondolella* tending to the reduction and disappearance of the platform (*cf*. Kozur 1968a, b; Trammer 1974b).

Particular forms of the genus *Gondolella*, representing various phylogenetic stages, have been included into four species and two subspecies, which make up index taxa of zones "*1—7*" (Kozur 1968a, b). These zones are marked by the presence of the following taxons:

Zones "*1*" and "*2*" — *Gondolella mombergensis mombergensis* Tatge
Zone "*3*" — *Gondolella mombergensis media* Kozur
Zones "*4*" and "*5*" — *Gondolella haslachensis* Tatge
Zone "*6*" — *Gondolella (Celsigondolella) watznaueri praecursor* Kozur
Zone "*7*" — *Gondolella (Celsigondolella) watznaueri watznaueri* Kozur

The conodont fauna of zones "*1—4*" has so far been known in the Polish part of the Upper Muschelkalk basin; higher zones cannot be recognized due to the absence of conodonts (Zawidzka 1970b, 1973, 1974a, b; Trammer 1971, 1972).

Zone "*1*"

This zone was established in the western part of the German Basin on the basis of a conodont assemblage, also characteristic of the Alpine Illyrian (Kozur 1968a, b). In addition to *Gondolella mombergensis mombergensis*, it contains such forms as *Dipododella meissneri, Chirodella dinodoides, Cornudina breviramulis breviramulis* and *C. pandodentata*. The lower boundary of this zone corresponds to the upper boundary of *Gondolella excelsa* zone and the upper to the place of disappearance of Alpine forms, *D. meissneri, C. breviramulis breviramulis, C. pandodentata* and *Ch. dinodoides*.

The occurrence of taxa characteristic of zone "*1*" was found at Tarnów Opolski in the Tarnowice Beds and at Ligota Samborowa in the Wilkowice Beds (Pl. 18).

At Tarnów Opolski, *G. mombergensis mombergensis* is accompanied by *C. dinodoides, C. breviramulis breviramulis* and *D. meissneri*, while at Ligota Samborowa *G. mombergensis mombergensis* concurs with *D. meissneri* in the lowermost part of the section (Pl. 18).

Zone "*2*" and the Anisian/Ladinian boundary

The species *Gondolella mombergensis mombergensis* is an index taxon of this zone. Its lower boundary is placed, as mentioned above, through the place of the disappearance of *D. meissneri, C. dinodoides, C.*

breviramulis breviramulis and *C. pandodentata* and its upper boundary runs in the place of the appearance of *Gondolella mombergensis media*.

The Anisian/Ladinian boundary, established mostly on the basis of ammonites *Paraceratites* and *Ceratites*, the index genera of the Upper Muschelkalk of the German Basin, runs within the range of zone "*2*". It corresponds to the upper boundary of the *Paraceratites* (Illyrian) assemblage zone and to the lower boundary of the *Ceratites compressus* Zone (Kozur 1974).

The conodont stratigraphic schema of the Middle Triassic, as it is used in Bulgaria (Budurov & Stefanov 1972), supplied additional data, confirming the correctness of the interpretation of the Anisian/Ladinian boundary within the range of the Upper Muschelkalk of the German Basin, based on the ammonites.

In Bulgaria, the Anisian/Ladinian boundary corresponds to the upper boundary of the *Gondolella cornuta* Zone (Budurov & Stefanov 1972) and to the lower boundary of the *Gondolella excentrica* (Budurov & Stefanov) Zone.

The Upper Muschelkalk of Opole Silesia (Wilkowice Beds) contains, in addition to conodonts characteristic of zone "*2*", the conodonts of the Bulgarian zones, viz.: *Gondolella cornuta* (index species of *G. cornuta* Zone), *Gondolella excentrica* (index species of *G. excentrica* Zone), as well as the species, *Gondolella suhodolica, G. longa* and *G. constricta*.

The species *Gondolella cornuta* has, however, a more extensive stratigraphic range in Silesia than in Bulgaria, occurring along the index species of the *G. excentrica* Zone. Consequently, it is suggested that the Anisian/Ladinian boundary corresponds to the appearance of *Gondolella excentrica* among the conodont assemblages which are characteristic of zone "*2*".

Thus, the higher parts of the Tarnowice Beds and the lower members of the Wilkowice Beds would correspond to the Illyrian, while the higher members of the Wilkowice and almost the whole of the Boruszowice Beds might be correlated with the Fassanian.

The deposits coresponding to the conodont zone "*2*" are exposed at Gąsiorowice (Wilkowice Beds) and at Ligota Samborowa (Tarnowice? and Wilkowice Beds), and they are recognized in the Tworóg *7* and Tworóg *13* (both in Wilkowice Beds) boreholes.

Zone "*3*"

The species *Gondolella mombergensis media* is the index taxon of this zone, the lower boundary of which is marked by the appearance of *G. mombergensis media* and the upper — of *G. haslachensis*. The zone "*3*" coresponds to the *Ceratites evolutus* Zone and to part of the *C. spinosus* Zone.

In Opole Silesia, the deposits containing *G. mombergensis media* were found at Izbicko, Wierchlesie, Pietraszów and Tworóg, within the Wilkowice Beds (Fig. 3).

Zone "*4*"

The lower boundary of this zone, called the *Gondolella haslachensis* zone, is determined by the appearance of *G. haslachensis* and the upper — by the disappearance of this species and appearance of *G. (Celsigondolella) watznaueri praecursor*.

A comparison with the Upper Fassanian deposits of the Austro-Alpine (Hungary) and the west-Mediterranean (Sardinia, the Baleares) provinces, in which *G. haslachensis* occurs next to the index ammonites, enabled an unequivocal correlation of the zone under study with the chronostratigraphic division of the Alpine Triassic. This zone includes the Upper Fassanian and the lowermost Langobardian (Kozur 1972a, b, 1974; Kozur & Mostler 1972a, b).

In Opole Silesia, the presence of *Gondolella haslachensis* was stated (*cf*. Fig. 3) at Pietraszów (Boruszowice Beds), Wierchlesie (Wilkowice and Boruszowice Beds), and Tworóg *7* and *13* (Wilkowice Beds).

Zones "*5—7*" and the Fassanian/Langobardian boundary

The zones "*5—7*", established in the Upper Muschelkalk of Germany, have never been found so far in other regions of the German Basin or in any other locality (Kozur 1968a, b).

In Opole Silesia, sandy-shaly deposits of the "*Lettenkohle*" devoid of conodonts occur over the Boruszowice Beds corresponding to the *G. haslachensis* Zone. In view of the lack of index conodonts younger than *G. haslachensis* which characterizes zone "*4*", abundant megaspores occurring in a series of shales and sandstones, containing flora, may be used to determine the position of the Fassanian/Langobardian boundary in the Silesian Muschelkalk and Keuper.

According to Kozur (1972c), an assemblage of spores, found in the Middle and Upper Triassic of the German Basin and of the Tethys, allows one to distinguish the *Dijkstraisporites beutleri* megaspore zone corresponding to the Ladinian (Fassanian, Langobardian). The occurrence of *D. beutleri* and *Maexisporites meditectatus* corresponds to the Langobardian *M. meditectatus* Subzone.

In Opole Silesia, the species mentioned above were found in the Boruszowice Beds and in the Lower Keuper of the Wierchlesie and Tworóg *7* boreholes. In the Boruszowice Beds, they appear about three to four meters above the last occurrence of *G. haslachensis,* the index species of the conodont zone "*4*".

Thus, the Fassanian/Langobardian boundary runs in Opole Silesia in the upper part of the Boruszowice Beds (Fig. 3).

THE MUSCHELKALK/KEUPER BOUNDARY

According to the original definition (Alberti 1864, *fide* Schmidt 1928), the Keuper consists of deposits displaying features of continental sedimentation, and containing intercalations of shallow-marine deposits.

In Poland, a change from facies displaying a predominance of carbonate deposits to those with clayey-sandy deposits (Assmann 1944; Siedlecki 1949; Kłapciński 1959; Gruszczyk 1956; Gajewska 1964; Śliwiński 1964) was adopted as the Muschelkalk/Keuper boundary.

The youngest lithological unit of the Silesian Muschelkalk, that is, the Boruszowice Beds, represents a transitional member between the sedimentation of the Muschelkalk type and that of the Keuper type. According to Gürich (1886 — *fide* Assmann 1944), the Boruszowice Beds are developed as marly clays with intercalations of marly dolomites and sandstones containing fish remains. The assignment of this series to the Muschelkalk results from the presence of abundant ceratitids. The Lower Keuper members, correlated in Poland with the *Lettenkohle,* display, particularly in the lowermost part, a considerable lithological similarity to the underlying Boruszowice Beds (*cf.* Siedlecki 1949).

As follows from the above considerations, the difficulty of a precise determination of the lithostratigraphic boundary between the Muschelkalk and Keuper in Poland is caused by gradual changes in sedimentary conditions on the Muschelkalk/Keuper boundary. In conformity with the standpoint of most previous authors, the present writer assumes conventionally that the Muschelkalk/Keuper boundary corresponds to the boundary between the Boruszowice Beds and the "*Lettenkohle*". It should be, however, emphasized that in some sections this boundary is rather indistinct and has to be traced in a somewhat arbitrary manner. Considering that no ceratitids younger than *Ceratites spinosus* were found (Assmann 1944; Siedlecki 1949) in the Boruszowice Beds, the assumption was possible that the Muschelkalk/Keuper boundary in Poland does not correspond in age to such a boundary in Germany and that the Keuper facies begin in Poland earlier than in Germany, as it has already been supposed by Brinkmann (1969).

The Muschelkalk/Keuper boundary is, therefore, heterochronous in the German Basin. In Poland, the Keuper facies appear earlier than in Germany, where conodont zones "5—7" are contained within the Muschelkalk, whereas it is at least in Silesia that deposits of this age are already developed in the Keuper facies (the "*Lettenkohle*").

It is, however, not to be precluded the possibility of finding in Poland a conodont fauna, younger than that known thus far, nearer the axial part of the Muschelkalk basin, which is indicated by, e.g., the presence in the Boża Wola borehole of the species *Gondolella (Celsigondolella) watznaueri watznaueri*, occurring in the uppermost conodont zones of the Upper Muschelkalk of Germany (*cf.* Zawidzka 1970a, Jurkiewicz 1973).

A clayey-sandy sedimentation occurs in the Polish part of the Triassic sedimentary basin (Silesian-Cracow monocline) above the deposits which correspond to conodont zone "*4*" (the *G. haslachensis* zone, that is, the middle and upper part of the Fassanian). At the same time, carbonate deposits with conodont fauna (zones "*5—7*"), whose absence from Polish "*Lettenkohle*" is clear for facial reasons, are formed in the western part of the Triassic epicontinental basin (Germany). In the northern areas of Germany, the Upper Muschelkalk (in the chronostratigraphic sense) is also of the paralic type, with a considerable amount of terrigenic elements (Rusitzka 1968; Kozur 1972d).

The Muschelkalk/Keuper boundary of Germany may be correlated in Upper Silesia with a boundary between sandy shales, containing abundant remains of flora and variegated mudstones underlying the "Grenzdolomit". Thus, the "*Lettenkohle*" would still belong to the Middle Triassic (the Ladinian stage) in the Alpine sense. An additional confirmation of this hypothesis is provided by the presence, in the shaly-sandy series just below the boundary with the variegated mudstones, of fragmentary jaw apparatus of the marine polychaetes *?Halla tortilis*, which occur in the German Muschelkalk, but already are not recorded in the German *Lettenkohle* (Zawidzka 1975, *cf.* also Kozur 1971, 1972d).

PALEOGEOGRAPHICAL REMARKS

Differences in the geographical distribution of Triassic conodonts have already been noticed by Huckriede (1958), who indicated a different character of the conodont fauna of the Tethys and of the German Basin.

Further studies on this problem revealed a free exchange of conodonts between particular regions in which the marine Triassic deposits occur, e.g. North America, the Alps, and the German part of the epicontinental basin. On the other hand, apparent differences are observed between the conodont fauna of the Alps and that of the epicontinental Triassic of Europe (Mosher 1968). These differences are strongly marked only in the German part of the Triassic basin, since in Poland the Alpine conodonts are represented abundantly (*cf.* Zawidzka 1970b, 1973, 1974a, b; Trammer 1971, 1972).

In subsequent years, a more accurate recognition of the distribution of the Triassic conodonts enabled to distinguish several conodont provinces (Kozur 1971, 1972a, b; Kozur & Mostler 1971a, 1972a).

On the territory of Poland, unlike Germany, a free exchange of conodont fauna between the Tethys and the epicontinental basin took place in the Lower Muschelkalk. Noteworthy are, however, certain differences in the occurrence of conodonts in the Lower Muschelkalk in the area of Poland itself. In Opole Silesia, no conodonts occur in lower members of the Gogolin Beds (Lower Anisian), while in the Holy Cross Mts they occur as early as the lower parts of the Lower Anisian Wellenkalk (Trammer 1972). Considering, at the same time, the lack of conodonts in the Lower Anisian of the Austro-Alpine province (the Alps, Bulgaria, Hungary, Rumania, Slovakia, the Tatra, Yugoslavia) and their abundance in Greece and in the Asian part of the Tethys, one might conjucture that the migration routes of the conodonts ran through the area of the present East Carpathians (*cf.* Głazek & al. 1973). It is also noteworthy that conodonts appear in Silesia earlier (late Lower Anisian) than in the Alps (Pelsonian).

In the Pelsonian, no significant differences are displayed by conodont faunas of Silesia and of the Holy Cross Mts. In Silesia, the Pelsonian strata (the uppermost part of the Gogolin Beds, the Górażdże and *Terebratula* Beds, as well as the lowermost part of the Karchowice Beds) yield a conodont fauna which displays a far-reaching similarity to that of the Austro-Alpine province (*cf.* the Pelsonian conodonts shown in Fig. 5 and the specific composition of the conodonts occurring in the Austro-Alpine province, as presented by Kozur & Mostler 1972a, Table 1). Corresponding similarities become yet more striking on the Pelsonian/Illyrian boundary, which results from an increase in the number of the Alpine platform conodonts (*Gondolella excelsa* and *G. navicula*) included in the conodont fauna of Silesia. This fact has its appropriate paleogeographical facies explanation: the Illyrian of the Carpathian-Alpine geosyncline is developed as more deep-water deposits than those which were formed in the Lower Anisian or Upper Ladinian (*cf.* Andrusov 1959; Brinkmann 1969).

Now, in turn, in Silesia, part of the Karchowice Beds, corresponding to the lowermost Illyrian, seems to display the most pelagic character of all Muschelkalk deposits. It is therefore believable that an extensive connection existed in the Lower Illyrian between the geosynclinal Carpathian-Alpine sea and the epicontinental basin, a part of which is Opole Silesia.

In the Middle Illyrian (Middle Muschelkalk) no conodonts occur in Silesia, although Alpine diplopores and brachiopods (*cf.* Assmann 1944; Kozur 1974) give ample evidence of a continued existence of the connection with the Tethys.

In the uppermost Illyrian (the lowermost part of the Upper Muschelkalk, the Tarnowice and Wilkowice beds), conodonts reappear in Silesia, although the Alpine influences are not so strong any more and disappear completely at the end of the Illyrian. We may conjecture that the Upper Illyrian migration route of the Alpine conodonts from the Tethys towards the center of the epicontinental basin ran through the Burgundian Gate (*cf.* Brinkmann 1954, 1969; Kozur 1968a, b, 1974; Głazek, Trammer & Zawidzka 1973).

Beginning with the uppermost Illyrian (Wilkowice Beds) up to the Upper Fassanian (Boruszowice Beds) the Silesian conodont and ammonite fauna display a close relationship to the western part of the Triassic epicontinental basin and, on the other hand, a lack of any relationship to the Tethys (*cf.* Kozur 1968a, b, 1972a, b; Kozur & Mostler 1972a).

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— 1974a. Stratygrafia triasu opolskiego w oparciu o konodonty. — Przewodnik 46 Zjazdu P. T. G., Opole 1974.

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K. ZAWIDZKA

STRATYGRAFIA KONODONTOWA WAPIENIA MUSZLOWEGO NA ŚLĄSKU OPOLSKIM

(Streszczenie)

Przedmiotem pracy jest biostratygrafia konodontowa wapienia muszlowego Śląska Opolskiego (*por.* fig. 1—3). Oprócz konodontów (*por.* Zawidzka 1970a, b, 1973, 1974a, b; Kozur 1971, 1972a, b, 1974; Kozur & Mostler 1970a, 1971a, 1972a, b) w wapieniu muszlowym Śląska Opolskiego stwierdzono stosunkowo obfite występowanie innej mikrofauny, jak różne części aparatów szczękowych wieloszczetów, skleryty strzykw, haki ramion głowonogów, otwornice oraz spory glonów (Zawidzka 1971a, 1972a, 1974b, 1975; Kozur & Mostler 1970b; Głazek & al. 1973; Gaździcki & al. 1975).

W wapieniu muszlowym badanego obszaru stwierdzono obecność siedmiu poziomów konodontowych. Trzy pierwsze spośród nich zawierają faunę konodontową niemal identyczną z zespołem triasu środkowego Tetydy (dolny anizyk — dolny illyr, *por.* fig. 4—5). Cztery młodsze poziomy (illyr — fassan) są charakterystyczne dla basenu epikontynentalnego triasu, znamionując germańską i wschodniomedyterańską prowincję konodontową (Kozur 1971, 1972a, b, 1974; Kozur & Mostler 1971a, 1972a).

Na Śląsku Opolskim, podobnie jak w wapieniu muszlowym innych obszarów Polski (*por.* Trammer 1971, 1972, 1975), brak jest fauny konodontowej wyższych poziomów ("5" do "7"). Odpowiadające im wiekowo utwory (langobard) wykształcone są w facjach kajprowych ("*Lettenkohle*").

Zespół konodontów śląskiego wapienia muszlowego różni się od dotychczas opisywanych podobnych zespołów przede wszystkim liczebną przewagą wśród konodontów platformowych form asymetrycznych, bifurkujących, oraz form z dodatkowymi zębami na platformie i przewężeniami tejże lub jej krenulacją (*por.* pl. 35—44).

Analiza typów litologicznych i mikrofacjalnych wapienia muszlowego Śląska Opolskiego (*por.* pl. 1—34) pozwala na stwierdzenie, że rozważane utwory powstały w płytkim i generalnie rzecz biorąc normalnie zasolonym zbiorniku. Wielokrotne sekwencje poziomów z kanałami jelitodysznych (*por.* pl. 8, 11—12) oraz występowanie oolitów, onkolitów i osadów zbliżonych do *grapestone facies* (*por.* pl. 21—22, 24—26, 28) pozwalają na przeprowadzenie analogii między środowiskiem sedymentacji tutejszego wapienia muszlowego a środowiskiem sedymentacji dzisiejszej Wielkiej Ławicy Bahamskiej oraz Zatoki Perskiej.

PLATE 34

1, 5, 7 — Oblong ooids and superficial ooids, the latter developed around echinoderm detritus; Middle Muschelkalk at Kamień Śląski (Illyrian), × 80.

2 — Brittle-star vertebra; Gogolin Beds at Górażdże (Lower Anisian), × 40.

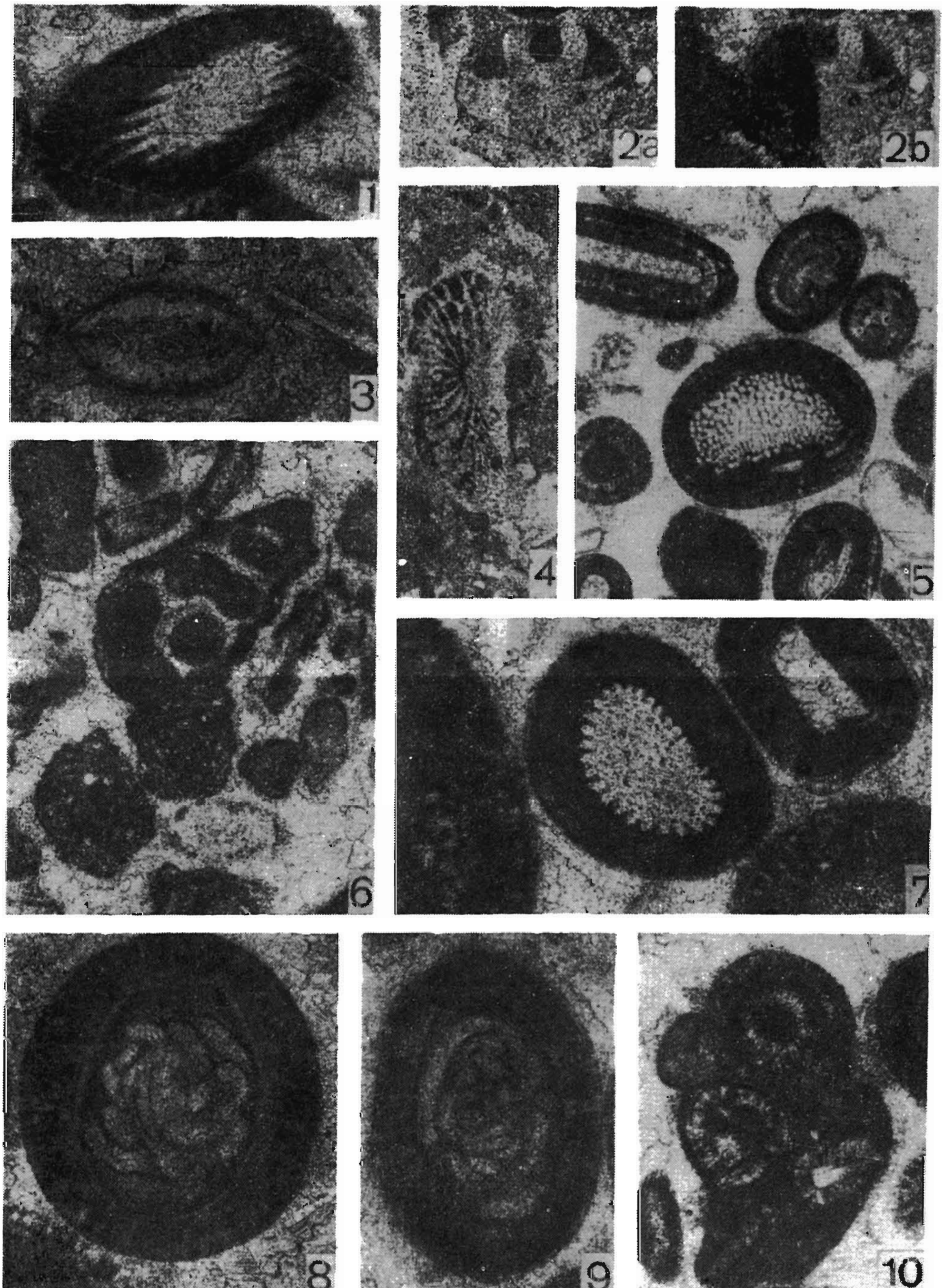
3 — Ostracode test; Górażdże Beds at Strzelce Opolskie (Pelsonian), × 60.

4 — Echinoid spine; Gogolin Beds at Górażdże (Lower Anisian), × 40.

6 — Lump composed of a gastropod shell and the foraminifer, *Glomospira densa* (Pantić); *Terebratula* Beds at Strzelce Opolskie (Pelsonian), × 35.

8-9 — Ooids developed around foraminifers *Glomospira;* Middle Muschelkalk at Kamień Śląski (Illyrian), × 90.

10 — Lump composed of a few ooids; Middle Muschelkalk at Kamień Śląski (Illyrian), × 40.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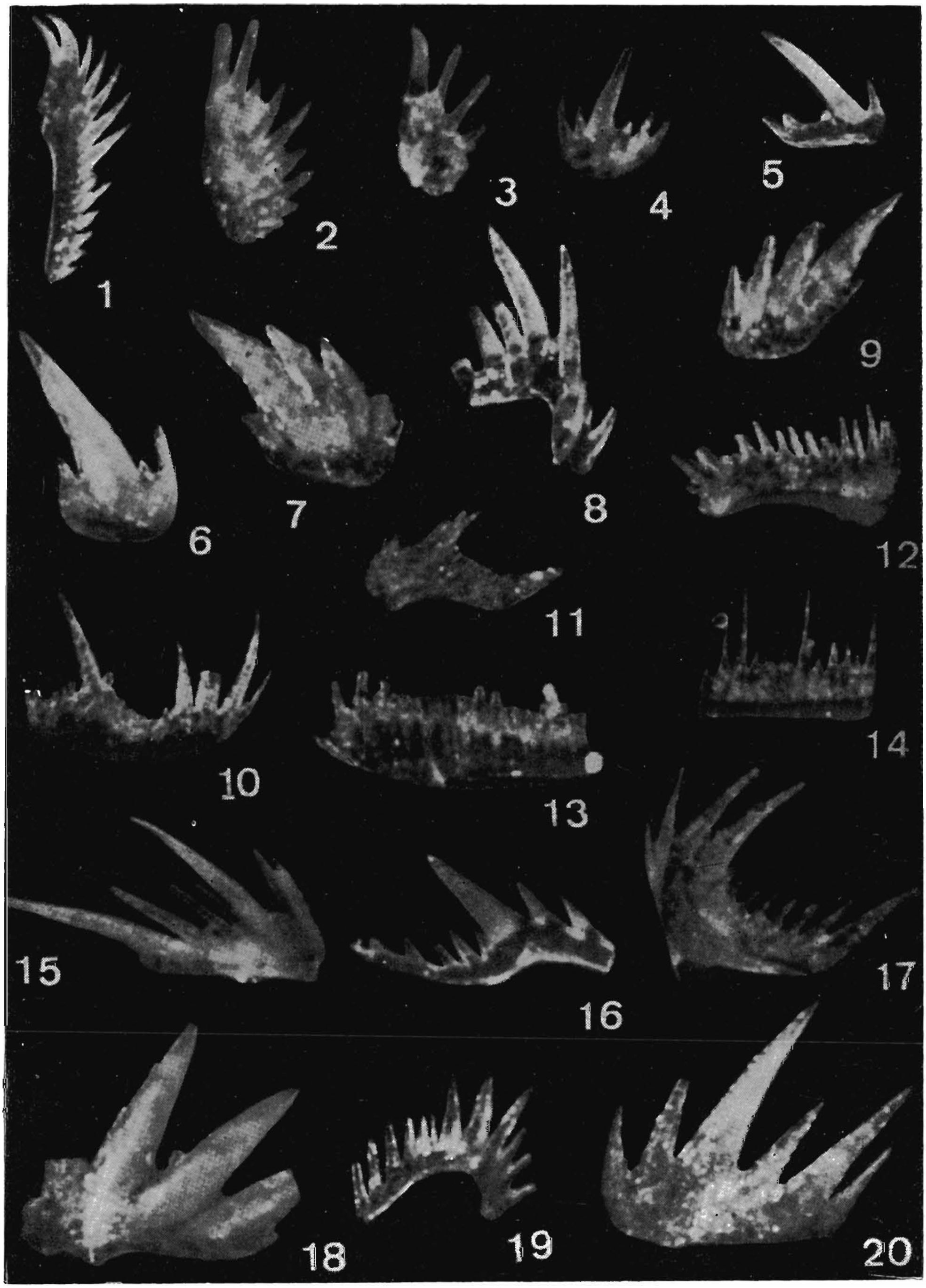
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PLATE 35

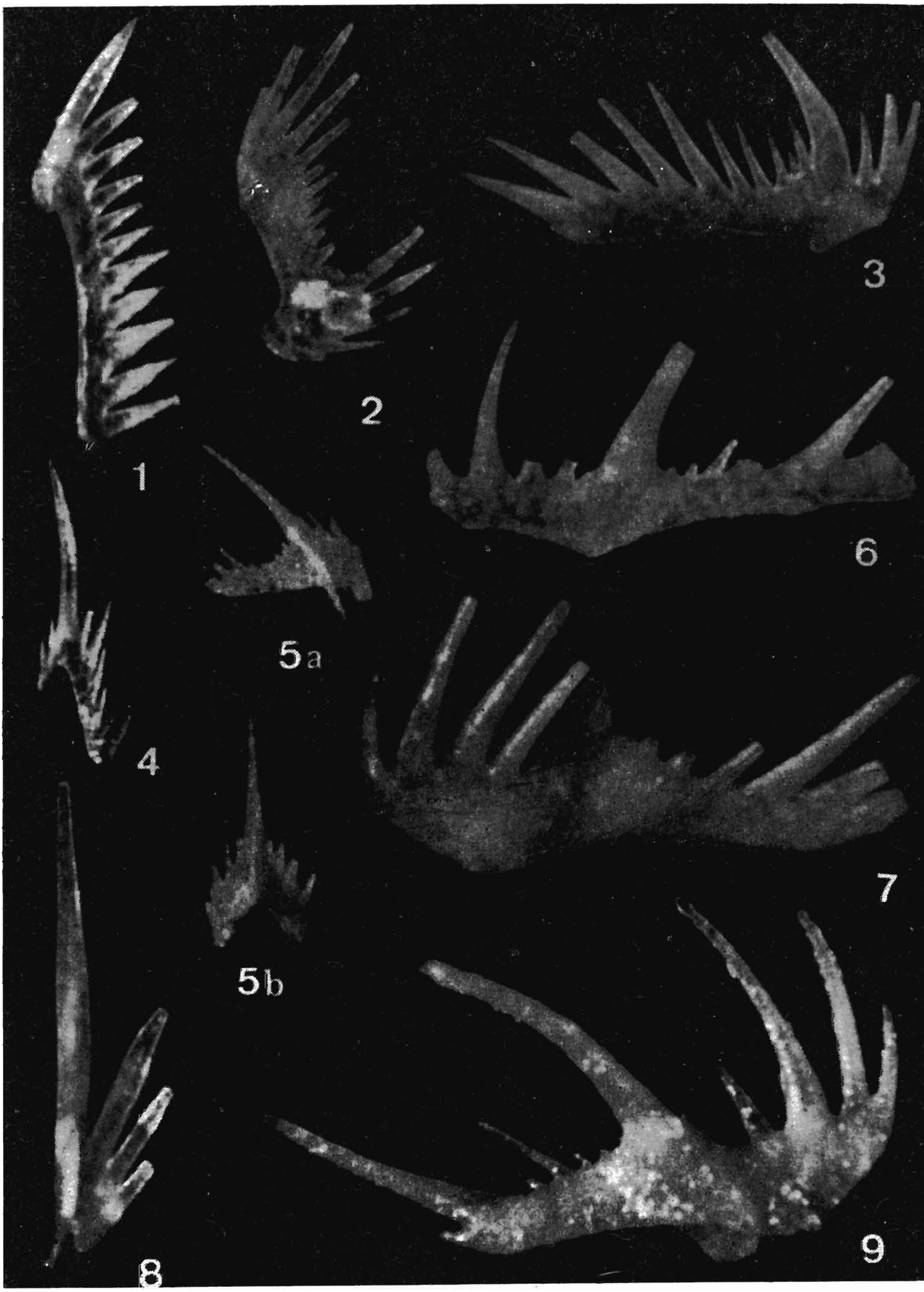
1 — *Chirodella dinodoides* (Tatge); Górażdże Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie, × 85.
2 — *Chirodella polonica* Kozur & Mostler; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Szymiszów.
3 — *Chirodella triquetra* (Tatge); Wilkowice Beds, zone "2" (Fassanian); Ligota Samborowa.
4 — *Cornudina breviramulis breviramulis* (Tatge); Gogolin Beds, *N. kockeli* Zone (Pelsonian); Górażdże.
5 — *Cornudina tortilis* Kozur & Mostler; Górażdże Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie, × 70.
6 — *Cornudina* cf. *breviramulis minor* Kozur; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Malnia.
7, 9 — *Cornudina latidentata* Kozur & Mostler; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Szymiszów.
8 — *Hibbardella bicuspidata* (Kozur); Boruszowice Beds, *G. haslachensis Zone* (Fassanian); Tworóg.
10 — *Neohindeodella aequiramosa* Kozur & Mostler; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie, × 85.
11 — *Neohindeodella summesbergeri ?praecursor* Kozur & Mostler; Górażdże Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.
12 — *Neohindeodella triassica ?riegeli* (Mosher); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Górażdże.
13-14 — *Neohindeodella dropla* (Spasov & Ganev); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Wierchlesie.
15 — *Neohindeodella triassica kobayashii* (Igo & Koike); Tarnowice Beds, zone *"1"* (Illyrian); Tarnów Opolski.
16 — *Ozarkodina tortilis* Tatge; Wilkowice Beds, zone *"2"* (Illyrian); Ligota Samborowa.
17 — *Diplododella bidentata* (Tatge); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Górażdże.
18 — *Cornudina pandodentata* (Budurov); Górażdże Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie, × 85.
19 — *Metalonchodina?* sp.; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Górażdże.
20 — *Cornudina pandodentata* (Budurov); Gogolin Beds, *N. kockeli* Zone (Pelsonian); Górażdże.

All photos × 100, except of Fig. 1, 5, 10 and 18; taken by L. Łuszczewska, M. Sc.

PLATE 36

1 — *Prioniodina (Cypridodella) muelleri* (Tatge); *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Szymiszów.
2 — *Enantiognathus latus* Kozur & Mostler; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Górażdże.
3 — *Neohindeodella triassica triassica* (Müller); Górażdże Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.
4 — *Enantiognathus ziegleri* (Diebel); Wilkowice Beds, zone "*3*" (Fassanian); Tworóg 7.
5 — *Hibbardella* sp.; Wilkowice Beds, zone "*2*" (Fassanian); Tworóg 7.
6 — *Neohindeodella nevadensis* (Müller) — specimen transitional to *N. triassica* (Müller); *Terebratula Beds, N. kockeli* Zone (Pelsonian) at Strzelce Opolskie.
7 — *Neohindeodella curvata* Kozur & Mostler; Gogolin Beds, *N. kockeli* Zone (Pelsonian); Górażdże.
8 — *Enantiognathus ziegleri* (Diebel); Wilkowice Beds, zone "*2*" (Fassanian); Tworóg 7.
9 — *Neohindeodella curvata* Kozur & Mostler; Gogolin Beds, *N. germanicus Subzone* (Lower Anisian); Strzelce Opolskie.

All photos × 100; taken by L. Łuszczewska, M. Sc.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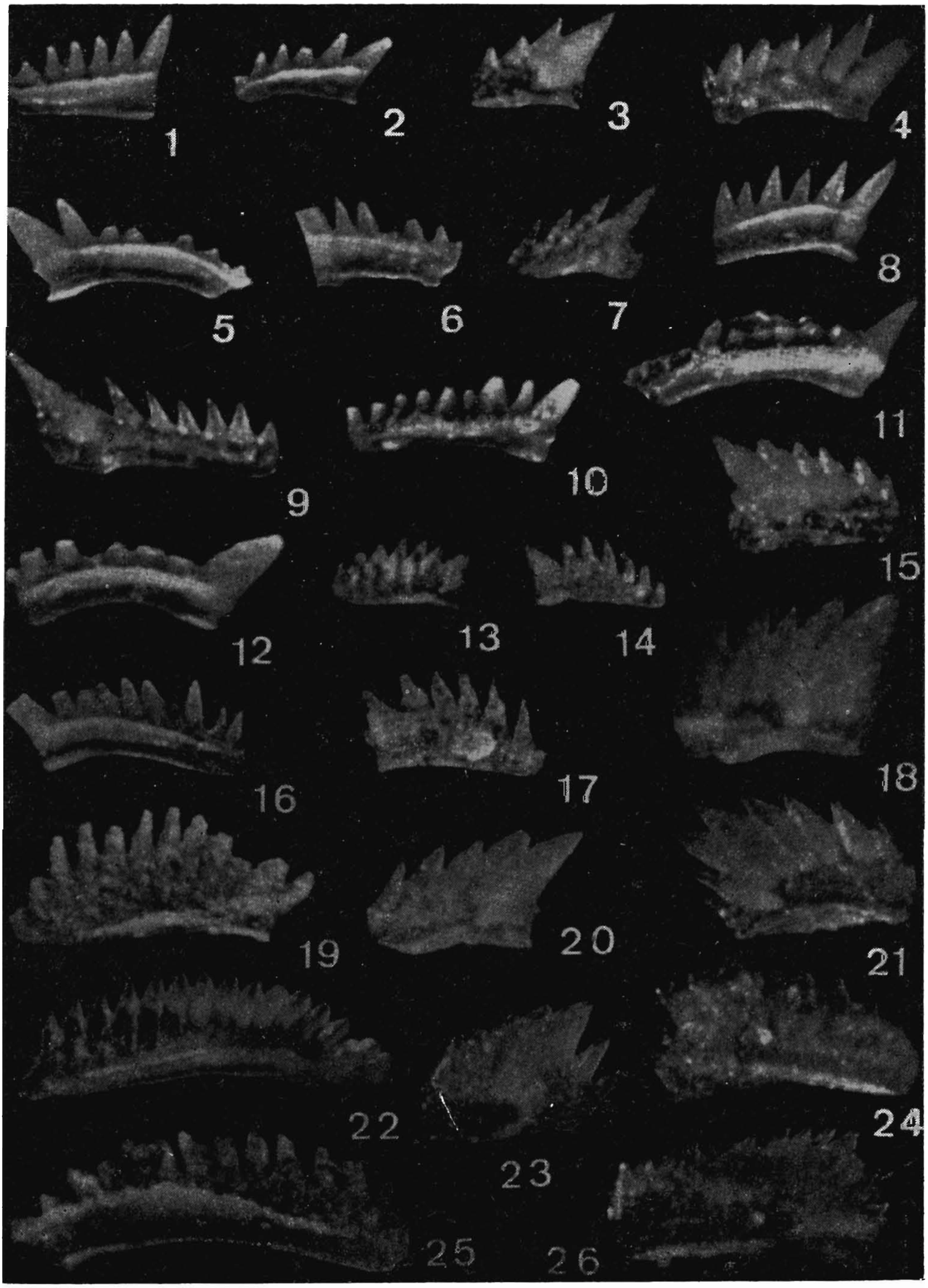
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PLATE 37

1 — *Gondolella watznaueri praecursor* Kozur; Boruszowice Beds, *G. haslachensis* Zone (Fassanian); Tworóg *13.*

2, 5-6, 10, 12, 16 — *Gondolella haslachensis* Tatge; Boruszowice Beds, *G. haslachensis* Zone (Fassanian); Tworóg *13.*

3 — *Neospathodus kockeli* (Tatge) — juvenile specimen; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian) at Szymiszów.

4 — *Gondolella watznaueri watznaueri* Kozur; Upper Muschelkalk, zone "*?5*"; borehole Boża Wola, western margin of the Holy Cross Mts.

7 — *Ozarkodina tortilis diebeli* Kozur & Mostler — juvenile specimen, very close to *Pollognathus germanicus* (Kozur); *Terebratula* Beds, *N. kockeli* Zone (Pelsonian) at Strzelce Opolskie.

8 — *Gondolella watznaueri praecursor* Kozur; Boruszowice Beds, *G. haslachensis* Zone (Fassanian); Tworóg *13.*

9 — *Pollognathus germanicus* (Kozur); Wilkowice Beds, zone "*3*" (Fassanian); Tworóg *13.*

11 — *Gondolella haslachensis* Tatge; Boruszowice Beds, *G. haslachensis* Zone (Fassanian); Tworóg 7.

13 — *Gondolella ?excelsa* (Mosher) — juvenile specimen, without platform; Karchowice Beds, assemblage zone *G. excelsa* (Illyrian?) at Szymiszów.

14 — *Gondolella navicula* Huckriede — juvenile specimen, without platform; Gorażdże Beds, *N. kockeli* Zone (Pelsonian), Strzelce Opolskie, × 85.

15, 20 — *Neospathodus kockeli* (Tatge); *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Szymiszów.

17 — *Gondolella excelsa* (Mosher) — juvenile specimen, without platform; Karchowice Beds, assemblage zone *G. excelsa* (Illyrian?) at Szymiszów.

18 — *Neospathodus kockeli* (Tatge); Karchowice Beds, *N. kockeli* Zone (Pelsonian); Mt. Święta Anna.

19, 22, 25 — *Gondolella excelsa* (Mosher); Karchowice Beds, assemblage zone *G. excelsa* (Illyrian?); Szymiszów.

21, 24 — *Neospathodus germanicus* Kozur; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Wierchlesie.

23 — *Neospathodus kockeli* (Tatge) — specimen very close to *N. germanicus* Kozur; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian) at Strzelce Opolskie.

26 — *Neospathodus* sp.; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Wierchlesie.

All photos × 100, except of Fig. 14; taken by L. Łuszczewska, M. Sc.

PLATE 38

1 — *Hibbardella meissneri* (Tatge); Wilkowice Beds, zone "*1*" (Illyrian); Ligota Samborowa.

2 — *Neoplectospathodus muelleri* Kozur & Mostler; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Wierchlesie.

3 — *Neohindeodella dropla* (Spasov & Ganev); *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Szymiszów.

4 — *Metaprioniodus suevica* (Tatge); Boruszowice Beds, *G. haslachensis* Zone (Fassanian); Tworóg *13*.

5 — *Diplododella bidentata* (Tatge); Górażdże Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.

6 — *Metalonchodina* sp.; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.

7 — *Diplododella bidentata* (Tatge); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Wierchlesie.

8 — *Hibbardella meissneri* (Tatge); *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.

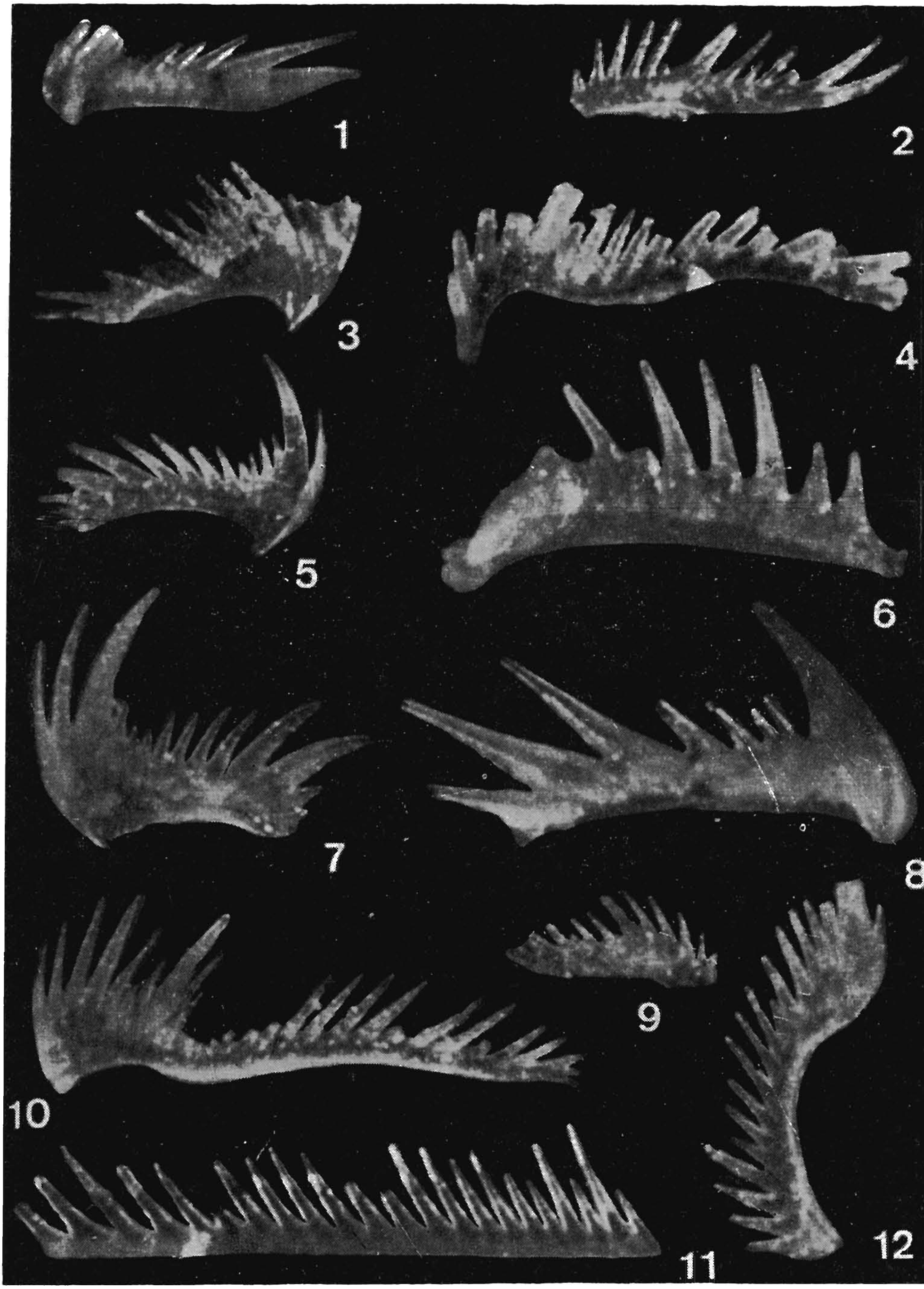
9 — *Neohindeodella triassica* (Müller); Górażdże Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.

10 — *Metaprioniodus suevica* (Tatge); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Wierchlesie.

11 — "*Prioniodella decrescens*" Tatge; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Szymiszów.

12 — *Grodella delicatula* (Mosher); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Wierchlesie.

All photos × 100; taken by L. Łuszczewska, M. Sc.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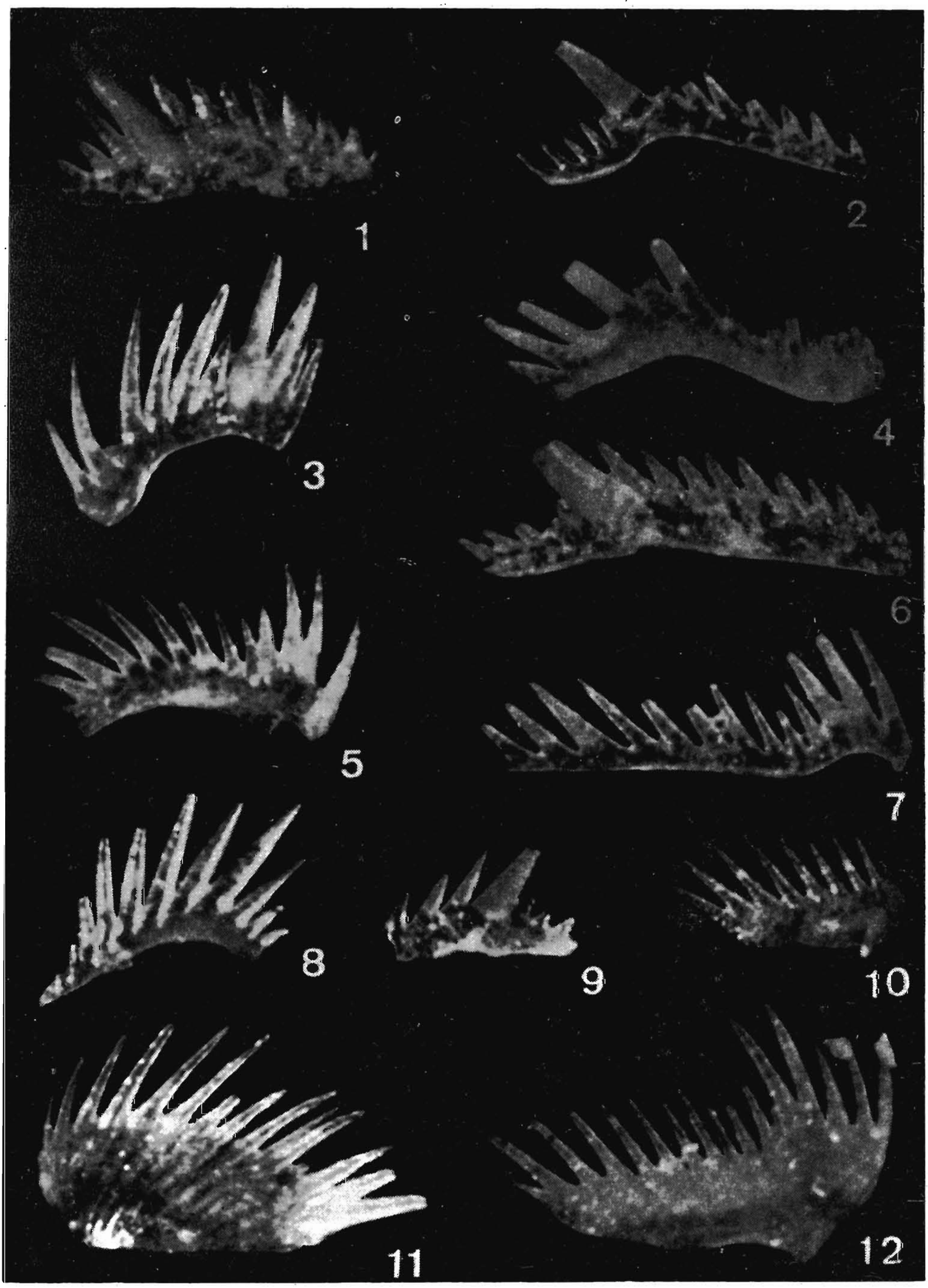


PLATE 39

1 — *Ozarkodina* sp.; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.
2 — *Ozarkodina tortilis* Tatge; Wilkowice Beds, zone *"2"* (Fassanian); Tworóg 7.
3 — *Metaprioniodus suevica* (Tatge); Wilkowice Beds, zone *"2"* (Fassanian); Tworóg 7.
4 — *"Prioniodella prioniodellides"* Tatge; Tarnowice Beds, zone *"1"* (Illyrian); Tarnów Opolski.
5 — *Neohindeodella triassica* (Müller); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Malnia.
6 — *Ozarkodina tortilis* Tatge; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.
7 — *Metaprioniodus bicuspidata* Kozur & Mostler; Boruszowice Beds, *G. haslachensis* Zone (Fassanian); Tworóg *13*.
8 — *"Prioniodella prioniodellides"* Tatge; Wilkowice Beds, zone *"3"* (Fassanian); Tworóg 7.
9 — *Ozarkodina tortilis diebeli* Kozur & Mostler; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Szymiszów.
10 — *Neoplectospathodus?* sp.; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Jemielnica.
11 — *Neohindeodella triassica riegeli* (Mosher); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Malnia.
12 — *Neohindeodella triassica* (Müller) — specimen close to *N. triassica aequidentata* Kozur & Mostler; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian) at Strzelce Opolskie.

All photos × 100; taken by L. Łuszczewska, M. Sc.

PLATE 40

1 — *Gondolella ?suhodolica* (Budurov & Stefanov); Wilkowice Beds, Zone "*2*" (Fassanian); Ligota Samborowa.

2 — *Gondolella bifurcata* (Budurov & Stefanov); *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Szymiszów.

3 — *Gondolella ?bifurcata* (Budurov & Stefanov); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Górażdże.

4 — *Gondolella navicula* Huckriede; arching carina and asymmetrical basal area close to those of *G. excentrica* (Budurov & Stefanov); Gogolin Beds, *N. kockeli* Zone (Pelsonian) at Górażdże.

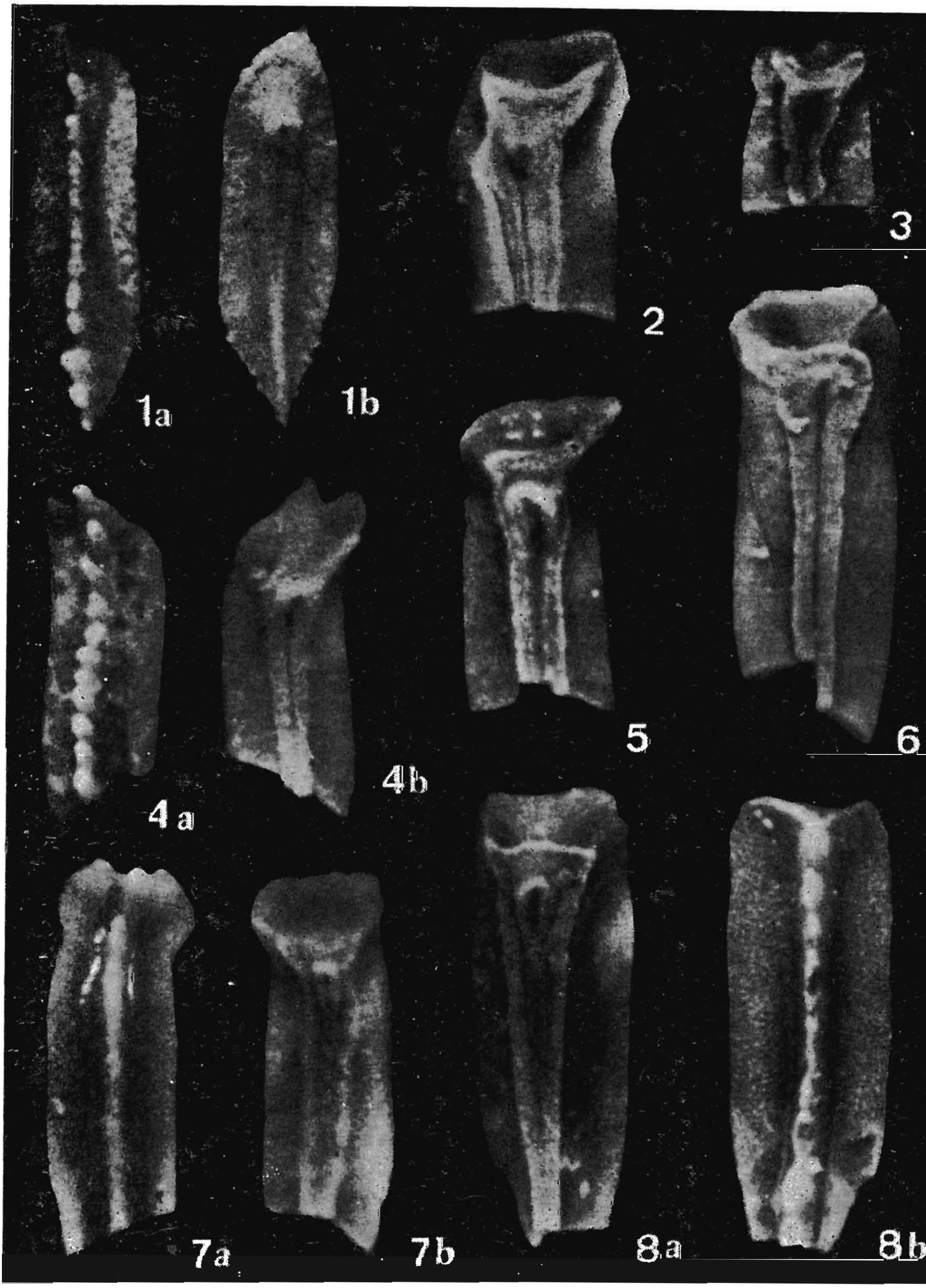
5 — *Gondolella excentrica* (Budurov & Stefanov) — specimen with tendency to bifurcation of basal area; Boruszowice Beds, *G. haslachensis* Zone (Fassanian) at Pietraszów.

6 — *Gondolella navicula* Huckriede — specimen transitional to *G. bifurcata* (Budurov & Stefanov); Karchowice Beds, assemblage zone *G. excelsa* (Illyrian) at Mt. Święta Anna.

7 — *Gondolella mombergensis ?mombergensis* Tatge — specimen very close to be transitional between *G. navicula* Huckriede and *G. bifurcata* (Budurov & Stefanov); Wilkowice Beds, zone "*2*" (Fassanian) at Ligota Samborowa.

8 — *Gondolella ?mombergensis* Tatge — massive specimen with tendency to bifurcation of basal area; Wilkowice Beds, zone "*2*" (Fassanian) at Ligota Samborowa.

All photos × 100; taken by L. Łuszczewska, M. Sc.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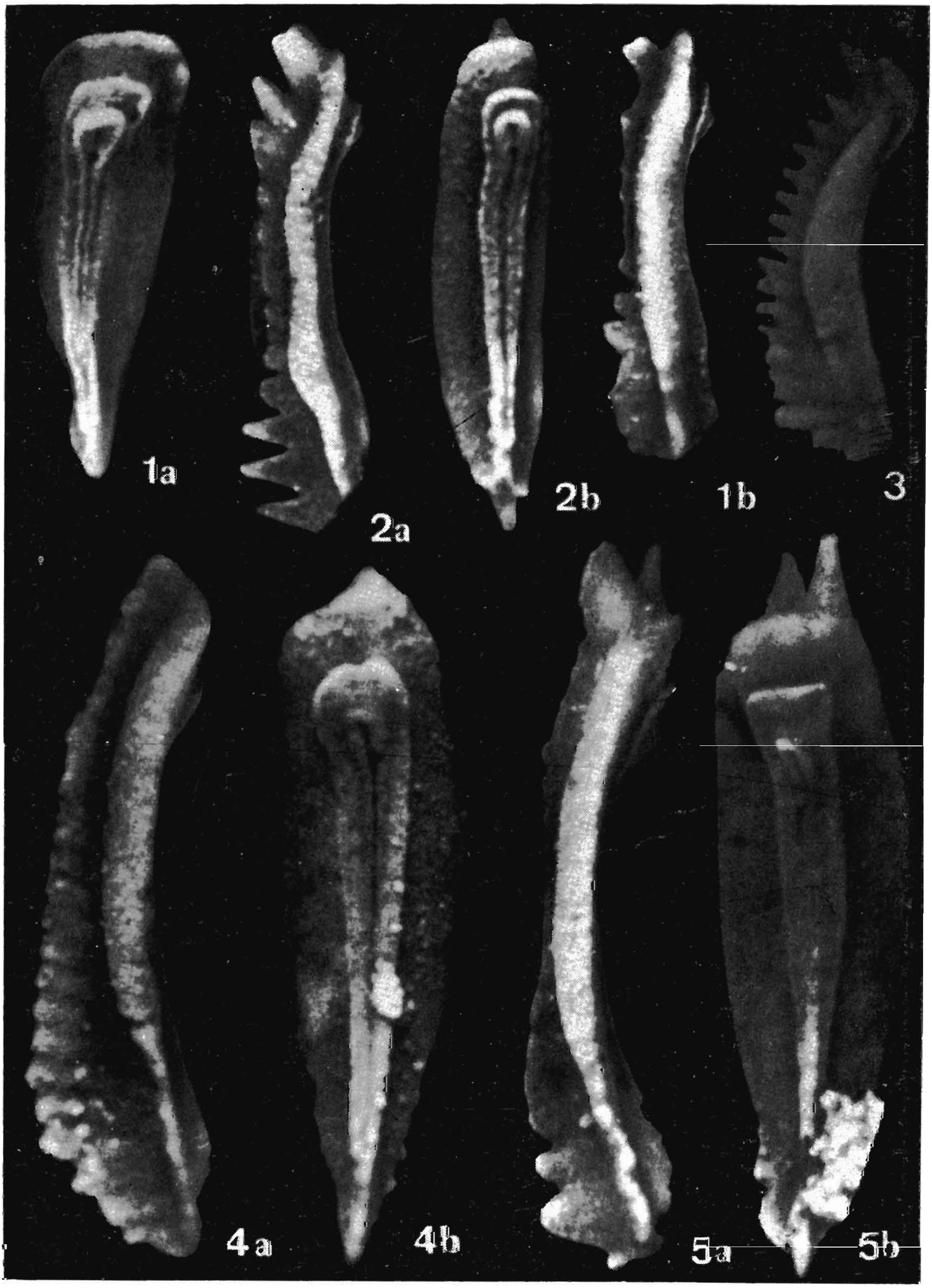
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PLATE 41

1-2 — *Gondolella mombergensis mombergensis* Tatge; Wilkowice Beds, zone *"3"* Fassanian); Tworóg 7.

3 — *Gondolella excelsa* (Mosher); *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.

4 — *Gondolella navicula* Huckriede; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian); Strzelce Opolskie.

5 — *Gondolella prava* Kozur; Wilkowice Beds, zone *"3"* (Fassanian); Tworóg 7.

All photos × 100; taken by L. Łuszczewska, M. Sc.

PLATE 42

1 — *Gondolella constricta* Mosher; Wilkowice Beds, zone "2" (Fassanian); Gąsiorowice.

2 — *Gondolella mombergensis mombergensis* Tatge — asymmetrical specimen, highly similar to *G. excentrica* (Budurov & Stefanov), and bearing distinct constriction of rear part of the platform; Górażdże Beds, *N. kockeli* Zone (Pelsonian) at Strzelce Opolskie.

3 — *Gondolella constricta* Mosher — specimen with bifurcation of rear part of the basal area similar to that of *G. basissymmetrica* (Budurov & Stefanov); Wilkowice Beds, zone "2" (Fassanian) at Ligota Samborowa.

4 — Asymmetrical specimen with features typical both of *Gondolella navicula* Huckriede and *G. mombergensis* Tatge; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian) at Strzelce Opolskie.

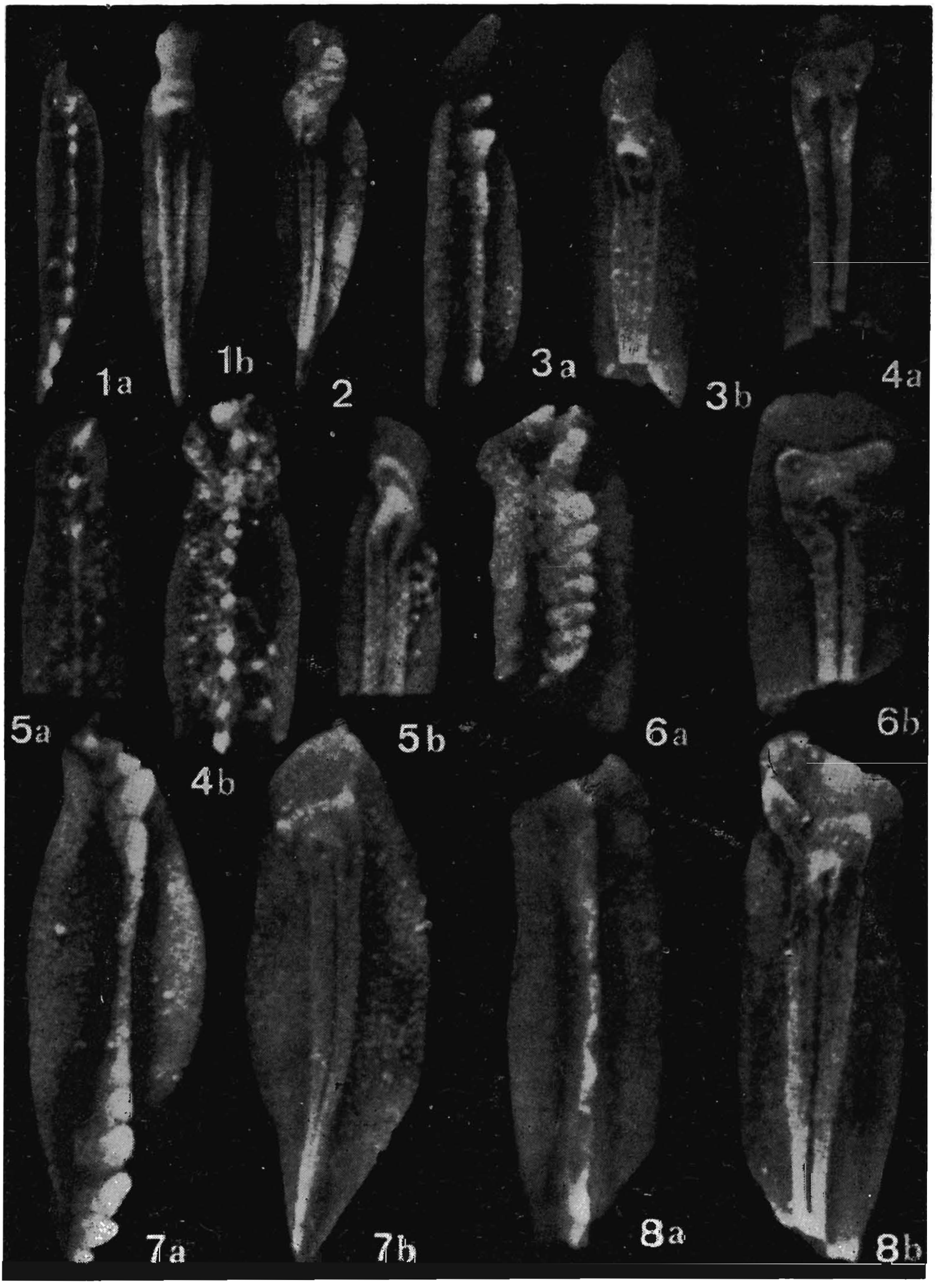
5 — *Gondolella excentrica* (Budurov & Stefanov); Wilkowice Beds, *G. haslachensis* Zone (Fassanian); Tworóg 7.

6 — *Gondolella navicula* Huckriede — specimen transitional to *G. bifurcata* (Budurov & Stefanov); *Terebratula* Beds, *N. kockeli* Zone (Pelsonian) at Strzelce Opolskie.

7 — *Gondolella ?mombergensis* Tatge; Górażdże Beds (Pelsonian); Wierchlesie.

8 — *Gondolella excentrica* (Budurov & Stefanov); Wilkowice Beds, zone "3" (Fassanian); Tworóg 7.

All photos × 100; taken by L. Łuszczewska, M. Sc.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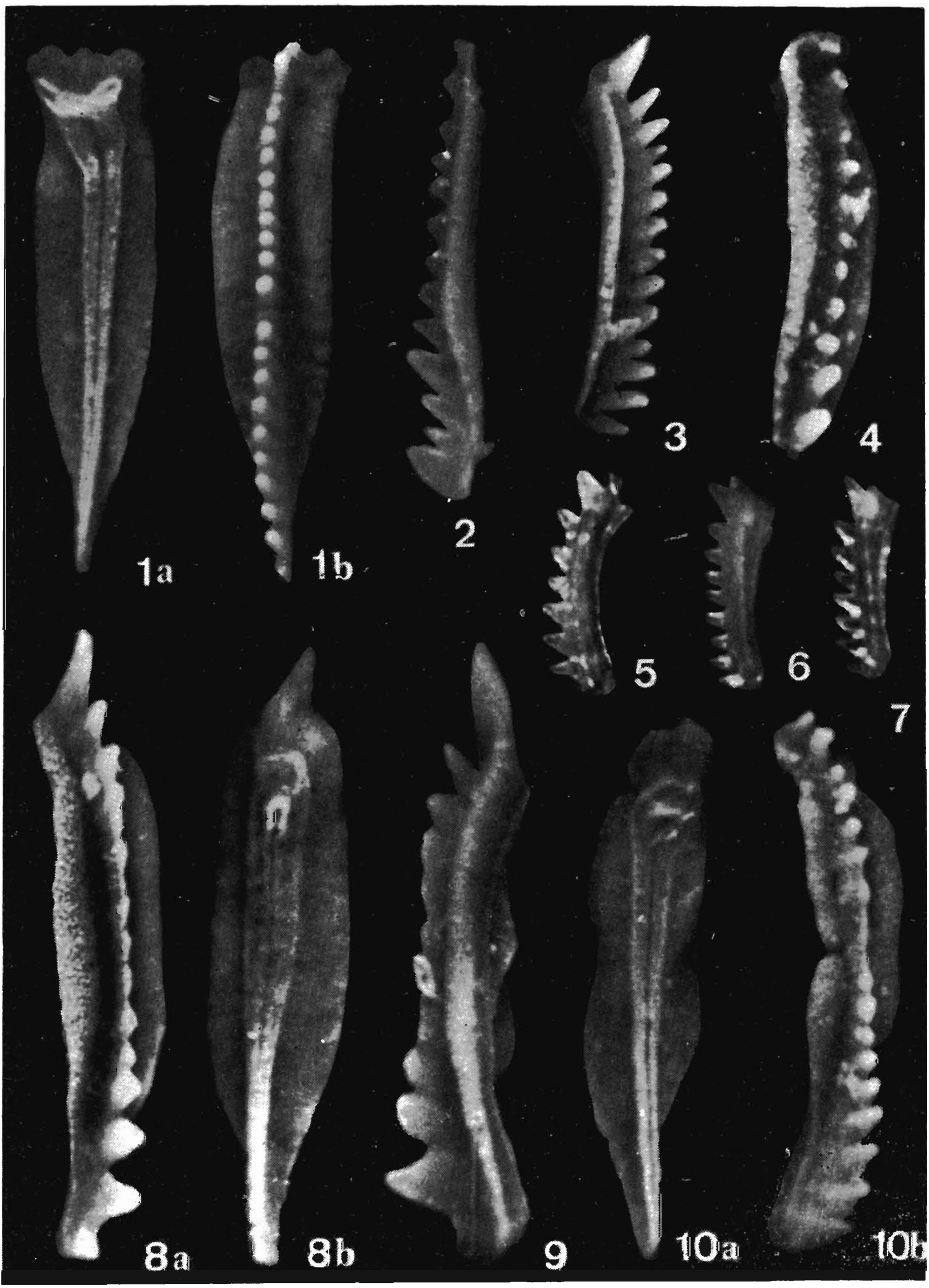
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PLATE 43

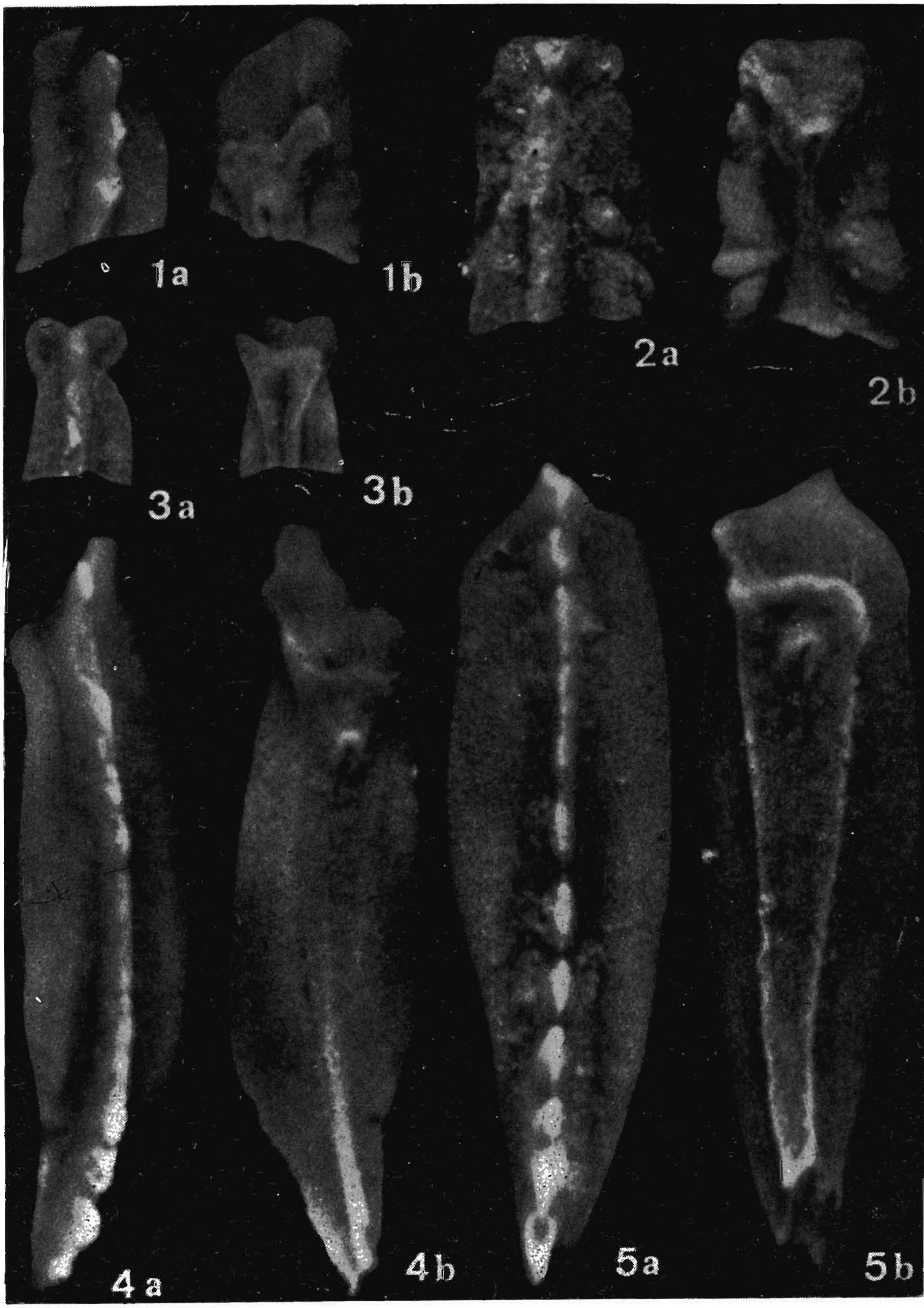
1 — *Gondolella bifurcata* (Budurov & Stefanov); Gogolin Beds, *N. germanicus* Subzone (Lower Anisian); Malnia.
2 — *Gondolella longa* Budurov & Stefanov; Wilkowice Beds, zone "*3*" (Fassanian); Tworóg 7.
3 — *Gondolella mombergensis media* Kozur — specimen close to immature forms of *G. cornuta* (Budurov & Stefanov); Wilkowice Beds, *G. haslachensis* Zone (Fassanian) at Tworóg 7.
4 — *Gondolella mombergensis mombergensis* Tatge; Boruszowice Beds, *G. haslachensis* Zone (Fassanian); Tworóg *13*.
5 — *Gondolella mombergensis media* Kozur — juvenile specimen; Wilkowice Beds, zone "*3*" (Fassanian) at Tworóg 7.
6 — *Gondolella mombergensis media* Kozur — juvenile specimen, bearing resemblance to *G. haslachensis* Tatge; Wilkowice Beds, *G. haslachensis* Zone (Fassanian) at Tworóg 7.
7 — *Gondolella mombergensis mombergensis* Tatge — juvenile specimen; Wilkowice Beds, zone "*2*" (Illyrian) at Ligota Samborowa.
8 — *Gondolella cornuta* (Budurov & Stefanov); Wilkowice Beds, zone "*3*" (Fassanian); Tworóg 7.
9 — *Gondolella cornuta* (Budurov & Stefanov); Tarnowice Beds, zone "*1*" (Illyrian); Tarnów Opolski.
10 — *Gondolella navicula* Huckriede — asymmetrical specimen with pronounced constrictions of the platform in its median and rear parts; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian) at Strzelce Opolskie.

All photos × 100; taken by L. Łuszczewska, M. Sc.

PLATE 44

1 — *Gondolella excentrica* (Budurov & Stefanov); Wilkowice Beds, zone *"2"* (Fassanian); Wierchlesie.
2 — *Gondolella navicula* Huckriede — ?pathological specimen; *Terebratula* Beds, *N. kockeli* Zone (Pelsonian) at Strzelce Opolskie.
3 — *Gondolella* sp. — specimen with asymmetrical basal area and two-sided constriction of the platform; Gogolin Beds, *N. germanicus* Subzone (Lower Anisian) at Wierchlesie.
4 — *Gondolella prava* Kozur; Wilkowice Beds, zone *"2"* (Illyrian); Ligota Samborowa.
5 — *Gondolella mombergensis mombergensis* Tatge — specimen with a characteristic ridge rib on the aboral side of rear part of the platform; Wilkowice Beds, zone *"3"* (Fassanian) at Izbicko.

All photos × 100; taken by L. Łuszczewska, M. Sc.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