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Stratigraphy and facies development of the Muschelkalk in the south-western Holy Cross Mts

ABSTRACT: Lithology and facies development of the Muschelkalk in the south-western Mesozoic margin of the Holy Cross Mts are discussed. Conodont datings made it possible to correlate Muschelkalk sections from Germany and the Holy Cross Mts; it was shown that the Muschelkalk section of the latter corresponds to the Alpine chronostratigraphic units — Anisian and Lower Ladinian (Fassanian). The analysis of conodont assemblages evidences that the Holy Cross area successively belonged during the Muschelkalk to three different paleobiogeographic provinces: Asiatic, Austro-Alpine, and German.

INTRODUCTION

The paper presents results of studies on stratigraphy and facies development of the Muschelkalk exposed in the south-western Mesozoic margin of the Holy Cross Mts (Fig. 1). The strata were folded, along with other Mesozoic series, at the turn of the Cretaceous and the Tertiary (Kutek & Głazek 1972). Locally the section of the Muschelkalk is incomplete because of tectonic gaps (*cf.* Senkowiczowa 1957, 1959, 1961); for example, the Upper Muschelkalk is lacking in the vicinity of Brzeziny and to the S of Chęciny and the whole Muschelkalk is missing in the area SE of Zajączków (Fig. 1).

In the investigated area the Muschelkalk sequence is exposed in several small and in three large quarries. The latter (Obice, Wolica and Wincentów, *cf.* Fig. 1) gave an opportunity to analyse the full profiles (Fig. 3).

The stratigraphic subdivision was carried out on the basis of conodont fauna. The data concerning stratigraphic distribution of ostracodes, holothurian sclerites, brachiopods, pelecypods and ceratitids were also occasionally used to elucidate some points, while the foraminifers are the subject of a separate paper (Gaździcki, Trammer & Zawidzka 1975).

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PREVIOUS INVESTIGATIONS

Muschelkalk strata of the south-western margins of the Holy Cross Mts were the subject of several papers from the 19th c. and early 20th c. (J. B. Pusch, L. Zejschner, M. Michalski, J. Siemiradzki and J. Czarnocki). However, the papers treated the Muschelkalk strata in a rather general and accidental way and thus are of historical importance (for a complete list of early references *see* Senkowiczowa 1970). The first detailed infor-

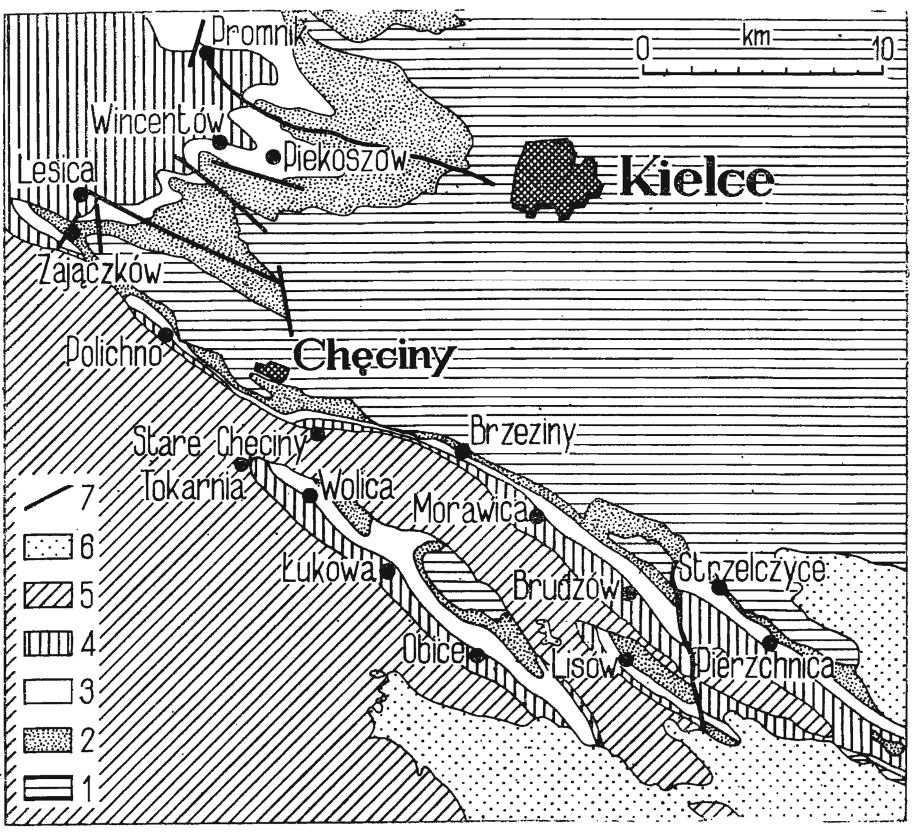


Fig. 1. Location map of the Muschelkalk outcrops along the SW margin of the Holy Cross Mts

1 Palaeozoic, *2* Bunter Sandstone, *3* Muschelkalk, *4* Keuper and Rhaetian, *5* Jurassic and Cretaceous, *6* Miocene (marine Tortonian), *7* faults mation on the Muschelkalk in the area studied is given by Kowalczewski (1926) who dealt with the Upper Muschelkalk and recorded numerous finds of German ceratitids.

The lithostratigraphic subdivision of the Muschelkalk from the south-western Mesozoic margin of the Holy Cross Mts, accepted in the present paper, was elaborated by Senkowiczowa (1957, 1959, 1961, 1962, 1970) who has also included detailed descriptions of exposures and full lists of macrofauna. Additional data on lithostratigraphy and faunal assemblages of the Muschelkalk from the Morawica area were given by Filonowicz (1968).

In his previous papers, the author presented first conodont datings and some new data on paleogeography and sedimentation of the Muschelkalk deposits (Trammer 1971, 1972a, b, 1973, 1974a, b, c; Bialik, Trammer & Zapaśnik 1972). The conodont datings made it possible to correlate the lithostratigraphic subdivision of the Lower Muschelkalk of the Holy Cross Mts with the chronostratigraphic schema (Trammer 1972b) and to compare the Upper Muschelkalk of this area with the contemporaneous strata in Germany (Trammer 1971, 1972b).

Kaźmierczak & Pszczółkowski (1969) and Kostecka (1972) contributed on some sedimentological and biosedimentological aspects of the Muschelkalk; Liszkowski (1973) and Gaździcki & Kowalski (1974) concerned new findings of the Muschelkalk fauna and flora.

RÖT/MUSCHELKALK BOUNDARY

The uppermost Röt from the area studied is represented by alternations of thin-bedded micritic, marly, and organodetrital yellow limestones. The limestones yield pelecypods *Costatoria costata* (Zenker); the Röt/ /Muschelkalk boundary was interpreted as delineated by disappearance of this form (*cf.* Senkowiczowa 1957).

A key horizon with crinoid stems was found about 1—2 m below the base of the Muschelkalk in organodetrital limestones forming the topmost part of the Röt (Pl. 6, Fig. 1). Another key horizon with burrows (Pl. 11, Figs 1—2) was found a few meters below this boundary in sections at Morawica, Brzeziny and Wolica.

THE MUSCHELKALK SEQUENCE

The lithostratigrahic subdivision proposed by Senkowiczowa (1957, 1961) for the Muschelkalk from the south-western Mesozoic margin of the Holy Cross Mts was accepted in the paper. The lithostratigraphic units proposed by this author may be characterized as follows.

LOWER MUSCHELKALK

WOLICA BEDS

The Wolica Beds are composed of gray micritic limestones intercalated with gray grained limestones and yellow marly limestones (*cf.* Fig. 2). Top surfaces of

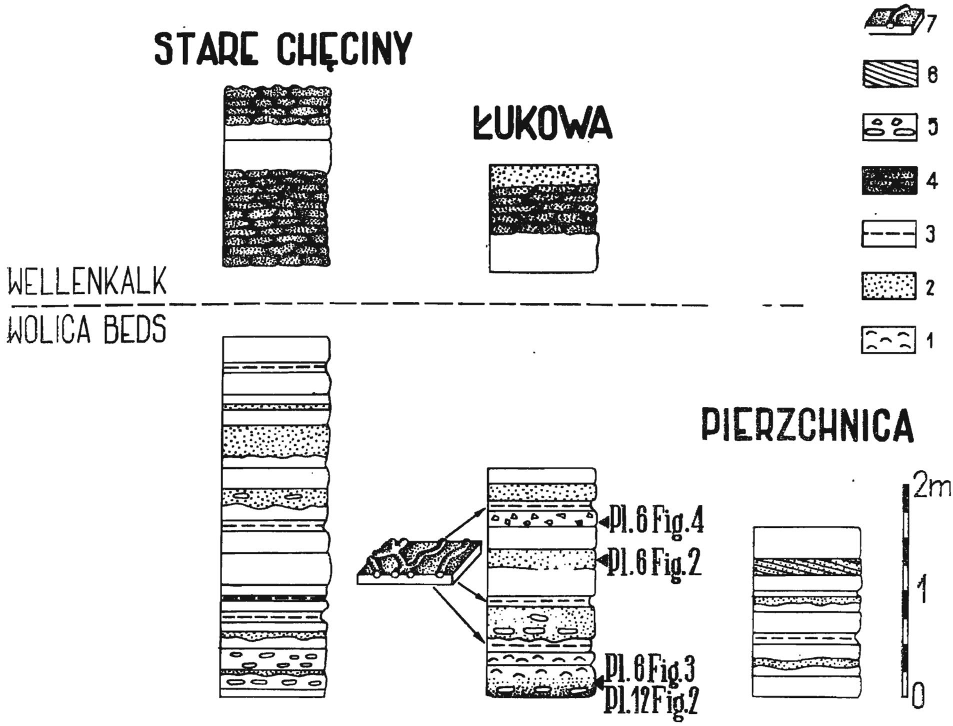


Fig. 2. Selected profiles of the Wolica Beds

1 lumachelles, *2* grained limestones, *3* micritic limestones, locally marly limestones (dashed), *4* crumpled limestones, *5* intraclasts, *6* diagonal bedding, *7* organic furrows

particular marly layers show biogenic furrows. Small erosional furrows are often found at the contact of grained and micritic limestone layers. Grained layers are generally represented by sparry-micritic organodetrital limestones (Pl. 6, Figs 2, 3). Crinoid stems are the main rock-forming elements here; other bioclasts such as debris of pelecypod and gastropod shells and lumps are represented in subordinate amounts. Therefore the rock may be termed as encrinite *sensu* Gwinner & al. (1968). In the encrinite layers, crinoid stems composed of more than a dozen columnals are sometimes found (Pl. 12, Fig. 2). Detrital limestones composed of fine micritic angular intraclasts are also occasionally found (Pl. 6, Fig. 4).

The Wolica Beds are about 6 m thick.

WELLENKALK

The Wellenkalk is represented (*cf.* Fig. 3) by alternating lumpy (Pl. 1; Pl. 2, Fig. 3; Pl. 12, Fig. 1), lenticular-bedded (*Linsen-* and *Flaserschichtung;* see Pl. 2, Figs 1, 2), micritic (Pl. 6, Fig. 6; Pl. 7, Fig. 2), grained, coquina-like and marly limestones and marls.

Coquinas, represented in subordinate amounts in the section, are built of *Lima* (Pl. 14) and sometimes of *Gervilleia* shells (Pl. 12, Fig. 3). The *Lima* shells are represented by single valves, usually uncrushed and set more or less parallelly to the bedding, and oriented convex-side up or down. The *Gervilleia* shells are kneaded, crushed and "perched" into stocks.

Micritic and marly limestones often show parallel lamination. Thin-shelled pelecypods and fragments of crinoid stems with preserved cirri occur sometimes in masses on top surfaces of the limestone layers. Moreover, traces of furrowing, primarily represented by horizontal burrows, *Rhizocorallium* sp., are also found here.

Small erosional furrows filled with grained material including angular micritic intraclasts were often found at the contact between grained and micritic limestones. Small current ripples occasionally shape the surface of grained limestones in the Obice profile. At Wolica, some surfaces of grained limestones are covered with scales, teeth and vertebrae of fishes (*cf.* Liszkowski 1973). Moreover, horizontal *Rhizocorallium* sp. are recognizable on the surfaces of grained limestones (Pl. 15, Fig. 1, 2).

The grained layers are represented by micritic and sparry-micritic organodetrital limestones with lumps. Pelecypod shell fragments predominate in the debris (Pl. 6, Figs 5, 6; Pl. 7, Figs 1, 2). Gastropod, brachiopod and ostracode shell debris, fragments of crinoid stems and fish teeth occur in subordinate amounts; moreover, foraminifers Nodosaridae gen. et sp. div. are occasionally present. Encrinites are also sometimes found (Pl. 12, Fig. 1).

Synsedimentary disturbances are fairly common in the Wellenkalk (*cf.* Fig. 3; and Bialik & al. 1972). Two layers of infraformational conglomerates (Pl. 13, Fig. 1; *cf.* also Bialik & al. 1972) and an organodetrital turbidite layer (Pl. 13, Fig. 2) were found at Wincentów.

The Wellenkalk series is about 22 m thick.

ŁUKOWA BEDS

The Łukowa Beds are composed of gray massive layers of micritic limestones with grained limestone intercalations (*cf.* Fig. 3). The contribution of marly limestones is subordinate.

The micritic limestones sometimes yield small admixture of organogenic debris (Pl. 7, Fig. 6). There also occur porous micritic limestones showing either calcium crystals moldic porosity (Pl. 7, Fig. 3) or pelecypod moldic porosity (*cf.* Choquette & Pray 1970).

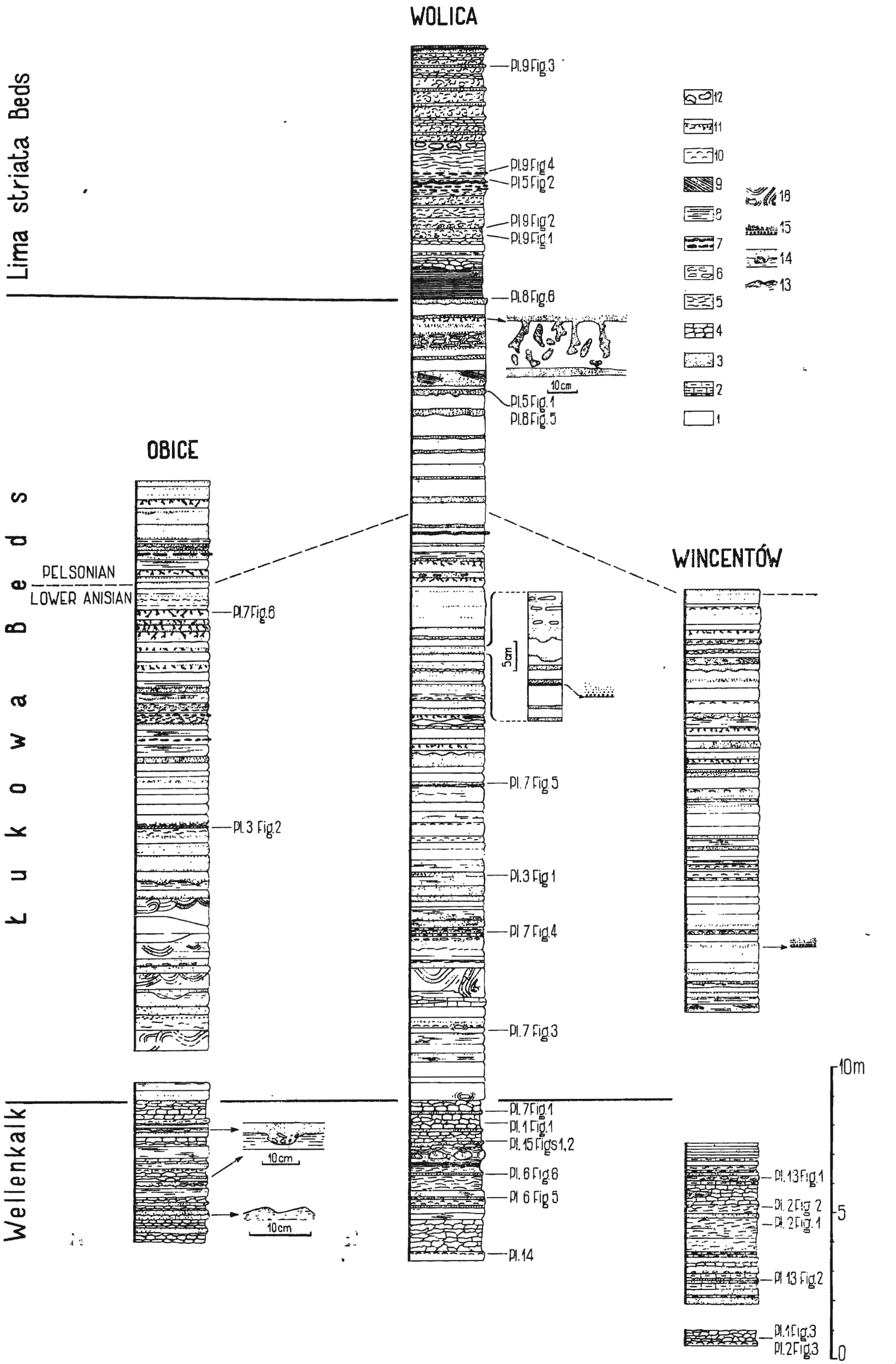
Horizons with enteropneustan burrows (Pl. 4; Pl. 5, Fig. 3; Pl. 7, Fig. 6; Pl. 17) are fairly common in the micritic limestones of the middle and upper parts of the Łukowa Beds (*cf.* Kaźmierczak & Pszczółkowski 1969). Some of these horizons also yield borings *Trypanites* Mägdefrau (Pl. 4, Fig. 2; Pl. 17, Fig. 1; *cf.* also Kaźmierczak & Pszczółkowski 1969).

A burrow supposedly attributable to a sea-anemone (Pl. 16, Fig. 1; *cf.* Trammer 1974c) was collected in the lower part of the Łukowa Beds at Zajączków.

The grained limestones are widely distributed in the Łukowa Beds. Their contacts with the micritic layers are often accentuated by erosion furrows (Pl. 5, Fig. 1; Pl. 16, Fig. 2). Basal parts of grained layers often yield angular intraclasts; well-rounded intraclasts (Pl. 3, Fig. 3) are a rarity here.

Some grained layers display parallel lamination (Pl. 3, Fig. 1) or transversal lamination (Pl. 3, Fig. 2); moreover, very thin layers displaying graded bedding are sometimes found.

The grained layers are usually represented by organodetrital limestones; crinoid-stem limestones (Pl. 7, Fig. 5; Pl. 8, Figs 3, 5) are the most common here. The limestones also contain small amounts of shell debris of gastropods, pelecypods, brachiopods and ostracodes and, occasionally, tests of foraminifers Nodosaridae gen. et sp. div.



WOLICA
OBICE
WINCENTÓW
Lima striata Beds
Łukowa Beds
Wellenkalk
PELSONIAN
LOWER ANISIAN
Pl.9 Fig.3
Pl.9 Fig.4
Pl.5 Fig.2
Pl.9 Fig.2
Pl.9 Fig.1
Pl.8 Fig.6
Pl.5 Fig.1
Pl.8 Fig.5
10cm
5cm
Pl.7 Fig.6
Pl.7 Fig.5
Pl.3 Fig.2
Pl.3 Fig.1
Pl.7 Fig.4
Pl.7 Fig.3
Pl.7 Fig.1
Pl.1 Fig.1
Pl.15 Figs 1,2
Pl.6 Fig.6
Pl.6 Fig.5
Pl.14
Pl.13 Fig.1
Pl.2 Fig.2
Pl.2 Fig.1
Pl.13 Fig.2
Pl.1 Fig.3
Pl.2 Fig.3
10m
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Lumpy-organodetrital limestones represent another common variety of the grained limestones. The bioclasts here include shell debris of pelecypods, brachiopods and ostracodes, and complete and crushed crinoid stems (Pl. 8, Figs 4, 6). Foraminifers are fairly common here (*cf.* Gaździcki & al. 1975). Pelecypod limestones (Pl. 7, Fig. 4) are relatively less common. Sparry lumpy-organodetrital limestones with microonkolites (Pl. 8, Fig. 1) occasionally appear in the middle part of the Łukowa Beds at Polichno. Algae *Aciculella bacillum* Pia were recently reported from the middle part of the Łukowa Beds at Zajączków (Gaździcki & Kowalski 1974). The algal genera *Solenopora* sp. and *Epimastopora* sp. were also found in crinoid-lumpy limestones with foraminifers (Pl. 8, Fig. 2) at Polichno.

Whitish flints appear in the upper part of the Łukowa Beds; they form either continuous layers or lenses confined to one layer.

Synsedimentary disturbances are fairly common in the lower part of the Łukowa Beds (*cf.* Bialik & al. 1972).

An assemblage of holothurian sclerites (Pl. 26, Figs 1—6) occurs in the upper part of the series, about 6 m below its top at Obice and Stare Chęciny. The assemblage comprises:

Theelia zapfei Kozur & Mostler, 1970
Theelia cf. *zapfei* Kozur & Mostler, 1970
Theelia cf. *subcirculata* Mostler, 1968

At Wolica, the layer 1.5 m below the top of the Łukowa Beds has yielded ostracodes (*cf.* Pl. 26, Figs 7—8) kindly determined by Dr. H. Kozur of Meiningen.

Judahella pulchra multinodosa (Kozur, 1970)
Ussuricavina cf. *rakovkensis* Gramm, 1969

The Łukowa Beds are about 30 m thick.

LIMA STRIATA BEDS

The *Lima striata* Beds are composed (*cf.* Fig. 3) of lumpy coquinas (Pl. 9, Fig. 1) intercalated by thin-bedded, grained, lumpy unfossiliferous and micritic limestones. Moreover, marly limestones and marls as well as limestones displaying *Linsen-* and *Flaserschichtung* were recorded. Flints are fairly common and form layers (Pl. 5, Fig. 2) or horizons of lenses. Silicified shells are common even in layers without any flints.

The lumpy coquinas are highly fossiliferous. The fauna occurring here forms a characteristic assemblage of the *Lima striata* Beds dominated by the following species (*vide* Senkowiczowa 1957):

Lima striata (Schloth.)
Lima radiata Goldf.
Lima lineata (Schloth.)
Coenothyris vulgaris (Schloth.)

Fig. 3. Selected profiles of the Wellenkalk, Łukowa Beds and *Lima striata* Beds

1 micritic limestones, *2* marly limestones, *3* grained limestones, *4* crumpled limestones, *5* lenticular bedding in limestones (*Linsen-* and *Flaserschichtung*), *6* intraclasts, *7* flints, *8* horizontal bedding, *9* diagonal bedding, *10* lumachelles, *11* enteropneustan burrows, *12* calcium carbonate concretions, *13* asymmetric ripples, *14* erosional furrows, *15* graded bedding, *16* synsedimentary disturbances

Enantiostreon difforme (Schloth.)
Spiriferina fragilis (Schloth.)
Hirsutina hirsuta (Alb.)
Encrinus liliiformis Schloth. (crinoid stems)
Pentacrinus sp. (crinoid stems)
Nautilus sp.

Less frequently there also occur the species listed below (vide Senkowiczowa 1957):

Decurtella decurtata (Gir.)
Mentzelia mentzeli (Dunk.)
Hoernesia socialis (Schloth.)
Pecten discites (Schloth.)

and *Beyrichites* (*Beyrichites*) sp., recently reported by the present author (Trammer 1972a) from Wolica.

Thin, grained beds are formed by lumpy-organodetrital limestones (Pl. 9, Figs 2—4). The debris includes sponge spicules, shell fragments of pelecypods, brachiopods, ostracodes and gastropods, and crinoidal stems and their fragments. The sole surfaces of the grained beds display fills of organic furrows and flute marks (Pl. 18).

A layer of elongated carbonate concretions is exposed at Wolica. The concretions are composed of radially arranged calcite crystals with a small admixture of chalcedony (*cf.* Kostecka 1972).

The *Lima striata* Beds are about 15 m thick.

MIDDLE MUSCHELKALK

The Middle Muschelkalk strata are poorly exposed in the area studied. Very scarce outcrops display yellow-brown and gray platy, marly unfossiliferous limestones. Senkowiczowa (1961) subdivided these strata into the Sub-dolomite Beds, Dolomite Beds and Supra-dolomite Beds on the basis of borehole data and identification of a dolomite unit.

UPPER MUSCHELKALK

PECTEN DISCITES BEDS

The *Pecten discites* Beds are composed (*cf.* Fig. 4) of light-gray and yellow coquinas full of shells of the pelecypods *Pecten discites* (Pl. 9, Figs 5—6; Pl. 10, Figs 1—2), and with intercalations of dark-grey, almost black lumpy limestones. The intercalations markedly increase in number towards the top part of the series. The lumpy limestones are formed of knobs 3—4 to 20 cm in diameter and they occasionally yield moulds of ceratitids (Pl. 19).

In the coquinas the pelecypod shell debris markedly predominates and fragments of brachiopod, gastropod and ostracode shells occur in subordinate amounts. Bone fragments appear to be fairly common.

About 4.5 m above base of the *Pecten discites* Beds, a horizon of intraclasts with the *Trypanites* borings (Pl. 20, Fig. 1) was found. The intraclasts are ovate in shape; they are built of gray-yellowish micritic limestone, and show differentiation in size: the smallest attain about 1—2 cm, and the average ones — about 4—6 cm in length.

The *Pecten discites* Beds attain about 10 m in thickness.

BOUNDARY OF *PECTEN DISCITES* BEDS AND *CERATITES* BEDS

The junction beds of these two units are represented by alternating light-coloured coquinas with scallop shells (typical of the *Pecten discites* Beds) and very dark, lumpy limestones occasionally yielding ceratitids (typical of the *Ceratites* Beds). Therefore the boundary between the two units may be delineated only in the arbitrary way. In the present paper it is assumed that the boundary passes at the top of the highest layer of the scallop lumachelles (*cf*. Fig. 4).

CERATITES BEDS

The *Ceratites* Beds are composed of dark-gray micritic limestones with intercalations of knobby limestones, particularly numerous in the lower part of this series, and with lumachelles (*cf*. Fig. 4).

The micritic and knobby limestones contain numerous moulds of ceratitids. The moulds are usually crushed or corroded, but well-preserved ones are also present. Micritic organodetrital limestones (Pl. 10, Fig. 3) sometimes yield better or worse preserved shells of *Terebratula, Lima, Pecten, Enantiostreon* and *Myophoria*. Moreover, *Pecten-Terebratula* lumachelles occur in the upper part of the *Ceratites* Beds at Pierzchnica and Brudzów.

The *Ceratites* Beds from the Holy Cross Mts yield ceratitids typical of the lower and middle *Ceratites* Beds of Germany, from the *robustus* to *enodis/laevigatus* zone (Senkowiczowa 1970).

The *Ceratites* Beds are about 13 m thick.

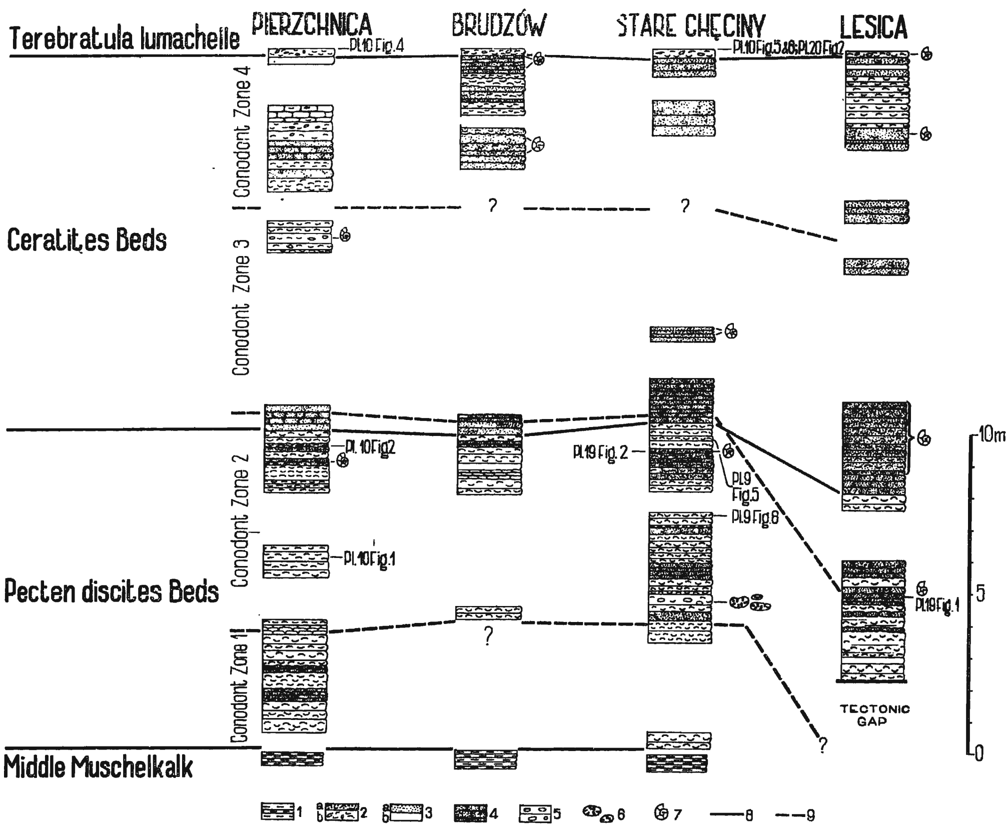


Fig. 4. Selected profiles of the Upper Muschelkalk

1 marly limestones and marls, *2* lumachelles (*a* dark gray, *b* light gray), *3* micritic limestones (*a* dark gray, *b* light gray), *4* crumpled limestones, *5* intraclasts, *6* intraclasts with *Trypanites* borings, *7* ceratitids, *8* lithostratigraphic boundaries, *9* biostratigraphic boundaries

TEREBRATULA LUMACHELLE

The *Terebratula* Lumachelle is a thin (20—30 cm thick) coquina layer (*cf.* Fig. 4) filled with shells of brachiopods (Pl. 10, Figs 4—6; Pl. 20, Fig. 2—3): *Coenothyris cycloides* (Zenker) and *C. vulgaris* (Schlotheim), which are associated with fish teeth and scales.

FACIES DEVELOPMENT

LOWER MUSCHELKALK

WOLICA BEDS, NON-KNOBBY LINKS OF THE WELLENKALK SERIES, ŁUKOWA BEDS

The sedimentary conditions under which the Wolica Beds, the non--knobby members of the Wellenkalk and the Łukowa Beds were deposited seem similar. These strata are generally represented by micritic limestones with intercalations of organodetrital limestones (Figs 2—3) and, occasionally, marly limestones. The layers of micritic limestones are generally thicker than the organodetrital limestones. The micritic limestones are almost completely unfossiliferous, whereas the organodetrital ones are almost exclusively formed of bioclasts. The micritic limestones were deposited in quiet waters, which is evidenced by their parallel lamination (*cf.* Kutek 1969). In turn, the organodetrital limestones were deposited in turbulent waters of diversified energy. In some horizons the action of hydrodynamic agents is evidenced only by crushed skeletal parts of the bionts. Sometimes consolidated deposit was subjected to scouring, which is evidenced by erosional furrows in the top part of a micritic layer, and micritic intraclasts occurring in the basal parts of the overlying grained layers (Figs 2—3; Pl. 5, Fig. 1; Pl. 16, Fig. 2), as well as by the enteropneustan burrows known from the Łukowa Beds and truncated to 3/4 of their original depth (Kaźmierczak & Pszczółkowski 1969). The organodetrital limestones sometimes show diagonal bedding (Pl. 3, Fig. 2). Attention should be paid to numerous organodetrital layers formed of heavily crushed and well-sorted bioclasts (Pl. 7, Fig. 5; Pl. 8, Fig. 3). There are also some layers built of strongly crushed and unsorted bioclasts (Pl. 8, Fig. 5) which most likely were deposited in highly agitated waters (*cf.* Skupin 1973; Schäfer 1973); the erosional furrows in the underlying micritic layers are generally related to these very layers.

Top surfaces of some micritic layers of the Łukowa Beds are marked with the *Trypanites* borings and are a typical hardground (*cf.* Müller 1956; Jahnke 1966; Ernst & Wachendorf 1968; Kaźmierczak & Pszczółkowski 1968, 1969; Bromley 1972). Basal parts of the grained layers often contain angular intraclasts derived from micritic limestone. This suggests a rapid lithification of the micritic beds. The micritic layers were intensively burrowed by enteropneustans; numerous top surfaces of the micritic layers revealing undamaged outlets of enteropneustan burrows and covered by organodetrital layers represent omission surfaces (*cf.* Shinn 1969;

Kennedy & Juignet 1974). All these features suggest that the deposition rate of micritic layers was relatively lower than that of organodetrital layers (*cf.* Shinn 1969; Taylor & Illing 1969; Zankl 1969; Purser 1969).

In the times of formation of these strata the development of organic communities (primarily consisting of crinoids, pelecypods, gastropods and brachiopods) proceeded only in some area. Temporarily active currents were destroying these communities and transported the organic debris into the areas of deposition of calcareous pelite. It is not necessary to assume that the areas populated by organic communities differed in bathymetry from those without the communities. The two types of areas could have coexisted at the same bathymetry, and their pattern may have been determined by local changes in depth, and consequently by differences in other environmental factors (*cf.* Ginsburg & Lowenstam 1958; Newell & al. 1959; Clarke & Keij 1973; Wagner & Togt 1973).

CRUMPLED LIMESTONES

The Wellenkalk series consists of several types of crumpled limestones (Pl. 1; Pl. 2, Fig. 3). The predominant type is represented by crumpled limestones built of smooth crumples of the micritic limestone. The crumples are sometimes angular and contorted, or even lenticular in shape (Pl. 1, Fig. 1). Marly limestone occurs between the crumples, forming coatings cementing them. Shapes of crumples contacting with one another appear to be adjusted. The crumpled limestones are also known from the *Lima striata* Beds.

The crumpled limestones of this type are common in the Wellenkalk in the whole area of the German Basin. Several hypotheses concerning their origin were advanced (*cf.* discussion *in* Bogacz & al. 1968, and Table 3 *in* Schwarz 1970). It was commonly assumed that these limestones originated as a result of actions of waves or currents, or that they represent deposits of subaqueous slumpings. However, Bogacz & al. (1968) have shown that these interpretations are not acceptable here. Neither these limestones have resulted from chemical dissolution as the crumples do not show any traces of chemical corrosion (*cf.* Hollmann 1962; Szulczewski 1965; Neumann & Schumann 1974). According to Schwarz (1970, 1971) the crumpled limestones from SW Germany originated from action of tides in the intertidal zone. Possibly, the crumpled limestones from SW Germany actually originated in this way, as ripple-bedding may be discerned within particular crumples. However, a bedding of such a type was not found in the crumpled limestones of the Holy Cross Mts. Moreover, micritic and marly limestones intercalating the crumpled ones display horizontally arranged burrows *Rhizocorallium* sp. These trace fossils are considered to be an index of permanently submerged zones (Ager & Wallace 1970). It may therefore be assumed that the Holy Cross crumpled limestones were formed under conditions of permanent submergence, i.e. under conditions comparable to those discussed by Bogacz & al. (1968) and Anketell & al. (1970; see also Freeman 1972). According to those authors the crumpled limestones originated from a reversed density gradient in a deposit consisting of alternating horizontal limestone and marly layers. Liquefaction of marly deposit, effected by any trigger, initiated disturbance and lead to breaking and bending of more solid limestone layers. Limestone fragments when sinking in the liquified deposit formed a layer of densely packed crumples.

It cannot be excluded that the phenomenon of early-diagenetic seggregation of calcareous mud has overlapped with the processes described above (*cf.* Hallam 1967; Jenkyns 1971).

In the Holy Cross area the rhythmicity of sedimentation marked by the deposition of alternating limestone and marly layers — a necessary prerequisite of the origin of the crumpled limestones — was the result of activity of several factors regulating the rate of supply of the clay material and precipitation of carbonates.

Limestones formed of angular crumples (Pl. 1, Fig. 3; Pl. 2, Fig. 3) represent a subordinate type of crumpled limestones. Continuous gradation is found between the two types of the crumpled limestones. In some angular crumples an undisturbed parallel bedding can be observed. They might have been formed in result of activity of currents; if that was the case, they may be interpreted as intraformational breccias composed of intraclasts derived from a relatively well-lithified layer (*cf.* Pl. 1, Fig. 2; Pl. 2, Fig. 2). However, it is also possible that the limestones, similarly as those discussed above, originated in result of disturbances of a system with reversed density gradients. In such a system strongly lithified micritic layers would behave like a fragile body; this may explain angular shape of the crumples (*cf.* Anketell & al. 1970).

The third type of crumpled limestones was locally formed in result of activity of furrowing and burrowing animals (Pl. 1, Fig. 2). Here the crumples are the smaller or larger fragments of channels made by the burrowers. The calcareous fill of the burrows, rich in organic matter, underwent lithification sooner than the surrounding deposit (*cf.* McCunn 1972; Fürsich 1973) and consequently resulted in a general knobby appearance of the deposit.

LENTICULAR LIMESTONES

In the Wellenkalk series and *Lima striata* Beds there are also so-called lenticular limestones displaying a bedding similar in shape to *Linsen-* and *Flaserschichtung* (Fig. 3; Pl. 2, Figs 1—2). Typical *Linsen-* and *Flaserschichtung* originate in the intertidal zone (*cf.* Reineck & Wunderlich 1968); it shows ripple-bedding, not found in the lenticular limestones from the Holy Cross Mts. The latter are interfingering with the crumpled limestones resulting from the systems with reversed density gradients; therefore it seems justified to assume that they are of the same origin. Alternating micritic and marly layers were here thinner, which may explain smaller dimensions of crumples and their lenticular shape, as well as smaller-scale disturbances.

SYNSEDIMENTARY DISTURBANCES

Synsedimentary disturbances in the Wellenkalk series and Łukowa Beds (*cf.* Bialik & al. 1972) include disintegration of layers into separate blocks and folded grained-limestone layers sunken in micritic or marly deposit. In addition, sedimentary diapirs were found. The disturbances originated in result of deformations of systems with reversed density gradients (*cf.* Anketell & al. 1970). No evident slides were found, which suggests that the sea bottom was devoided of any greater denivelations in a regional scale in times of deposition of the Wellenkalk series and the Łukowa Beds.

THE WELLENKALK SERIES AT WINCENTÓW

Special attention should be paid to the Wellenkalk series section from Wincentów. The upper part of the section displays (*cf.* Fig. 3) a turbidite layer (Fig. 3; Pl. 13, Fig. 2) and two specifically developed layers of intraformational conglomerates (Pl. 13, Fig. 1; *cf.* also Bialik & al. 1972). The conglomerate layers display an irregular course and soon wedge out. Intraclasts are randomly distributed and markedly differ in size. They are formed of limestone different from that building the underlying layers and are, therefore, interpreted as allochthonous. All the above facts suggest that the deposits forming the conglomerates were transported in the form of mud flows (Bialik & al. 1972).

In the times of deposition of the Wellenkalk the sea bottom was flat and without any greater elevations of a regional scale (*cf.* Bogacz & al. 1968; Bialik & al. 1972). The products of mud flows and of the turbidite layer found in the upper part of the Wellenkalk series in the Wincentów area indicate however the existence of a local elevation. A complete development of the turbidite layer, as well as the ripple marks from its upper surface evidence that this layer actually represents a product of transportation from an elevation of the sea bottom (*cf.* Meischner 1964). In turn, thin turbidite layers from the Łukowa Beds (Fig. 3) presumably originated from the stirring up of the deposits by storm waves (*cf.* Kuenen & Menard 1952; Ager 1974).

CRUMPLED LUMACHELLES FROM THE *LIMA STRIATA* BEDS

Crumpled lumachelles represent the most typical member of the *Lima striata* Beds. The crumpled structure of the rock is related to the random arrangement of shells. The shells are either complete or crushed to a various degree. The nature of the rocks suggests intraformational erosion (in this case, the heavily crushed shells would be derived from top parts of an eroded layer — *cf.* Ager 1963) or transportation of the crushed shells from the zones of higher agitation. The former interpretation is supported by the fact that the *Lima striata* Beds are as a rule thinner than contemporaneous organodetrital complexes from other parts of the German Basin (*cf.* Kozur 1974); thus they may be interpreted as a condensed unit.

THE PROBLEM OF FLINTS

Flints occur in the upper part of the Łukowa Beds and in the *Lima striata* Beds (Fig. 3; Pl. 5, Fig. 2; Pl. 9, Fig. 4). The bedding of the limestone surrounding the flints is of an envelope type, which indicates the syngenetic character of the flints. The limestones surrounding the flints always show mass occurrence of sponge spicules of the triaxone type. The triaxons were never found in other flint-devoided horizons. Therefore genetic relationship between the flints and sponges may be assumed. Silification of shells is common in the flint-bearing horizons.

GENERAL REMARKS ON BATHYMETRY

A number of effects of hydrodynamic activity on the sea bottom were mentioned above. All of them indicate a shallow depth of the sea. Lumpy-organodetrital limestones with microonkolites, occurring in the middle part of the Łukowa Beds, yield green algae *Aciculella bacillum* Pia, typical of waters 0 to 20 m deep (Gaździcki & Kowalski 1974). Such depth estimations is supported by the occurrence of onkolites, also typical of that depth interval (*cf.* Radwański 1968, and literature cited therein).

According to Kaźmierczak & Pszczółkowski (1969), mass occurrence of enteropneustan burrows in the Lower Muschelkalk of the Holy Cross Mts indicates bathymetric conditions similar to those under which burrowing enteropneustans live at present, i.e., the lowermost part of intertidal zone, occasionally, to subtidal zone. However, deposition of sediments burrowed by these animals in the intertidal zone seems hardly acceptable. Recent carbonate sediments deposited in that zone are characterized by the occurrence of stromatolites, desiccation cracks, breccias composed of crushed mud cracks, syngenetic gypsum and dolomite, tidal channels, or even by the development of karst processes (*cf.* Roehl 1967; Laporte 1967;

Textoris 1968; Shinn & al. 1969; Kahle & Floyd 1971; Purser 1973), none of which are found in the Lower Muschelkalk of the area studied. Moreover, it should be noted that the enteropneustan burrows are widely distributed in the Lower Muschelkalk almost throughout the whole German Basin (Mägdefrau 1932; Ziegenhardt 1966; Jahnke 1966; Ernst & Wachendorf 1968; Schulz 1972; Kozur 1974) and it can hardly be assumed that the intertidal zone was occupying so vast areas in that time.

As it was previously mentioned, horizontally arranged burrows *Rhizocorallium* sp. found in the Wellenkalk series indicate deposition of the sediments under the conditions of continuous submergence (Ager & Wallace 1970).

Oolites — typical of extremely shallow depths — are common in several parts of the German Basin but not in the Holy Cross Mts area. In the latter, lumpy limestones with microonkolites are also only occasionally developed. It may be therefore concluded that Lower Muschelkalk deposits from the Holy Cross Mts were deposited in shallow waters, however deeper than in the other parts of the German Basin.

MIDDLE MUSCHELKALK

The Middle Muschelkalk in the Holy Cross Mts yields two dolomite series separated by marls and limestones (Senkowiczowa 1961). In those times two cycles of salt precipitation took place in some area of Germany (Bestel 1929; Kozur 1974). In turn, the Middle Muschelkalk of the Fore-Sudetic monocline displays two cycles of deposition of anhydrites (Tokarski 1969). Thus it may be concluded that the two evaporitic cyclothems of the Middle Muschelkalk were marked also in the Holy Cross Mts by a repeated limestone/dolomite succession.

UPPER MUSCHELKALK

PECTEN DISCITES LUMACHELLES

Valves of thin-shelled scallops *Pecten discites*, the main component of the lumachelles, are usually slightly crushed and set parallel to the bedding (Pl. 9, Fig. 5). Thin onkolitic coatings developed on upper side of the shells are occasionally found. Edges of some shells display borings of algae or fungi as well as a micritization effect (Pl. 10, Fig. 1). Bioclasts are cemented with micrite. These facts indicate that deposition of the lumachelles took place in shallow waters and the contribution of hydromechanical agents was not too high (*cf.* Kutek 1969).

Layers built of valves arranged transversally or vertically and of shell debris (Pl. 10, Fig. 1) are occasionally found. Sparite is sometimes the cement in such layers, and these were deposited in slightly more agitated waters (*cf.* Müller 1959; Kutek 1969; Schwarz 1970).

CORRELATION WITH WILKOWICE BEDS OF UPPER SILESIA

A horizon of ovate intraclasts was found in the lumachelles about 4.5 m below the base of the *Pecten discites* Beds. This horizon presumably stretches over the whole area studied and till now it has been found at Obice, Stare Chęciny and Promnik (Fig. 1), i.e. in localities fairly distant from one another. The majority of intraclasts show densely spaced borings *Trypanites* Mägdefrau (Pl. 20, Fig. 1), which indicate that this horizon originated under conditions of impeded sedimentation.

The horizon with intraclasts is contemporaneous with the conglomerate beds from Wilkowice in Upper Silesia, as both of them are dated at 2nd conodont zone of Kozur, 1968 (*cf.* Kozur 1974, Zawidzka 1975). From the sedimentological point of view, the two horizons appear to be identical in development (*cf.* Kubicz 1970, Zawidzka 1975), except for the fact that the one from the Holy Cross Mts displays less complete development and smaller thickness. Identification of the equivalent of the Wilkowice Beds in the Holy Cross Mts suggests that the process leading to the formation of conglomerate beds was of a regional significance.

CRUMPLED LIMESTONES OF *PECTEN DISCITES* AND *CERATITES* BEDS

Subaqueous corrosion was of primary importance for the formation of these limestones. Ceratitid moulds with corroded upper surface (Pl. 19, Figs 1—2) are found in these limestones. Surfaces of individual crumples and of more continuous layers separating them are rough and marked with irregular pattern of pits and knolls (Pl. 19, Fig. 2). Such features are typical of a subaqueous solution of deposits (Hollmann 1962; Einasto 1964; Jaworowski & Modliński 1972; Neumann & Schumann 1974). The crumpled limestones are similar in development to "ammonitico rosso" facies from the Tethyan Jurassic. However, the latter are usually red, whereas the former are brown to yellow-brown.

No traces of hydrodynamic agents are stated in the crumpled limestones. In turn, the lumachelles from *Pecten discites* and *Ceratites* beds, interfinging with the crumpled limestones, were formed there with the contribution of turbulent waters, which is indicated by the occurrence of shell debris.

The problem of stratigraphic condensation. The sedimentation under conditions of chemical corrosion should lead to stratigraphic condensation. And this seems to be the case: the crumpled limestones always yield about 100 conodonts per 300 g rock sample, in comparison to a few to about a dozen conodonts found in the same weight rock sample of non-crumpled intercalations. Moreover, 4 conodont zones of the Upper Muschelkalk are markedly thinner in the Holy Cross Mts than in Germany (*cf.* Kozur 1974). However, the condensation was not strong enough here to result in a mixing of conodont assemblages from adjacent zones.

TEREBRATULA LAYER

A thin layer full of brachiopods *Coenothyris cycloides* (Zenker) and *C. vulgaris* (Schlotheim), known in Germany as the *Cycloides*-Bank, occurs in several parts of the German Basin, except for the Upper Muschelkalk of Swiss Jura, Subhercynian Basin and Silesia (Kozur 1974).

It appears to be isochronous as it is found everywhere, the Holy Cross Mts including, in the upper part of the 4th conodont zone of Kozur (1968). This layer is known from both parts of the German Basin where marine sedimentation ended at the end of Fassanian (in the Holy Cross Mts) and those where it continued throughout the whole Langobardian (in SW Germany). In the former area the layer discussed represents the top part of the Muschelkalk and it is fairly thin (30 cm thick); in the latter — it separates middle and upper *Ceratites* Beds and is markedly thicker (85 cm — Geisler 1939).

In the Holy Cross Mts, the brachiopod shells forming this layer are rarely complete; usually there occur single valves or their fragments (Pl. 10, Figs 4—6; Pl. 20, Fig. 2). The matrix also yields dolomite crystals and clay material (Pl. 10, Fig. 6).

Brachiopod shells are relatively highly resistant to mechanical disintegration. Therefore, a mass occurrence of brachiopod shell debris indicates that the lumachelle originated under conditions of high water turbulence. Less damaged shells, which are less numerous, presumably represent local material which did not undergo any longer transportation.

Mass occurrence of brachiopod shells in this thin complex is a separate problem. It cannot be explained by local activity of currents because of widespread distribution of the layer, always rich in brachiopod shells. It seems that this phenomenon may be explained by an increased salinity in the sea basin at the end of the Muschelkalk, which is evidenced by the size of brachiopod shells being smaller than the average size of these species (*cf.* Schmidt 1928), almost complete lack of other faunal elements, and occurrence of dolomite in the matrix. The appearance of dolomite indicates that gradual changes towards the hypersaline conditions that prevailed later in the Lower Keuper basin (local dolomite intercalations — Senkowiczowa 1970), had marked as early as the decline of Late Muschelkalk.

When analysing mass occurrence of shells in this layer it can be noted that it is built almost exclusively of shells and that the calcareous matrix is of subordinate importance. There it may be stated that the rate of deposition of biomass was several times higher than the rate of deposition of calcareous ooze.

BIOSTRATIGRAPHY

The chapter presents results of studies on conodonts, carried out by the present author for several years, (*cf.* Trammer 1971, 1972b, 1974b). In the course of these studies, 207 samples of Röt and Muschelkalk limestones were dissolved in acetic acid. All samples from the Röt (30) and the Middle Muschelkalk (24) were negative. About 95 samples of the

Lower Muschelkalk were collected at Pierzchnica, Obice, Wolica, Stare Chęciny, Polichno and Wincentów (*cf.* Fig. 1); 84 of them appeared positive and gave, on the average, 18 conodonts per 300 g of rock. Fifty eight samples of the Upper Muschelkalk were taken from Pierzchnica, Stare Chęciny, Brudzów, Zajączków, Lesica and Promnik (*cf.* Fig. 1); 55 of them appeared positive and yielded, on the average, 48 conodonts per 300 g of rock.

Paleontological identification of the conodonts obtained was carried out using all the available literature on Triassic conodonts (see lists of references *in* Kozur & Mostler 1972a; as well as Wenger 1966; Hayashi 1968, 1972; Flügel & Ramovš 1970; Pantić & Čičić 1970; Hirsch 1971, 1972; Hirsch & Süssli 1973; Jenkins & Jenkins 1971; Mock 1971; Sweet & al. 1971; Kozur & Mostler 1971a, b, 1972b; Kozur & Mock 1972; Kozur 1972a; Zawidzka 1972; Budurov 1972, 1973; Budurov & Stefanov 1972, 1973; Budurov & Pantić 1973; Durdanović 1973; Boogaard & Simon 1973; Krystyn 1973; McTavish 1973; Mosher 1973a).

The list of forms previously illustrated (Trammer 1971, 1972b) from the Muschelkalk of the Holy Cross Mts includes (for stratigraphic ranges see Figs 5—6):

Chirodella dinodoides (Tatge, 1956)
Chirodella triquetra (Tatge, 1956)
Cornudina breviramulis (Tatge, 1956)
Cornudina minor Kozur, 1968
Cornudina tortilis Kozur & Mostler, 1970 (including *Cornudina* sp. *A*, and *Cornudina* sp. *B* in Trammer 1971)
Diplododella meissneri (Tatge, 1956)
Enantiognathus ziegleri (Diebel, 1956)
Enantiognathus incurvus Kozur, 1968
Hibbardella magnidentata (Tatge, 1956)
Hibbardella bicuspidata (Kozur, 1968)
Hindeodella (Metaprioniodus) suevica (Tatge, 1956); including *Hindeodella (Metaprioniodus) latidentata* (Tatge, 1956) in Trammer 1971 (*cf.* Kozur & Mostler 1972a)
Hindeodella (Metaprioniodus) bicuspidata Kozur & Mostler, 1970
Hindeodella (Metaprioniodus) sp. (*sensu* Trammer 1972b)
Neohindeodella triassica (Müller, 1956)
Neohindeodella kobayashii (Igo & Koike, 1965) = *Neohindeodella triassica hirschmanni* Kozur, 1968 in Trammer 1971 (*cf.* Kozur & Mostler 1972a)
Neohindeodella riegeli (Mosher, 1968)
Neohindeodella nevadensis (Müller, 1956)
Neohindeodella sp. (*sensu* Trammer 1972b)
Neospathodus kockeli (Tatge, 1956)
Ozarkodina tortilis (Tatge, 1956)
Parachirognathus pandotentata (Budurov, 1962)
Pollognathus germanicus (Kozur, 1968)
Pollognathus sequens (Kozur, 1968)
Prioniodina muelleri (Tatge, 1956)
Prioniodina sp. (*sensu* Trammer 1972b)
Prioniodella prioniodellides (Tatge, 1956)
Gondolella aegea (Bender, 1967) = *Gondolella regale* (Mosher, 1970) (*cf.* Trammer 1972b)
Gondolella navicula Huckriede, 1958
Gondolella excelsa (Mosher, 1968)
Gondolella mombergensis mombergensis Tatge, 1956
Gondolella mombergensis media Kozur, 1968
Gondolella haslachensis Tatge, 1956
Gondolella (Celsigondolella) watznaueri praecursor Kozur, 1968
Gondolella prava Kozur, 1968.

Because morphology of some conodonts was inadequately displayed in the previous papers (Trammer 1971, 1972b) it was found useful to reillustrate here the following species:

Neospathodus kockeli (Tatge) — Pl. 22, Figs 1—3,
Gondolella navicula Huckriede — Pl. 23, Fig. 5; Pl. 24, Fig. 1.

Moreover, it was desirable to figure for the second time the species *Neohindeodella riegeli* (Mosher) — Pl. 21, Figs 1, 3—4, formerly known only from the Upper Muschelkalk (Trammer 1972b) and subsequently recorded from the Lower Muschelkalk.

The list of recent conodont findings comprises (for stratigraphic ranges see Figs 5—6):

Chirodella polonica Kozur & Mostler, 1970; 8 specimens — Wolica, Wincentów (Łukowa Beds, *Lima striata* Beds) — Pl. 22, Fig. 7;

Cornudina latidentata Kozur & Mostler, 1970; 6 specimens — Wolica, Wincentów (Łukowa Beds) — Pl. 25, Fig. 3;

Cornudina sp.; 1 specimen — Wolica (Łukowa Beds) — Pl. 25, Fig. 2;

Diplododella bidentata (Tatge, 1956); 37 specimens — Pierzchnica, Obice, Wolica, Wincentów (the whole Lower Muschelkalk) — Pl. 21, Figs 5—8;

Neohindeodella aequidentata Kozur & Mostler, 1970; 3 specimens — Pierzchnica, Stare Chęciny (*Ceratites* Beds) — Pl. 21, Fig. 2;

Neospathodus germanicus Kozur, 1972; 41 specimens — Obice, Wolica, Stare Chęciny, Wincentów (Łukowa Beds, *Lima striata* Beds) — Pl. 22, Figs 4—6;

Gondolella acuta Kozur, 1972; 12 specimens — Stare Chęciny, Lesica (*Pecten discites* Beds, *Ceratites* Beds) — Pl. 24, Figs 4—5;

Gondolella cf. *basisymmetrica* (Budurov & Stefanov, 1972); 8 specimens — Stare Chęciny (*Pecten discites* Beds, *Ceratites* Beds) — Pl. 23, Fig. 1 and Pl. 24, Fig. 6;

Gondolella bifurcata (Budurov & Stefanov, 1972); 2 specimens — Wolica (*Lima striata* Beds) — Pl. 25, Fig. 6;

Gondolella constricta Mosher & Clark, 1965; 16 specimens — Pierzchnica, Stare Chęciny, (*Pecten discites* Beds, *Ceratites* Beds) — Pl. 24, Figs 2—3, 7;

Gondolella cornuta (Budurov & Stefanov, 1972); 51 specimens — Pierzchnica, Stare Chęciny, Lesica (*Pecten discites* Beds, *Ceratites* Beds) — Pl. 22, Figs 8—9;

Gondolella excentrica (Budurov & Stefanov, 1972); 11 specimens — Pierzchnica, Stare Chęciny (*Pecten discites* Beds, *Ceratites* Beds) — Pl. 25, Fig. 4—5;

Gondolella haslachensis trammeri Kozur 1972; 38 specimens — Pierzchnica, Stare Chęciny, Lesica (*Ceratites* Beds) — Pl. 25, Fig. 1;

Gondolella longa (Budurov & Stefanov, 1973); 17 specimens — Lesica, Stare Chęciny (*Pecten discites* Beds, *Ceratites* Beds) — Pl. 23, Figs 2—3;

Gondolella suhodolica (Budurov & Stefanov, 1973); 10 specimens — Stare Chęciny, Lesica (*Pecten discites* Beds, *Ceratites* Beds) — Pl. 21, Figs 9—10.

CONODONT STRATIGRAPHY IN THE LOWER MUSCHELKALK

It is not possible to delineate the Scythian/Anisian boundary in the Holy Cross Mts on the basis of conodonts. According to Kozur (1973) the boundary is placed where *Gondolella timorensis* Nogami, 1968, changes into *G. aegea* (Bender, 1967). According to non-conodont stratigraphic data the boundary passes in the Upper Röt. The first condonts were found in the Wolica Beds, i.e. about 2.5 m above the top of the Röt, and the species *Gondolella aegea* (Bender, 1967) did not appear until the Wellenkalk series (see Fig. 5).

In the Holy Cross Mts, the section from the lower part of the Wellenkalk series to the lower part of the Łukowa Beds is characterized by the occurrence of conodonts *Neohindeodella nevadensis* (Müller) and *Gondolella aegea* (Bender). The former species is recognized all over the

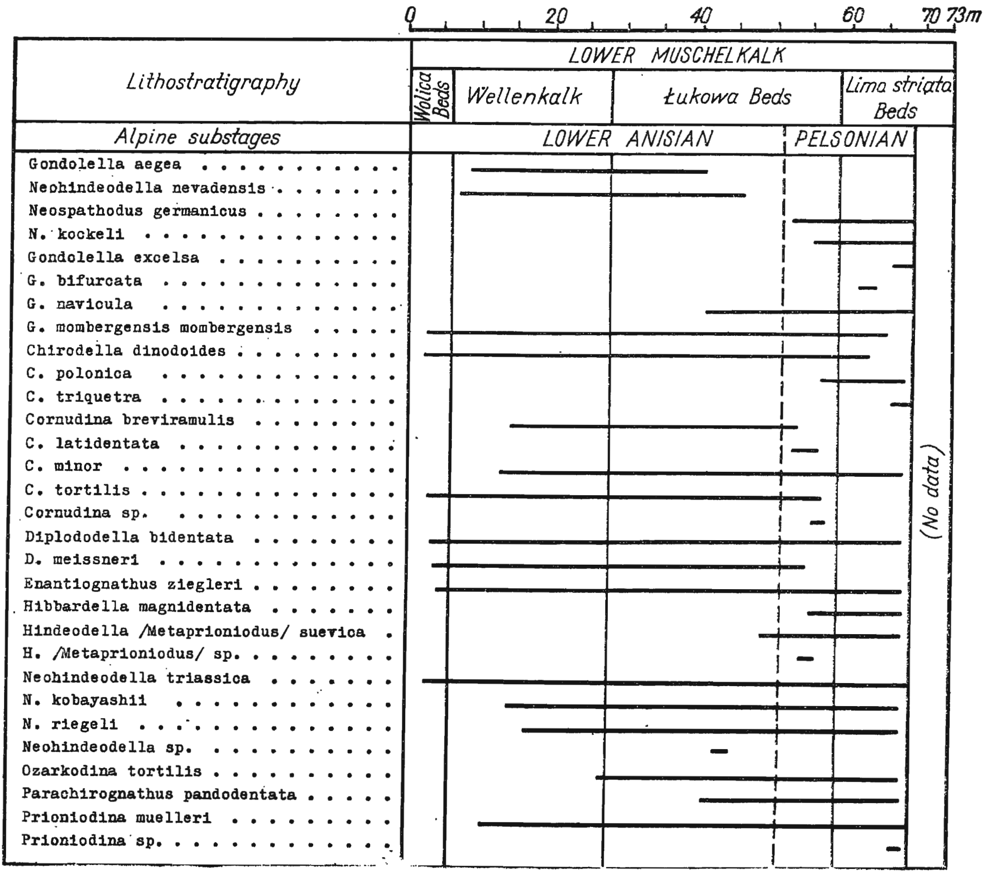


Fig. 5. Stratigraphic ranges of Lower Muschelkalk conodonts in the Holy Cross Mts (compiled from profiles presented in Figs 2—3)

world as typical of the Scythian and Lower Anisian (Mosher 1968; Kozur 1971a, 1974) whereas the latter is considered as typical of the Lower Anisian of North America, Asia, Chios Island, and the Holy Cross Mts (Mosher 1970; Sweet & al. 1971; Trammer 1972b; Kozur & Mostler 1972b); on the basis of the range of its occurrence the *aegea* biozone was defined (Kozur & Mostler 1972b).

The upper part of the Łukowa Beds and lower and middle parts of the *Lima striata* Beds from the Holy Cross Mts yield (*cf.* Trammer 1971, 1972b): *Neospathodus kockeli* (Tatge)[1] and *Gondolella excelsa* (Mosher). The former species is the index of the Pelsonian in Europe (Kozur 1971a, 1974; Kozur & Mostler 1971a, 1972b; Trammer 1972b; Budurov & Stefanov 1972). It should be noted that this species was found associated with

[1] Jurkiewicz (1974) reported *Neospathodus kockeli* (Tatge) from the Upper Muschelkalk of the Nida Trough. However, this species in the whole area of the German Basin is only known from the Lower Muschelkalk (Tatge 1956; Wilczewski 1967; Trammer 1971; Kozur 1974); it thus seems that this identification is erroneous.

the typical Pelsonian ammonites in classical exposures at Rahnbauerkogel in Austria and Felsöörs in Hungary (*cf.* Assereto 1971; Summesberger & Wagner 1972; Kozur 1974). On the basis of the range of this species Kozur & Mostler (1972b) and Budurov & Stefanov (1972) independently distinguished the *kockeli* biozone. The species *Gondolella excelsa* appears in the upper part of the Pelsonian and it occurs till the end of the Ladinian (Mosher 1968; Kozur & Mostler 1971a, 1972b; Mock 1971).

The above data make it possible to assign the Lower Muschelkalk of the Holy Cross Mts (with the exception of the upper *Lima striata* Beds, not sampled because of the lack of exposures in the area studied) to the Lower Anisian and Pelsonian (*cf.* also Trammer 1972b). The youngest bed yielding conodonts typical of the Lower Anisian and the oldest bed with Pelsonian conodonts are separated by a 10-meter part of the section (*cf.* Fig. 5), interpreted here as an interval of correlation error.

It should be emphasized that the species *Gondolella aegea* and *Neospathodus kockeli* were not found anywhere in the same section except for the area studied. Therefore it is difficult to state whether the two forms are absent in the 10-meter part of the section because they happened not to be collected or because of the fact that *Gondolella aegea* disappeared somewhat before the first appearance of *Neospathodus kockeli* (see also Kozur & Mostler 1972b).

The remaining conodonts recorded from the Lower Muschelkalk of the area studied (*cf.* Fig. 5) usually have much longer stratigraphic ranges and thus they are of minor stratigraphic importance. In the Holy Cross area some of these forms display short stratigraphic ranges (e.g. *Cornudina latidentata* and *Hibbardella magnidentata* — *cf.* Fig. 5), however, these are merely partial ranges; in other areas the stratigraphic ranges of such forms are much wider (*cf.* Kozur & Mostler 1972b, Figs 1—2). However, the attention should be paid to *Chirodella polonica* Kozur & Mostler, 1970, which seems to be confined to the Pelsonian in all areas wherefrom it has been recorded (Hungary, Bulgaria and Germany — *cf.* Kozur & Mostler 1972a, b), the Holy Cross Mts including. This species may therefore be regarded as the second (after *N. kockeli)* index species for this stage.

The species *Gondolella bifurcata* (Budurov & Stefanov) an index species of the Lower Illyrian according to Budurov & Stefanov (1972), was recorded from the Pelsonian of the Holy Cross Mts (Fig. 5). Thus the *bifurcata* zone *sensu* Budurov & Stefanov (1972) may be termed as partial-range zone.

Attention should also be paid to the stratigraphic position of *Neospathodus germanicus* Kozur, an ancestor of *N. kockeli.* According to Kozur (1972a, 1974), the former appears in the upper part of the Lower Anisian, whereas in the Holy Cross Mts (Fig. 5) it does not appear before the Pelsonian, just before the first occurrence of *N. kockeli.*

The presented conodont correlation of the Lower Muschelkalk from the Holy Cross Mts with the Anisian was confirmed by the results of analysis of other micro- and macrofaunal groups. For example, holothurian sclerite assemblage comprising *Theelia zapfei* Kozur & Mostler and *T.* cf. *subcirculata* Mostler, accompanying *N. kockeli* in the upper part of the Łukowa Beds (Pl. 26, Figs 1—6), is typical of the Pelsonian (*cf.* Kozur & Mostler 1970; Senkowiczowa 1972; Mostler 1972a). Moreover, the stratigraphic range of the ostracod *Judahella pulchra multinodosa* (Kozur) found in the uppermost Łukowa Beds (Pl. 26, Figs 7—8) is confined to the Pelsonian (Kozur 1972b). Brachiopods *Decurtella decurtata* (Girard) and *Hirsutina hirsuta* (Alberti), reported by Senkowiczowa (1957) from the *Lima striata* Beds, are similarly typical of the Alpine Pelsonian (Senkowiczowa 1962; Speciale 1967; Scholz 1972; Kozur 1974).

CONODONT STRATIGRAPHY IN THE UPPER MUSCHELKALK

The conodonts are of remarkable importance for the stratigraphy of the Upper Muschelkalk. In Germany this unit was divided into 7 conodont zones (Kozur 1968). Four lower zones of the German Upper Muschelkalk were recognized in the Holy Cross Mts (*cf.* Fig. 6 and Trammer 1971, 1972b), the area in which the remaining three uppermost zones are not represented as bioprotostratigraphic zones *sensu* Henningsmoen (1961). This results from the fact that in this area terrestrial Keuper facies appeared earlier than they did in Germany (*cf.* Fig. 8) and the conodont fauna must have disappeared earlier because of ecological factors.

The schema of conodont zones of Kozur (1968) was accurately correlated with German ceratitid zonal schema (*cf.* Fig. 8 and Kozur 1968, 1974; Trammer 1971). This conodont zonation is based on rapid evolution in the series of species *Gondolella mombergensis mombergensis* → *G. mombergensis media* → *G. haslachensis* → *G.* (*Celsigondolella*) *watznaueri* (see Fig. 6). The boundary between the 1st and 2nd zone is defined by the extinction of *Diplododella meissneri, Chirodella dinodoides* and *Parachirognathus pandodentata.* Delineation of so defined boundary (Kozur 1968) is sometimes difficult as it is not known whether the lack of the forms typical of the 1st zone may be attributed to their actual extinction or to failure in collection. The boundary between the 2nd and 3rd zone was here delineated by the first appearance of *G. mombergensis media* [2] and not in the place where its contribution in *Gondolella* spectrum exceeds 50% as it was suggested by Kozur (1968).

The conodont zonation proposed by Kozur (1968) is based on the evolution of endemic German species and, therefore, it is suitable for

[2] This definition originally proposed by the present author (Trammer 1972b) was subsequently accepted by Kozur & Mostler (1972b).

correlations within the German Basin and not for the correlation of German lithostratigraphic sequence with the chronostratigraphic subdivision.

A partial, not fully reliable correlation (Kozur 1972a, c) of these subdivisions is possible as some members of the evolutionary series *G. mombergensis* — *G. (C.) watznaueri* have been recorded from separate horizons in areas outside the German Basin (e.g., *G. mombergensis media* in Sicily and *G. haslachensis* in Sardinia and Hungary; *cf.* Kozur & Mostler 1971b; Kozur 1972c, 1974).

In the Upper Muschelkalk of the Holy Cross Mts some Bulgarian (Tethyan) conodonts have recently been found, on the basis of which Budurov & Stefanov (1972, 1973) proposed a conodont zonal schema correlatable with chronostratigraphic subdivision. The occurrence of these Bul-

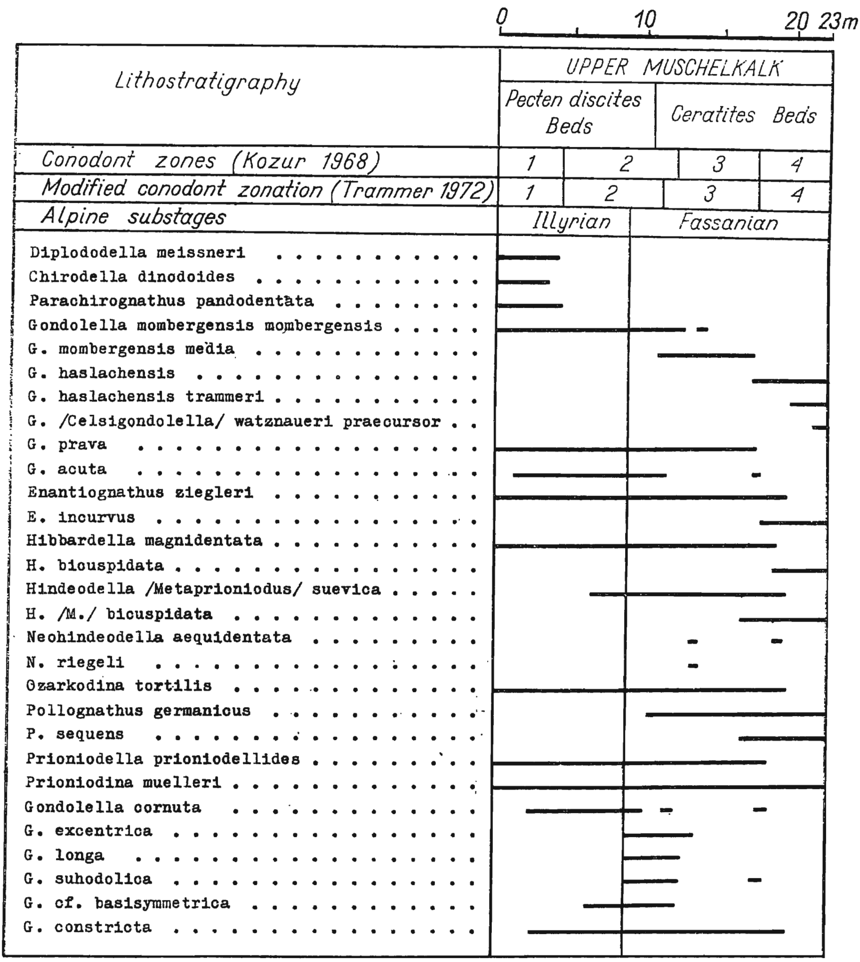


Fig. 6. Stratigraphic ranges of Upper Muschelkalk conodonts in the Holy Cross Mts (compiled from profiles at Pierzchnica, Brudzów and Stare Chęciny — *cf.* Fig. 4)

garian species made it possible to correlate the stratigraphic ranges of typical endemic German conodonts with those of the Tethys.

The conodont assemblage that comprises *Gondolella excentrica* (Budurov & Stefanov), *G. longa* (Budurov & Stefanov) and *G. suhodolica* (Budurov & Stefanov), typical of the *excentrica* zone of the Bulgarian Triassic i.e., of the Lower Fassanian (Budurov & Stefanov 1972, 1973), appears in the Holy Cross Mts in the *Pecten discites* Beds about 8 m below the base of the Upper Muschelkalk. The Illyrian/Fassanian boundary (= Anisian/Ladinian boundary) was therefore drawn at this very place (*cf.* Fig. 6). The form *Gondolella cornuta* (Budurov & Stefanov), index species of the *cornuta* zone established by Budurov & Stefanov (1972), was also found in the Holy Cross Mts (*cf.* Fig. 6). This species passes the Anisian/ /Ladinian boundary in the latter area, whereas in Bulgaria the situation is just reverse and *G. excentrica* appears for the first time just when *G. cornuta* disappears (Budurov & Stefanov 1972). It should be added that *Gondolella constricta* Mosher & Clark was recorded in the Holy Cross Mts in the junction beds of the Anisian and Ladinian (Fig. 6), i.e. in the same stratigraphic position as in Bulgaria and British Columbia (Budurov & Stefanov 1972; Mosher 1973a).

In Bulgaria, the *excentrica* zone is overlaid by the *bakalovi* zone corresponding to the upper parts of the Fassanian. In the strata overlying the beds with *G. excentrica* in the Holy Cross Mts, no stratigraphically younger platform conodonts typical of the *bakalovi* zone were found. This may be explained by some facies conditions unfavourable for the development of platform conodonts; these facies began to predominate in the uppermost parts of the German Muschelkalk (*cf.* Trammer 1974b).

As it was mentioned above, the subdivision proposed by Kozur (1968) is correlatable with German ceratitid zonal schema of Riedel (1916; see Wenger 1957; Busse 1970; Kozur 1974). Consequently, it is possible to correlate the Upper Muschelkalk of the Holy Cross Mts with any contemporaneous section from the German Basin and from the Tethyan areas, provided that the section has sufficient faunal record. The presented correlation (Fig. 6) is very close to that given by Kozur (1972a, c) on a strictly different basis, i.e. correlation of records of German conodonts from separate Triassic members of Sardinia and Hungary and the associated macrofauna.

CORRELATION WITH CHRONOSTRATIGRAPHIC SUBDIVISION

The correlations of the Muschelkalk section from the Holy Cross Mts with the chronostratigraphic schema [3] and with the Muschelkalk section

[3] An analogous correlation, unfortunately without any comments, was given by Kozur (1974; Tables 2a, 4) in a graphic form. At that time Dr. H. Kozur had no faunistic material from the Holy Cross Mts at his disposal and the correlation was made on the basis of the data published by the present author (Trammer 1971);

of Thuringia needs some comments. In this comparison (Fig. 7), the ranges of guide conodonts are those as established by Kozur (1972c, 1974).

The Lower Anisian/Pelsonian boundary passing within the Łukowa Beds, and the Illyrian/Fassanian boundary passing within the *Pecten discites* Beds, were delineated directly on the basis of conodont datings (see previous chapters and Figs 5—6).

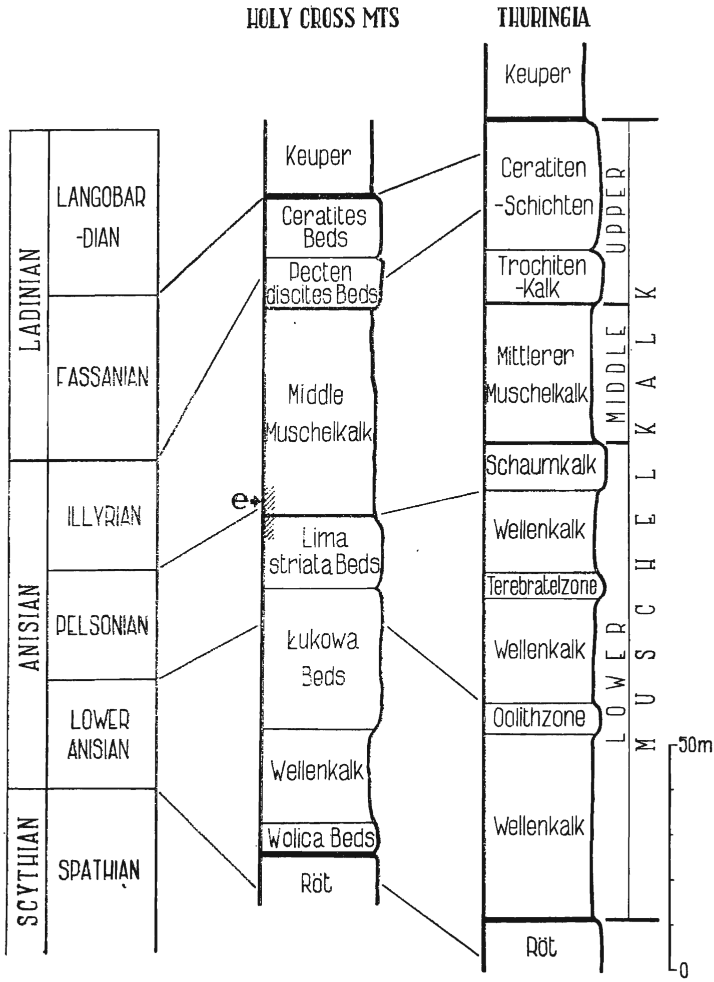


Fig. 7. Chronostratigraphic position of the Muschelkalk sequence from the Holy Cross Mts and from Thuringia (*e* correlation error interval)

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incidentally the paper was ommitted in the list of references (Kozur, a letter to the present author). Moreover, some new data given by the present author in a successive paper (Trammer 1972b), concerning stratigraphic significance of conodonts from the Muschelkalk of the Holy Cross Mts, were not taken into account in that correlation by Kozur (1974). Therefore the latter correlation failed to reconstruct the actual relationship between the lithostratigraphic subdivision and conodont zonation of the Upper Muschelkalk of the Holy Cross Mts (*cf.* Table 4 *in* Kozur 1974, and Text-fig. 3 in Trammer 1972b and Text-figs 6 and 8 herein).

The uppermost part of the Lower Muschelkalk (i.e., the uppermost *Lima striata* Beds) was not sampled, as it is not exposed in the area studied. The topmost exposed part of the Lower Muschelkalk yields the Pelsonian index form, *Neospathodus kockeli*, and thus it is assigned to the Pelsonian (Fig. 5). The species *Neospathodus kockeli* is accompanied by *Gondolella excelsa*, known everywhere from the upper part of the Pelsonian (Mosher 1968; Kozur & Mostler 1971a). Occurrence of the latter in the middle of the *Lima striata* Beds indicates the proximity of the Pelsonian/Illyrian boundary. It therefore was assumed that this boundary passes somewhere in the interval comprising the upper part of the *Lima striata* Beds and the lowermost Middle Muschelkalk (Fig. 7).

The Scythian/Anisian boundary was drawn in the upper part of the Röt (Fig. 7), and the Röt/Muschelkalk boundary, as it is widely assumed, is delineated by the disappearance of the pelecypod *Costatoria costata* (Zenker). The recent studies have shown that the upper boundary of the *C. costata* biozone does not coincide with the chronostratigraphic boundary between the Scythian and Anisian. For example, typical Anisian faunal assemblage is recorded in the top parts of the *C. costata* zone in Bulgaria and Germany (Ganev & al. 1970; Kozur 1972c, 1974), and the conodont species *Chirodella dinodoides*, known exclusively from the Anisian of the Tethys appears before the final disappearance of *C. costata* in Bulgaria (Kozur & Mostler 1972a). In the German Basin the topmost part of the *C. costata* zone yields *Myophoria vulgaris*, always confined to the Lower Anisian in the Tethyan areas (Speciale 1967; Kozur 1974). A general analysis of Triassic faunas of the German and Alpine basins, carried out by Rieber (1973), has also shown that the upper part of the German Röt corresponds to the Alpine Lower Anisian.

The Fassanian/Langobardian boundary passes in the top part of the Upper Muschelkalk, close to the *Terebratula* Lumachelle in the Holy Cross Mts (Fig. 7). In this part of the section the phylogenetic series *G. mombergensis mombergensis* → *G. (Celsigondolella) watznaueri* displays a phenomenon of evolutionary replacement of *G. haslachensis* by *G. (Celsigondolella) watznaueri*. Numerous forms transitional between the two taxa have been recorded here (Trammer 1972b, Pl. 1, Fig. 12; Trammer 1974b). The same transitional forms were found in the Fassanian/Langobardian junction beds in Hungary and Sardinia (Cherchi 1967; Kozur 1972c, 1974). It should also be noted that the ammonoid *Ceratites (Paraceratites) muensteri* Riedel, a form known from German Upper Muschelkalk and from the Holy Cross Mts (Kowalczewski 1926) in the upper part of the *spinosus* and *enodis/laevigatus* zones, was recorded from the uppermost Fassanian and Lower Langobardian of the Southern Alps and Sardinia (Wenger 1957; Müller 1973; Kozur 1974). The upper part of the *spinosus* and *enodis/laevigatus* zones correspond to the 4th conodont zone, with *Gondolella haslachensis* (see Figs 6 and 8). The stratigraphic position

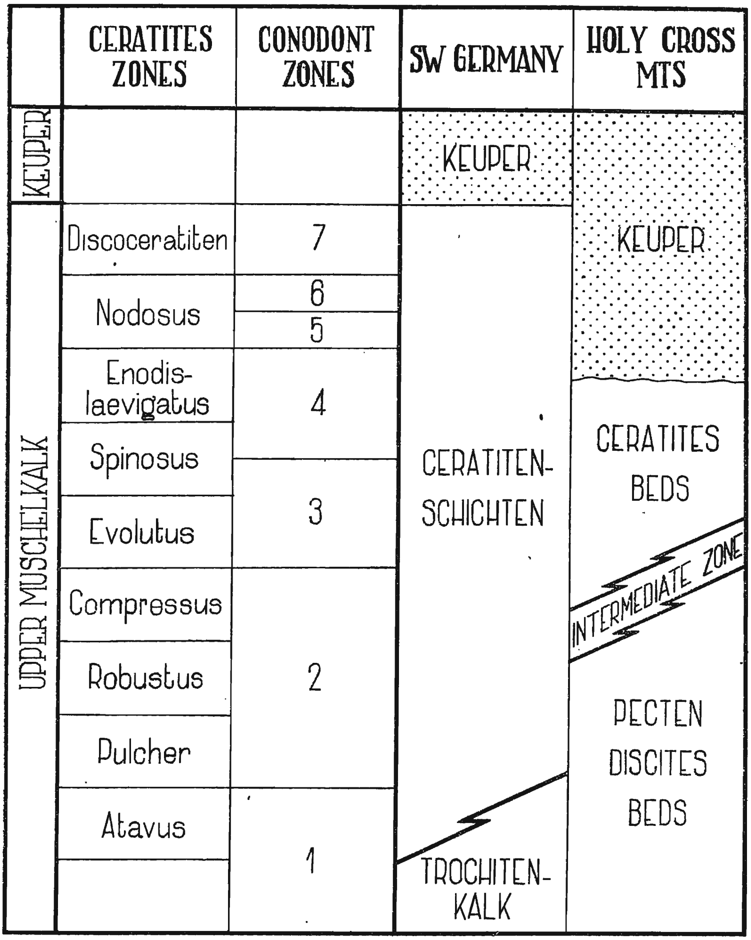

Fig. 8. Correlation of the Upper Muschelkalk sequence from SW Germany and from the Holy Cross Mts

of *Ceratites (Paraceratites) muensteri* in the Tethyan section gives therefore a further support to the above identification of the Fassanian/Langobardian boundary.

PROBLEM OF THE MUSCHELKALK/KEUPER BOUNDARY

As it was already shown for the German Basin (Brinkmann 1954; Senkowiczowa 1957, 1961; Trammer 1971, 1972b, 1974a; Kozur 1971b, 1974; Busse 1972a), the Muschelkalk/Keuper boundary is here heterochroneous.

The uppermost conodont zone recognized in the Holy Cross Mts as bioprotostratigraphic zone *sensu* Henningsmoen (1961) is the 4th zone (Fig. 8). The strata of that zone are overlaid in this area by the Keuper strata (Fig. 8) which yield no conodonts for ecological reasons. The transition from the Muschelkalk to Keuper is here continuous (Filonowicz 1968; Senkowiczowa 1970; Trammer 1974a). In SW Germany, where the Upper Muschelkalk has a full sequence of German ceratitids and conodonts, Keuper overlays the strata yielding conodonts typical of the 7th zone (Fig. 8). The zones 5—7, lacking in the Holy Cross Mts, correspond to the ceratitid zones *nodosus* and *Discoceratiten* from SW Germany (Kozur 1968; Text-fig. 8 herein).

The above data indicate that the Keuper facies began to develop in the Holy Cross area in times when Upper Muschelkalk carbonate deposition was still continuing in the areas of SW Germany (Fig. 8). Thus the end of carbonate deposition in the Holy Cross area took place at the turn of the Fassanian and Langobardian (Fig. 7), and the Langobardian itself is here developed in the Keuper facies.

As it was shown by Kozur (1974), the marine deposition ceased at the end of the Fassanian also in the eastern and north-eastern parts of Germany (see also Busse 1972a) and persisted for some time in SW Germany, Swiss Jura and Lorraine. An intermediate position was occupied by Thuringia, where the Keuper facies began to predominate in the lower part of the *Discoceratiten* zone.

LITHOSTRATIGRAPHIC BOUNDARIES WITHIN THE MUSCHELKALK

The boundary between the 2nd and 3rd conodont zones at Pierzchnica and Stare Chęciny passes through the *Ceratites* Beds, at Lesica it however passes through the *Pecten discites* Beds (Fig. 4). This indicates heterochroneity of the boundary between the *Pecten discites* and *Ceratites* beds (Trammer 1972b), and it records that lateral facies changes are marked in this area. When sedimentation of dark-gray *Ceratites*-bearing limestones started in the Pierzchnica — Stare Chęciny area, deposition of light-coloured *Pecten*-bearing limestones still continued in the Lesica area. A transitional zone is developed between the *Pecten discites* and *Ceratites* beds; thus it should be assumed that the whole zone is heterochroneous (Fig. 8).

A similar situation is found in the Upper Muschelkalk of Germany (Fig. 8), where such heterochroneity is evidenced by the boundary between the Trochitenkalk and the *Ceratites* beds (*cf.* Stolley 1934; Kleinsorge 1935; Hieke 1967; Busse 1972b, 1973).

In this situation heterochroneity of boundaries of other lithostratigraphic units of the Holy Cross Muschelkalk is very likely to occur. However, the conodont zones are insufficiently sensitive for univocal determination of the heterochroneity.

PALEOBIOGEOGRAPHY OF THE HOLY CROSS MUSCHELKALK

Kozur & Mostler (1971a, 1972b) distinguished several conodont provinces in the Triassic on the basis of differences in geographic distribution of particular conodonts.

The Lower Anisian (upper Röt, Wolica Beds, Wellenkalk and the lower part of the Łukowa Beds) of the Holy Cross Mts, starting from the Wolica Beds, is characterized by the occurrence of numerous branched conodonts as well as some platform conodonts, such as *Gondolella mombergensis mombergensis* and *G. aegea*. The conodonts are not known from the Lower Anisian of the Austro-Alpine or west-Mediterranean province (with the exception of some parts of Bulgaria) because of unsuitable facies conditions (Kozur & Mostler 1971a, 1972b). The Lower Anisian of the German part of the German Basin is characterized by the occurrence of branching conodonts at the complete lack of gondolellids. The latter are widely distributed in the contemporaneous strata of the Asiatic conodont province (*cf.* Kozur & Mostler 1971a, 1972b), which is also characterized by multielement *Gladigondolella tethydis,* not known from the Holy Cross Mts.

The geographic distribution of the discussed conodont faunas shows that the Holy Cross area was a transitional region between the Asiatic and German conodont provinces in the Early Anisian times (Trammer 1972b, 1973). It may be added that crinoids appeared in the Holy Cross area markedly earlier than in other parts of the German Basin, i.e. in the Röt (Senkowiczowa 1970), whereas in the latter area they did not occur before the Muschelkalk.

In Silesia and the adjoining Tethyan areas, the conodonts did not appear in the Early Anisian times, whereas they are represented in the Lower Anisian of the German part of the German Basin (Kozur & Mostler 1972c; Kozur 1974). It may therefore be stated that the migration of the faunas from the Tethys to the German Basin could not proceed through the Silesian region but it must have come from the Asiatic parts of the Tethys throughout Bulgaria (the only region of Alpine province inhabited in those times by conodonts) and further in the direction of the Danish-Polish Trough, the Holy Cross region including, through the area of the present eastern margin of the Carpathians (*cf.* Senkowiczowa 1962; Kozur & Mostler 1972c; Kutek & Głazek 1972; Głazek & al. 1973; Kozur 1974).

In the Pelsonian (upper part of the Łukowa Beds, *Lima striata* Beds) the Holy Cross area belonged to the Austro-Alpine faunal province (Trammer 1972b, 1973), as it was inhabited by such typical Alpine elements as conodonts *Gondolella navicula* and *G. excelsa,* cephalopods *Pleuronautilus mosis* Mojsisovics and *Beyrichites (Beyrichites)* sp., foraminifers

Glomospira densa (Pantić) and *Glomospirella grandis* (Salaj), and green algae *Aciculella bacillum* Pia (*cf.* Łuniewski 1923; Trammer 1971a, 1973; Głazek & al. 1973; Gaździcki & Kowalski 1974), all of which have not been known from the German parts of the German Basin. The remaining fauna of the Holy Cross Pelsonian is also known from the western parts of the German Basin and from the Tethys. Alpine faunal elements also occured in those times in Silesia (Rassmuss 1913; Assmann 1926; Senkowiczowa 1962; Zawidzka 1970; Trammer 1973; Głazek & al. 1973), so it seems justified to follow Samsonowicz (1929) and speak about the Polish faunal subprovince, which in the Pelsonian times was much more closely related to the Austro-Alpine than to the German province.

It should be added here that strong analogies in lithofacies development between the Tethyan and the Holy Cross areas were marked in the Pelsonian. In these two regions flints and silicified shells are fairly common, which results from high concentration of sponge spicules in the deposits (*cf.* Marković 1967; Mostler 1971, 1972b).

Biogeographic differentiation within the German Basin in the Early Anisian and Pelsonian times into the eastern (Polish) and western subprovinces does not implicate existence of any morphological barrier. Any further migration, from Poland to Germany, of some Asiatic or Alpine faunal elements was presumably impeded by disadvantageous facies conditions prevailing in the German areas. For example, gondolellids could not have lived when the salinity became slightly higher than normal, as it happened in the latter areas (Kozur 1971a, b; Kozur & Mostler 1971a). On the other hand, such conditions could not have prevented development of branching conodonts, more tolerant to environmental conditions (*cf.* Kozur & Mostler 1971a; Mosher 1973b).

The faunas of the Middle Muschelkalk (Lower and Middle Illyrian) of the Holy Cross Mts are very poor and badly preserved (*cf.* Senkowiczowa 1970). However, it should be noted that this almost complete lack of faunas in the early and middle Illyrian times is typical exclusively of the German Basin, with the exception of Silesia (*cf.* Zawidzka 1975). It may therefore be assumed that in those times the Holy Cross area belonged to the German province.

The Late Illyrian and Fassanian deposits (Upper Muschelkalk) of the Holy Cross Mts yield platform conodonts of endemic German evolutionary series *Gondolella mombergensis mombergenis* — *G. (Celsigondolella) watznaueri* and numerous, exclusively German branching conodonts *Enantiognathus incurvus, Hibbardella bicuspidata, Hindeodella (Metaprioniodus) bicuspidata, Neohindeodella aequidentata, Pollognathus germanicus* and *P. sequens*. Moreover, there occur German endemic ceratitids (Senkowiczowa 1970). All these data indicate that the Holy Cross area belonged to the German faunal province in those times.

The lower part of the Fassanian also yields conodonts known exclusively from Bulgaria, i.e., *Gondolella excentrica, G. longa,* and *G. suhodolica.* This conodont assemblage reflects influences of the Austro-Alpine province at least in the early Fassanian times (upper *Pecten discites* Beds, lower *Ceratites* Beds). Analogous influences were recorded in the uppermost Fassanian and lowermost Langobardian of Thuringia (Müller 1973; Kozur 1974); they are reflected by the occurrence of the conodont species *Gladigondolella tethydis,* typical of the Ladinian of the Austro-Alpine province.

The problem of the discussed paleobiogeographic provinces cannot be treated as solved to the very end. Any few findings of conodont faunas in areas wherefrom they have not been known up to the present may result in more or less substantial changes in the here presented considerations.

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REFERENCES

AGER D. V. 1963. Principles of paleoecology. New York — San Francisco — Toronto — London.

— 1974. Storm deposits in the Jurassic of the Moroccan High Atlas. — Paleogeography, Paleoclimatology, Paleoecology, Vol. 15, No. 1. Amsterdam.

— & WALLACE P. 1970. The distribution and significance of trace fossils in the uppermost Jurassic rocks of the Boulonnais, Northern France. — *In:* CRIMES T. P. & HARPER J. C. (*Eds*), Trace fossils (Geol. J. Special Issue, No. 3). Liverpool.

ANKETELL J. M., CEGŁA J. & DŻUŁYŃSKI S. 1970. On the deformational structures in systems with reversed density gradients. — Ann. Soc. Géol. Pol., Vol. 40, No. 1. Kraków.

ASSERETO R. 1971. Die *Binodosus*-Zone. Ein Jahrhundert wissenschaftlicher Gegensätze. Wien.

ASSMANN P. 1926. Die Fauna der Wirbellosen und die Diploporen der oberschlesischen Trias mit Ausnahme der Brachiopoden, Lamellibranchiaten, Gastropoden und Korallen. — Jb. Königl. Preuss. Geol. L.-A., Vol. 46. Berlin.

BESTEL G. 1929. Das Steinsalz im germanischen Mittleren Muschalkalk. — *Ibidem,* Vol. 50.

BIALIK A., TRAMMER J. & ZAPAŚNIK T. 1972. Synsedimentary disturbances in Middle Triassic carbonates of the Holy Cross Mts. — Acta Geol. Pol., Vol. 22, No. 2. Warszawa.

BOGACZ K., DŻUŁYŃSKI S., GRADZIŃSKI R. & KOSTECKA A. 1968. Origin of crumpled limestone in the Middle Triassic of Poland. — Ann. Soc. Géol. Pol., Vol. 38, No. 2/3. Kraków.

BOOGAARD M. van den & SIMON O. J. 1973. *Pseudofurnishius* (Conodonta) in the Triassic of the Betic Cordilleras, SE Spain. — Scripta Geol., Vol. 16. Leiden.

BRINKMANN R. 1954. Abriss der Geologie. — Bd. 2. Stuttgart.

BROMLEY R. G. 1972. On some ichnotaxa in hard substrates with a redefinition of *Trypanites* Mägdefrau. — Paläont. Z., Vol. 46, No. 1/2. Stuttgart.

BUDUROV K. 1972. *Ancyrogondolella triangularis* gen. et sp. n. (Conodonta) — Mitt. Ges. Geol. Bergbaustud., Vol. 21. Innsbruck.
— 1973. *Carinella* n. gen. und Revision der Gattung *Gladigondolella* (Conodonta). — C. R. Acad. Bulg. Sci., Vol. 26, No. 6. Sofia.
— & PANTIĆ S. 1973. Conodonten aus den Campiller Schichten von Brassina (Westserbien). — Bull. Geol. Inst., Ser. Paleont., Vol. 22. Sofia.
— & STEFANOV S. 1972. Plattform-Conodonten und ihre Zonen in der Mittleren Trias Bulgariens. — Mitt. Ges. Geol. Bergbaustud., Vol. 21. Innsbruck.
— & — 1973. Etliche neue Plattform-Conodonten aus der Mitteltrias Bulgariens. — C. R. Acad. Bulg. Sci., Vol. 26, No. 6. Sofia.
BUSSE E. 1970. Ceratiten und Ceratiten-Stratigraphie. — Notizbl. Hess. L.-A. Bodenforsch., Vol. 98. Wiesbaden.
— 1972a. Zur Stratigraphie des Oberen Muschelkalks im Diemeltal bei Warburg. — *Ibidem*, Vol. 100.
— 1972b. Fazies und Fauna des Oberen Muschelkalkes von Willebadessen. — Philipia, Vol. 1/3.
— 1973. Aufschlüsse im Oberen Muschelkalk bei Eberschütz und Manrode (Diemelgebiet, Bl. 4422 Trendelburg). — Notizbl. Hess. L.-A. Bodenforsch., Vol. 101. Wiesbaden.
CHERCHI A. 1967. I. Conodonti del Muschelkalk della Nurra (Sardegna nord-occidentale). — Riv. Ital. Paleont., Vol. 73, No. 1. Milano.
CHOQUETTE P. W. & PRAY L. C. 1970. Geologic nomenclature and classification of porosity in sedimentary carbonates. — Bull. Amer. Assoc. Petrol. Geol., Vol. 54, No. 2. Denver.
CLARKE M. W. H. & KEIJ A. J. 1973. Organisms as producers of carbonate sediment and indicators of environment in the Southern Persian Gulf. — *In:* PURSER B. H. (*Ed.*), The Persian Gulf. Berlin — Heidelberg — New York.
DURDANOVIĆ Ž. 1973. About the Paleozoic and the Triassic of Medvednica Mountain and the area near Dvor na Uni on the basis of conodonts. — Geol. Vjesnik, Vol. 25. Zagreb.
EINASTO R. 1964. K voprosu o klassifikacii i formirovanii poverkhnostej pereryva. — *In:* Litologija paleozojskikh otlozhenij Estonii. Tallinn.
ERNST G. & WACHENDORF H. 1968. Feinstratigraphisch-fazielle Analyse der „Schaumkalk-Serie" des Unteren Muschelkalks im Elm (Ost-Niedersachsen). — Beih. Ber. Naturh. Ges., Vol. 5. Hannover.
FILONOWICZ P. 1968. Morawica (objaśnienia do szczegółowej mapy geologicznej Polski). Warszawa.
FLÜGEL H. & RAMOVŠ A. 1970. Zur Kenntnis der Amphiclinen — Schichten Sloweniens. — Geol. Vjesnik, Vol. 23. Zagreb.
FREEMAN T. 1972. Sedimentology and dolomitization of Muschelkalk carbonates (Triassic), Iberian Range, Spain. — Bull. Amer. Assoc. Petrol. Geol., Vol. 56, No. 3. Denver.
FÜRSICH F. T. 1973. *Thalassinoides* and the origin of nodular limestone in the Corallian Beds (Upper Jurassic) of Southern England. — N. Jb. Geol. Paläont., Mh. 3. Stuttgart.
GANEV M., STEFANOV S. & ČATALOV G. 1970. Die Grenze zwischen Unter- und Mittel-Trias in der Umgebung von Teteven (Zentral-Vorbalkan). — Bull. Geol. Inst., Ser. Strat. Lythol., Vol. 19. Sofia.
GAŹDZICKI A. & KOWALSKI W. R. 1974. Green algae *Aciculella* Pia from the Muschelkalk of the Holy Cross Mts (Poland). — Bull. Acad. Pol. Sci., Sér. Sci. Terre, Vol. 22, No. 1. Varsovie.
—, TRAMMER J. & ZAWIDZKA K. 1975. Foraminifers from the Muschelkalk of southern Poland. — Acta Geol. Pol., Vol. 25, No. 2. Warszawa.

GEISLER R. 1939. Zur Stratigraphie des Hauptmuschelkalks in der Umgebung von Würzburg mit besonderer Berücksichtigung der Ceratiten. — Jb. Preuss. Geol. L.-A., Vol. 59. Berlin.

GINSBURG R. N. & LOWENSTAM H. A. 1958. The influence of marine bottom communities on the depositional environment of sediments. — J. Geol., Vol. 66, No. 3. Chicago.

GŁAZEK J., TRAMMER J. & ZAWIDZKA K. 1973. The Alpine microfacies with *Glomospira densa* (Pantić) in the Muschelkalk of Poland and some related paleogeographical and geotectonic problems. — Acta Geol. Pol., Vol. 23, No. 3. Warszawa.

GWINNER M. P., BACHMANN G., SCHÄFER K. & SKUPIN K. 1968. The bioclastic limestones of the "Trochitenkalk" (Upper Muschelkalk) in SW Germany. — *In:* Recent Developments in Carbonate Sedimentology in Central Europe. Berlin — Heidelberg — New York.

HALLAM A. 1967. Sedimentology and palaeogeographic significance of certain red limestones and associated beds in the Lias of the Alpine region. — Scott. J. Geol., Vol. 3. Edinburgh.

HAYASHI S. 1968. The Permian conodonts in chert of the Adoyama Formation, Ashio Mountains, Central Japan. — Earth Science, Vol. 22, No. 2. Tokyo.

— 1972. Conodonts at the Permian-Triassic boundary in Japan. Conodonts from the basal part of the Adoyama Formation. — J. Geol. Soc. Japan, Vol. 78, No. 7. Tokyo.

HENNINGSMOEN G. 1961. Remarks on stratigraphical classification. — Norges Geol. Undersøkelse, No. 213. Oslo.

HIEKE W. 1967. Feinstratigraphie und Paläogeographie des Trochitenkalkes zwischen Leinetal-Graben und Rhön. — Geologica et Palaeontologica, Vol. 1. Marburg.

HIRSCH F. 1971. Conodontes nouvelles du Trias méditerranéen. — C. R. Séances SPHN Genève, Vol. 6, No. 1. Genève.

— 1972. Middle Triassic conodonts from Israel, Southern France and Spain (1). — Mitt. Ges. Geol. Bergbaustud., Vol. 21. Innsbruck.

— & SÜSSLI P. 1973. Lower Triassic conodonts from the Lower Elikah Formation, Central Alborz Mountains (North Iran). — Eclogae Geol. Helv., Vol. 66, No. 3. Basel.

HOLLMANN R. 1962. Über Subsolution und die "Knollenkalke" des Calcare Ammonitico Rosso Superiore im Malm des Monte Blado, Norditalien. — N. Jb. Geol. Paläont., Mh. 4. Stuttgart.

JAHNKE H. 1966. Beobachtungen an einem Hartgrund (Oberkante Terebratelbank mu² bei Göttingen). — Der Aufschluss, Vol. 17, No. 1. Heidelberg.

JAWOROWSKI K. & MODLIŃSKI Z. 1972. Discontinuity surfaces in the Ordovician limestones of the eastern part of the peribaltic syneclise (NE Poland). — Acta Geol. Pol., Vol. 22, No. 4. Warszawa.

JENKINS T. B. H. & JENKINS D. G. 1971. Conodonts of the Haast Schist and Torlesse Groups of New Zealand. Part 1 — Biostratigraphic significance of the Triassic conodonts from the Mount Mason and Okuku Limestones. — New Zealand Journal Geol. Geoph., Vol. 14, No. 4. Christchurch.

JENKYNS H. C. 1971. Speculations on the genesis of crinoidal limestones in the Tethyan Jurassic. — Geol. Rundschau, Vol. 60, No. 2, Stuttgart.

JURKIEWICZ H. 1974. Development of the Triassic in the central area of the Nida Trough. — Kwartalnik Geol., Vol. 18, No. 1. Warszawa.

KAHLE C. F. & FLOYD J. C. 1971. Stratigraphic and environmental significance of sedimentary structures in Cayugan (Silurian) tidal flat carbonates, Northwestern Ohio. — Bull. Geol. Soc. Amer., Vol. 82, No. 8. Boulder.

KAŹMIERCZAK J. & PSZCZÓŁKOWSKI A. 1968. Sedimentary discontinuities in the Lower Kimmeridgian of the Holy Cross Mts. — Acta Geol. Pol., Vol. 18, No. 3. Warszawa.

— & — 1969. Burrows of Enteropneusta in Muschelkalk (Middle Triassic) of the Holy Cross Mountains. — Acta Palaeont. Pol., Vol. 14, No. 2. Warszawa.

KENNEDY W. J. & JUIGNET P. 1974. Carbonate banks and slump beds in the Upper Cretaceous (Upper Turonian — Santonian) of Haute Normandie, France. — Sedimentology, Vol. 21, No. 1. Amsterdam.

KLEINSORGE H. 1935. Paläogeographische Untersuchungen über den oberen Muschelkalk in Nord- und Mitteldeutschland. — Mitt. Geol. Staatsinst. Hamburg, Vol. 15. Hamburg.

KOSTECKA A. 1972. Calcite paramorphs in the aragonite concretions. — Ann. Soc. Géol. Pol., Vol. 42, No. 2/3. Kraków.

KOWALCZEWSKI B. 1926. Sur le Muschelkalk du versant méridional du Massif de Święty Krzyż entre le Łośnia et la Czarna Nida. — Bull. Serv. Géol. Pol., Vol. 3, No. 3/4. Varsovie.

KOZUR H. 1968. Conodonten aus dem Muschelkalk des germanischen Binnenbeckens und ihr stratigraphischer Wert. — Geologie, Vol. 17, No. 8/9. Berlin.

— 1971a. Zur Verwertbarkeit von Conodonten, Ostracoden und einigen anderen Mikrofossilien für biostratigraphische und ökologisch-fazielle Untersuchungen in der Trias. — Geol. Zborn. Slov. Akad. Věd, Vol. 22, No. 1. Bratislava.

— 1971b. Ökologisch-fazielle Probleme der Biostratigraphie des Oberen Muschelkalkes. — Freiberger Forschungsh. C 267. Leipzig.

— 1972a. Die Conodontengattung *Metapolygnathus* Hayashi 1968 und ihr stratigraphischer Wert. — Geol. Paläont. Mitt. Innsbruck, Vol. 2, No. 11. Innsbruck.

— 1972b. Die Bedeutung triassischer Ostracoden für stratigraphische und paläoökologische Untersuchungen. — Mitt. Ges. Geol. Bergbaustud., Vol. 21. Innsbruck.

— 1972c. Vorläufige Mitteilung zur Parallelisierung der germanischen und tethyalen Trias sowie einige Bemerkungen zur Stufen- und Unterstufungliederung der Trias. — *Ibidem.*

— 1973. Beiträge zur Stratigraphie von Perm und Trias. — Geol. Paläont. Mitt. Innsbruck, Vol. 3. No. 3. Innsbruck.

— 1974. Biostratigraphie der germanischen Mitteltrias. — Freiberger Forschungsh. C 280 Leipzig.

— & MOCK R. 1972. Neue Conodonten aus der Trias der Slowakei und ihre stratigraphische Bedeutung. — Geol. Paläont. Mitt. Innsbruck, Vol. 2, No. 4. Innsbruck.

— & MOSTLER H. 1970. Holothuriensklerite aus der Unter- und Mitteltrias des Germanischen Beckens und alpinen Raumes, sowie deren stratigraphische Bedeutung. — Festband d. Geol. Inst., 300-Jahr Feier Univ. Innsbruck. Innsbruck.

— & — 1971a. Probleme der Conodontenforschung in der Trias. — Geol. Paläont. Mitt. Innsbruck, Vol. 1, No. 4. Innsbruck.

— & — 1971b. Holothurien-Sklerite und Conodonten aus der Mittel- und Obertrias von Köveskal (Balatonhochland, Ungarn). — *Ibidem,* No. 10.

— & — 1972a. Die Conodonten der Trias und ihr stratigraphischer Wert. I. Die "Zahnreihen-Conodonten" der Mittel- und Obertrias. — Abh. Geol. B.-A., Vol. 28, No. 1. Wien.

— & — 1972b. Die Bedeutung der Conodonten für stratigraphische und paläogeographische Untersuchungen in der Trias. — Mitt. Ges. Geol. Bergbaustud., Vol. 21. Innsbruck.

— & — 1972c. Die Bedeutung der Mikrofossilien für stratigraphische, paläoökologische und paläogeographische Untersuchungen in der Trias. — *Ibidem.*

KRYSTYN L. 1973. Zur Ammoniten- und Conodonten-Stratigraphie der Hallstätter Obertrias (Salzkammergut, Österreich). — Verh. Geol. B.-A., Jg. 1973, No. 1. Wien.

KUBICZ A. 1970. Charakterystyka ławic konglomeratowych warstw wilkowickich na Śląsku Opolskim. — Spraw. Pos. Kom. PAN, Vol. 14, No. 2. Kraków.

KUENEN P. H. & MENARD H. 1952. Turbidity currents, graded and non graded deposits. — J. Sedim. Petrol., Vol. 22, No. 2. Menasha.

KUTEK J. 1969. The Kimmeridgian and uppermost Oxfordian in the SW margins of the Holy Cross Mts (Central Poland); Part II, Paleogeography. — Acta Geol. Pol., Vol. 19, No. 2. Warszawa.

— & GŁAZEK J. 1972. The Holy Cross area, Central Poland, in the Alpine cycle. — *Ibidem,* Vol. 22, No. 4.

LAPORTE L. F. 1967. Carbonate deposition near mean sea-level and resultant facies mosaic: Manlius formation (Lower Devonian) of New York State. — Bull. Amer. Ass. Petrol. Geol., Vol. 51, No. 1. Tulsa.

LISZKOWSKI J. 1973. A bone bed from the "Wellen-Beds" of the Lower Muschelkalk (Lowermost Anisian) at Wolica near Kielce (Holy Cross Mts). — Przegląd Geol., 1973, No. 12. Warszawa.

ŁUNIEWSKI A. 1923. Sur les éléments alpins dans la faune du Muschelkalk sur le versant nord des montagnes de Święty Krzyż. — Bull. Serv. Géol. Pol., Vol. 2, No. 1/2. Varsovie.

MARKOVIČ B. 1967. Ein Beitrag zum Aufbau der Trias Jugoslawiens (Einige paläogeographischen Beobachtungen). — Geol. Sborn. Slov. Akad. Věd, Vol. 18, No. 2. Bratislava.

MÄGDEFRAU K. 1932. Über einige Bohrgänge aus dem Unteren Muschelkalk von Jena. — Paläont. Z., Vol. 14, No. 3. Berlin.

McCUNN H. J. 1972. Calcite and aragonite phenomena precipitated by organic decay in high lime concentrate brines. — J. Sedim. Petrol., Vol. 42, No. 1. Menasha.

McTAVISH R. A. 1973. Triassic conodont faunas from Western Australia. — N. Jb. Geol. Paläont., Abh. 143, No. 3. Stuttgart.

MEISCHNER K. D. 1964. Allodapische Kalke, Turbidite in riffnähen Sedimentations--Becken. — *In:* BOUMA A. H. & BROUWER A. (*Eds*), Turbidites. Developments in Sedimentology, Vol. 3. Amsterdam — London — New York.

MOCK R. 1971. Conodonten aus der Trias der Slowakei und ihre Verwendung in der Stratigraphie. — Geol. Sborn. Slov. Akad. Věd, Vol. 22. 2. Bratislava.

MOSHER L. 1968. Triassic conodonts from western North America and Europe and their correlation. — J. Paleontology, Vol. 42, No. 4. Menasha.

— 1970. New conodont species as Triassic guide fossils. — *Ibidem,* Vol. 44, No. 4.

— 1973a. Triassic conodonts from British Columbia and the Northern Arctic Islands. — Geol. Surv. Can. Bull., Vol. 222. Ottawa.

— 1973b. Evolutionary, ecologic, and geographic observations on conodonts during their decline and extinction. — Geol. Soc. Amer. Spec. Paper, Vol. 141. Boulder.

MOSTLER H. 1971. Häufigkeit und Bedeutung von Schwammspiculae in triassischen Mikrofaunen. — Geol. Paläont. Mitt. Innsbruck, Vol. 1, No. 11. Innsbruck.

— 1972a. Holothuriensklerite der alpinen Trias und ihre stratigraphische Bedeutung. — Mitt. Ges. Geol. Bergbaustud., Vol. 21. Innsbruck.

— 1972b. Die Spiculae triassischer Porifera. — *Ibidem.*

MÜLLER A. H. 1956. Weitere Beiträge zur Ichnologie, Stratonomie und Ökologie der germanischen Trias, Teil I. — Geologie, Vol. 5, No. 4/5. Berlin.

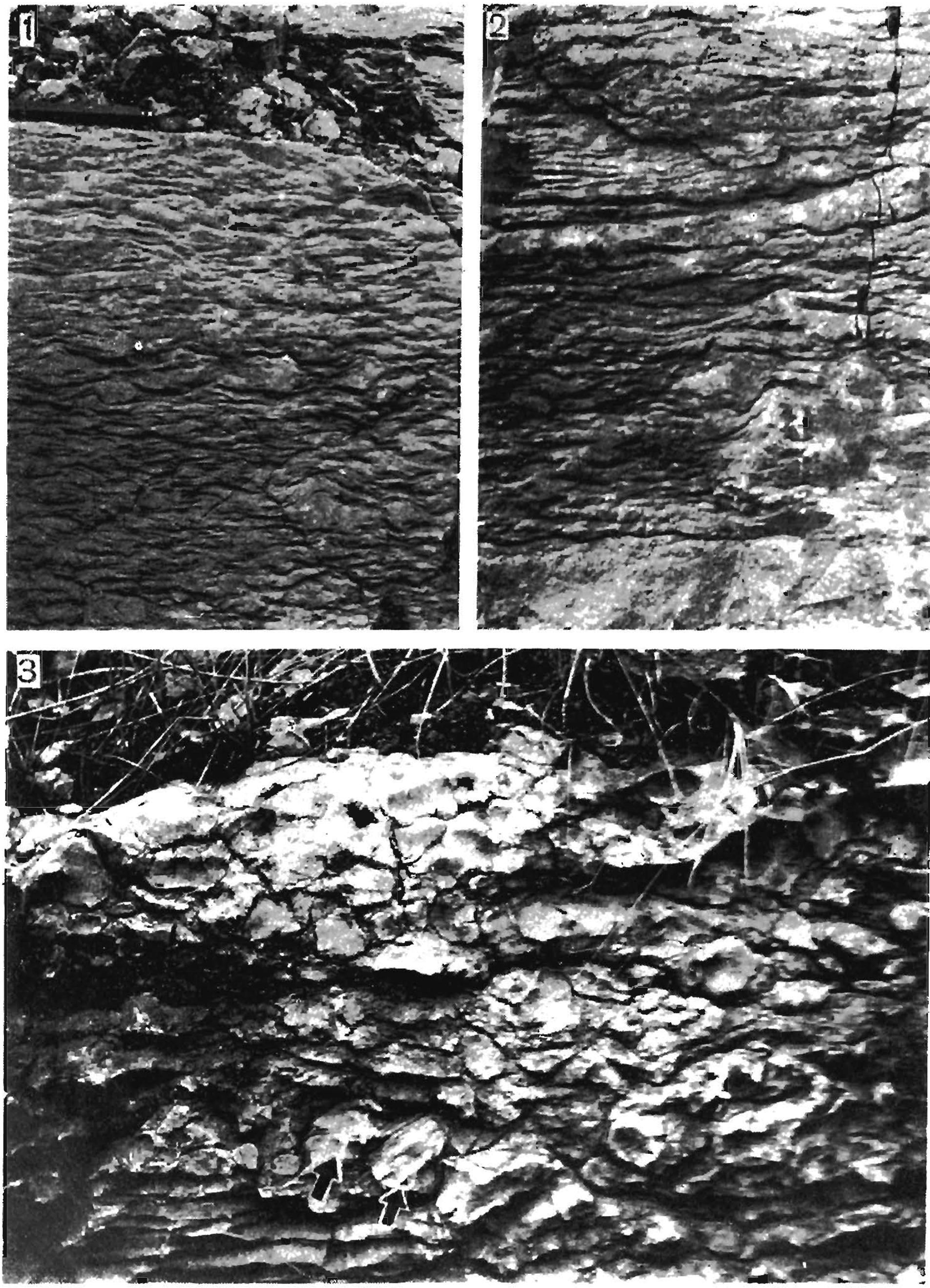
— 1959. Weitere Beiträge zur Ichnologie, Stratonomie und Ökologie der germanischen Trias. Teil II. — *Ibidem,* Vol. 8, No. 3.
— 1973. Über Ammonoidea (Cephalopoda) aus der Grenzdolomitregion des germanischen Unterkeupers. — Z. geol. Wiss., Vol. 1, No. 8. Berlin.
NEUMANN N. & SCHUMANN D. 1974. Zur Fossilerhaltung, besonders der Goniatiten, in roten Knollenkalken vom „Ammonitico Rosso" — Typ. — N. Jb. Geol. Paläont., Mh. 5. Stuttgart.
NEWELL N. D., IMBRIE J., PURDY E. G. & THURBER D. L. 1959. Organism communities and bottom facies, Great Bahama Bank. — Bull. Amer. Mus. Nat. Hist., Vol. 117, No. 4. New York.
PANTIĆ S. & ČIČIĆ S. 1970. Ein Beitrag zur Kenntnis der litho- und biofazialen Charakteristiken des oberen Perms und der Trias in der Gegend von nordöstlicher Majevica. — Bull. Geol., Vol. 14. Sarajevo.
PURSER B. H. 1969. Syn-sedimentary marine lithification of Middle Jurassic limestones of the Paris Basin, France. — Sedimentology, Vol. 12, No. 3/4. Amsterdam.
— (*Ed.*) 1973. The Persian Gulf. Holocene carbonate sedimentation and diagenesis in a shallow epicontinental sea. Berlin — Heidelberg — New York.
RADWAŃSKI A. 1968. Petrographical and sedimentological studies of the high-tatric Rhaetic in the Tatra Mountains. — Studia Geol. Pol., Vol. 25. Warszawa.
RASSMUSS H. 1913. Alpine Cephalopoden in niederschlesischem Muschelkalk. — Jb. Königl. Preuss. Geol. L.-A., Vol. 34, No. 2. Berlin.
REINECK H. E. & WUNDERLICH F. 1968. Classification and origin of flaser and lenticular bedding. — Sedimentology, Vol. 11, No. 1/2. Amsterdam.
RIEBER H. 1973. Ergebnisse paläontologisch-stratigraphischer Untersuchungen in der Grenzbituminenzone (Mittlere Trias) des Monte San Giorgio (Kanton Tessin, Schweiz). — Eclogae Geol. Helv., Vol. 66, No. 3. Basel.
RIEDEL A. 1916. Beiträge zur Paläontologie und Stratigraphie der Ceratiten des deutschen oberen Muschelkalks. — Jb. Königl. Preuss. Geol. L.-A., Vol. 37. Berlin.
ROEHL P. O. 1967. Stony Mountain (Ordovician) and Interlake (Silurian) facies analogs of recent low-energy marine and subaerial carbonates, Bahamas. — Bull. Amer. Ass. Petrol. Geol., Vol. 51, No. 10. Tulsa.
SAMSONOWICZ J. 1929. Le Zechstein, le Trias et le Liassique sur le versant nord du Massif de S-te Croix. — Bull. Serv. Géol. Pol., Vol. 5, No. 1/2. Varsovie.
SCHÄFER K. A. 1973. Zur Fazies und Paläogeographie der *Spiriferina*-Bank (Hauptmuschelkalk) im nördlichen Baden-Württemberg. — N. Jb. Geol. Paläont., Abh. 143, No. 1. Stuttgart.
SCHMIDT M. 1928. Die Lebewelt unserer Trias. Öhringen.
SCHOLZ G. 1972. An Anisian Wetterstein limestone reef in North Hungary. — Acta Univ. Szeged., Acta Mineral. Petrograph., Vol. 20, No. 2. Szeged.
SCHULZ M. G. 1972. Feinstratigraphie und Zyklengliederung des Unteren Muschelkalks in N-Hessen. — Mitt. Geol.-Paläont. Inst. Univ. Hg, Vol. 41. Hamburg.
SCHWARZ H. U. 1970. Zur Sedimentologie und Fazies des Unteren Muschelkalkes in Südwestdeutschland und angrenzenden Gebieten. — Diss. Tübingen.
— 1971. Facies analysis of shallow marine cabonates (Lower Muschelkalk, Middle Triassic). *In:* Sedimentology of parts of Central Europe. Guidebook, VIII International Sedimentological Congress 1971 in Heidelberg. Frankfurt a.M.
SENKOWICZOWA H. 1957. The Muschelkalk on the southern slope of the Holy Cross Mts, between Czarna Nida and Chmielnik. — Bull. Inst. Géol. Pol., Vol. 122. Warszawa.
— 1959. Röth and Muschelkalk in the vicinity of Chęciny (Holy Cross Mountains.) — *Ibidem,* Vol. 159.

— 1961. The Röth and Muschelkalk in the western marginal area of the Holy Cross Mountains. — *Ibidem*, Vol. 167.
— 1962. Alpine fauna in the Röth and Muschelkalk sediments of Poland. — Memory Book of Professor J. Samsonowicz. Warszawa.
— 1970. Triassic, without Rhaetian deposits. — Prace Inst. Geol., Vol. 56. Warszawa.
— 1972. Holothuroidea and Ophiuroidea in the Lower Muschelkalk from borehole Żebrak. — Kwartalnik Geol., Vol. 16, No. 4. Warszawa.
SHINN E. A. 1969. Submarine lithification of Holocene carbonate sediments in the Persian Gulf. — Sedimentology, Vol. 12, No. 1/2. Amsterdam.
— , LLOYD R. M. & GINSBURG R. N. 1969. Anatomy of a modern carbonate tidal-flat, Andros Island, Bahamas. — J. Sedim. Petrol., Vol. 39, No. 3. Menasha.
SKUPIN K. 1973. Stratigraphy and microfacies in the crinoidal limestones (Trochiten Limestone, Triassic) of Southwest Germany. — Sedimentary Geol., Vol. 9, No. 1. Amsterdam.
SPECIALE A. 1967. Il Trias in Lombardia (studi geologici e paleontologici). XXI. Fossili del Trias medio valli Trompia e Sabbia. — Riv. Ital. Paleont., Vol. 73, No. 4. Milano.
STOLLEY E. 1934. Der stratigraphische Wert des Trochitenkalkes für die Gliederung des deutschen oberen Muschelkalkes. — N. Jb. Mineral., Abt. B, Vol. 72. Stuttgart.
SUMMESBERGER H. & WAGNER L. 1972. Der Stratotypus des Anis (Trias). — Ann. Naturhist. Mus. Wien, Vol. 76. Wien.
SWEET W. C., MOSHER L. C., CLARK D. L., COLLINSON J. W. & HASENMUELLER W. A. 1971. Conodont biostratigraphy of the Triassic. — *In*: SWEET W. C. & BERGSTROM S. M. (*Eds*), Symposium on conodont biostratigraphy (Geol. Soc. Amer. Mem., 127). Boulder.
SZULCZEWSKI M. 1965. Observation sur la genèse des calcaires noduleux des Tatras. — Ann. Soc. Géol. Pol., Vol. 35, No. 2. Kraków.
TATGE U. 1956. Conodonten aus dem germanischen Muschelkalk. — Paläont. Z., Vol. 30, No. 1/2, 3/4. Stuttgart.
TAYLOR J. C. M. & ILLING L. V. 1969. Recent intertidal calcium carbonate cementation at Qatar, Persian Gulf. — Sedimentology, Vol. 12, No. 1/2. Amsterdam.
TEXTORIS D. A. 1968. Petrology of supratidal, intertidal, and shallow subtidal carbonates, Black River group, Middle Ordovician, New York, U.S.A. — Intern. Geol. Congr. Rep., 23 Sess., Part 8. Prague.
TOKARSKI A. 1969. Key horizon of problematica in the Muschelkalk of Ziemia Lubuska. — Acta Geol. Pol., Vol. 19, No. 4. Warszawa.
TRAMMER J. 1971. Middle Triassic (Muschelkalk) conodonts from the SW margin of the Holy Cross Mts. — Acta Geol. Pol., Vol. 21, No. 3. Warszawa.
— 1972a. *Beyrichites (Beyrichites)* sp. from the Lower Muschelkalk of the Holy Cross Mts. — *Ibidem*, Vol. 22. No. 1.
— 1972b. Stratigraphical and paleogeographical significance of conodonts from the Muschelkalk of the Holy Cross Mts. — *Ibidem*, Vol. 22, No. 2.
— 1973. The particular paleogeographical setting of Polish Muschelkalk in the German basin. — N. Jb. Geol. Paläont., Mh. 9. Stuttgart.
— 1974a. Muschelkalk/Keuper boundary at southwestern margins of the Holy Cross Mts. — Przegląd Geol., 1974, No. 1. Warszawa.
— 1974b. Evolutionary trends and pattern of extinction of Triassic conodonts .— Acta Palaeont. Pol., Vol. 19, No. 2. Warszawa.
— 1974c. Über zwei Lebensspuren aus dem Unteren Muschelkalk des Heilige--Kreuz-Gebirges, Polen. — Der Aufschluss, Vol. 25, No. 6. Heidelberg.

1 — Crumpled limestones composed of obtuse lumps; Wolica, Wellenkalk.

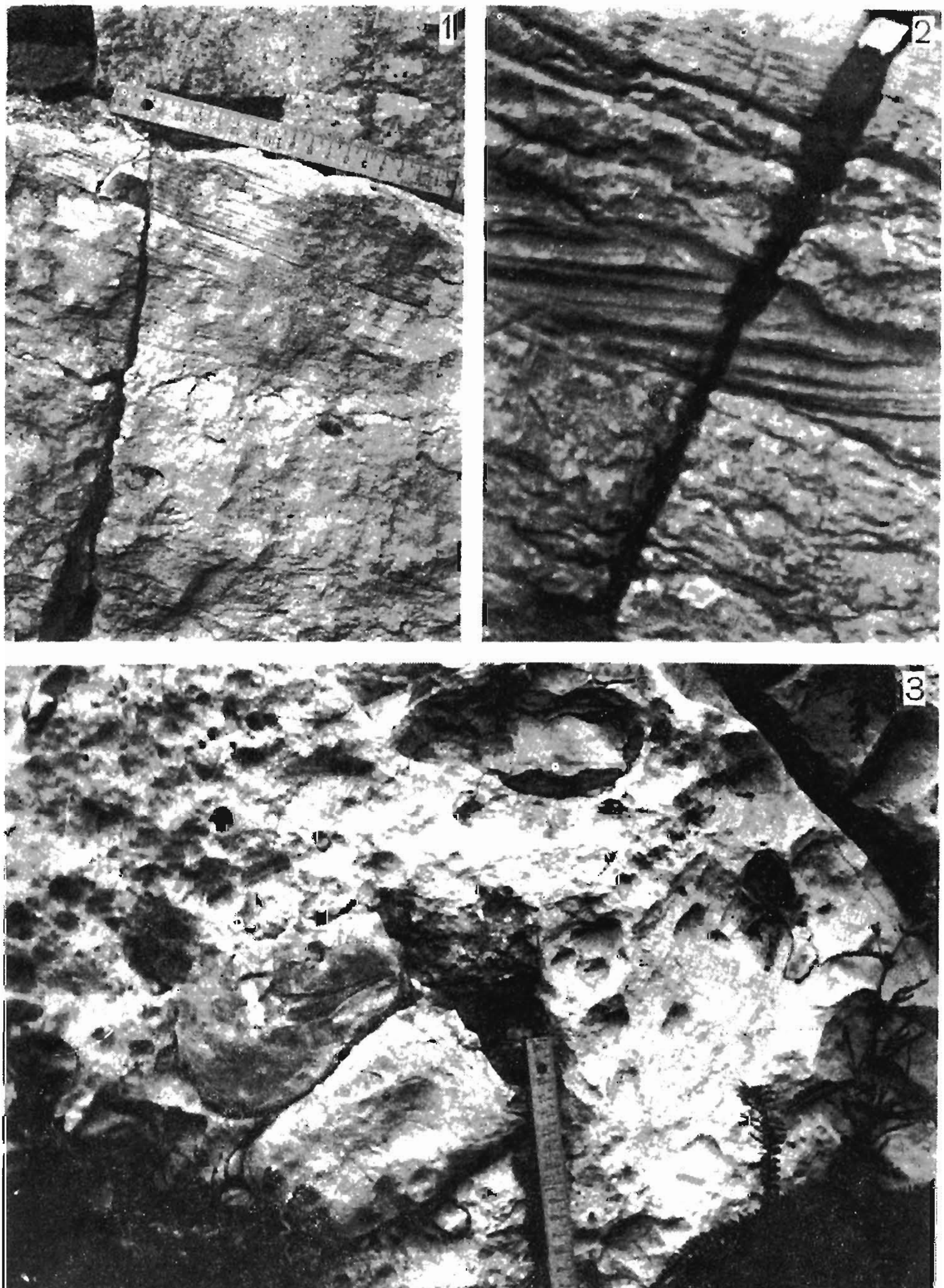
2 — Crumpled limestones composed of organic burrows (topside view); Zajączków, Wellenkalk.

3 — Crumpled limestones composed of angular lumps (arrowed are lumps with undisturbed lamination — *cf.* Pl. 2, Fig. 3); Wincentów, Wellenkalk.



1-2 — Limestones yielding lenticular bedding (*Linsen-* and *Flaserschichtung*); Wincenów, Wellenkalk.

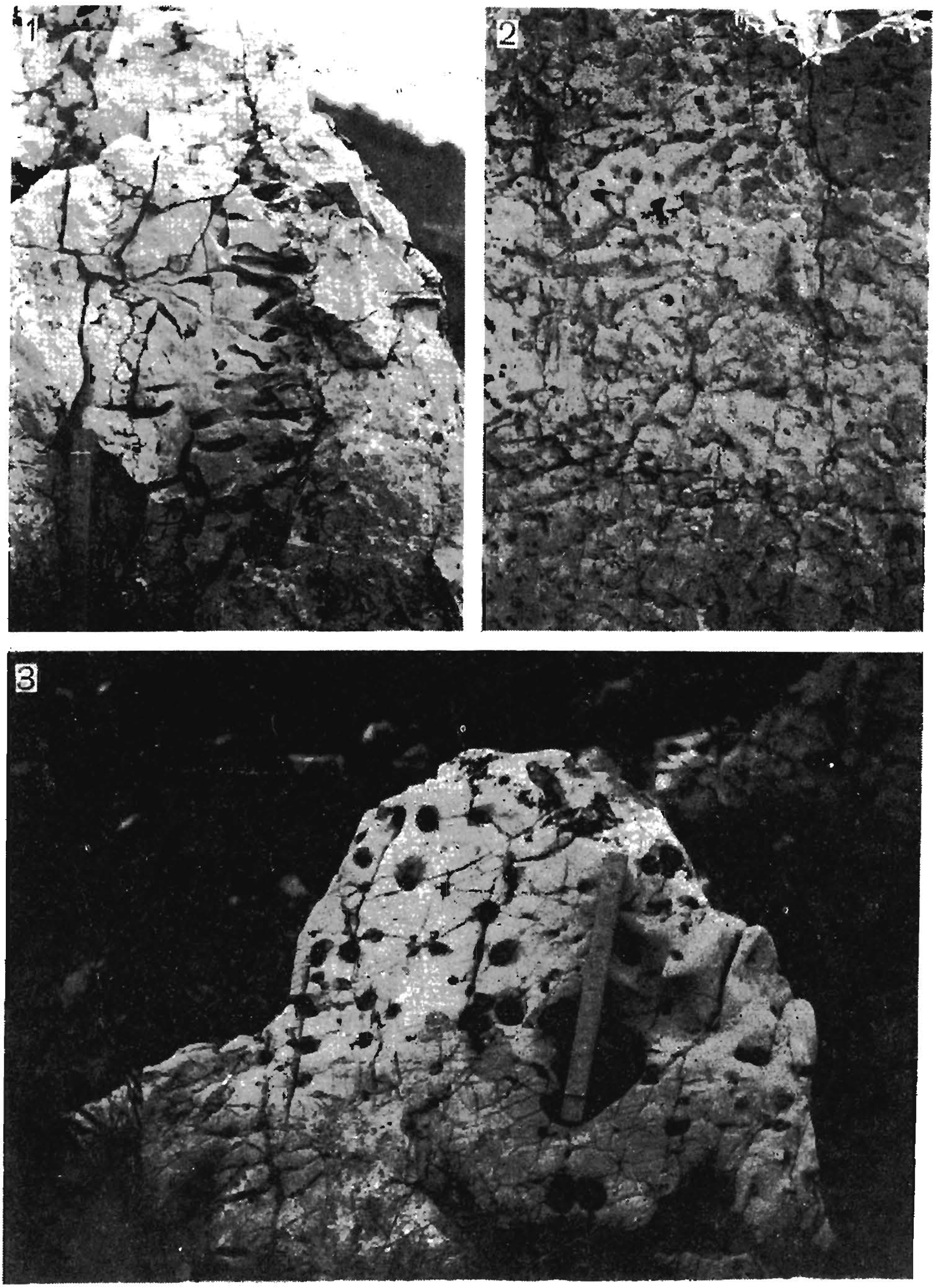
3 — Crumpled limestones composed of angular lumps (close-up view of Fig. 3 in Pl. 1).



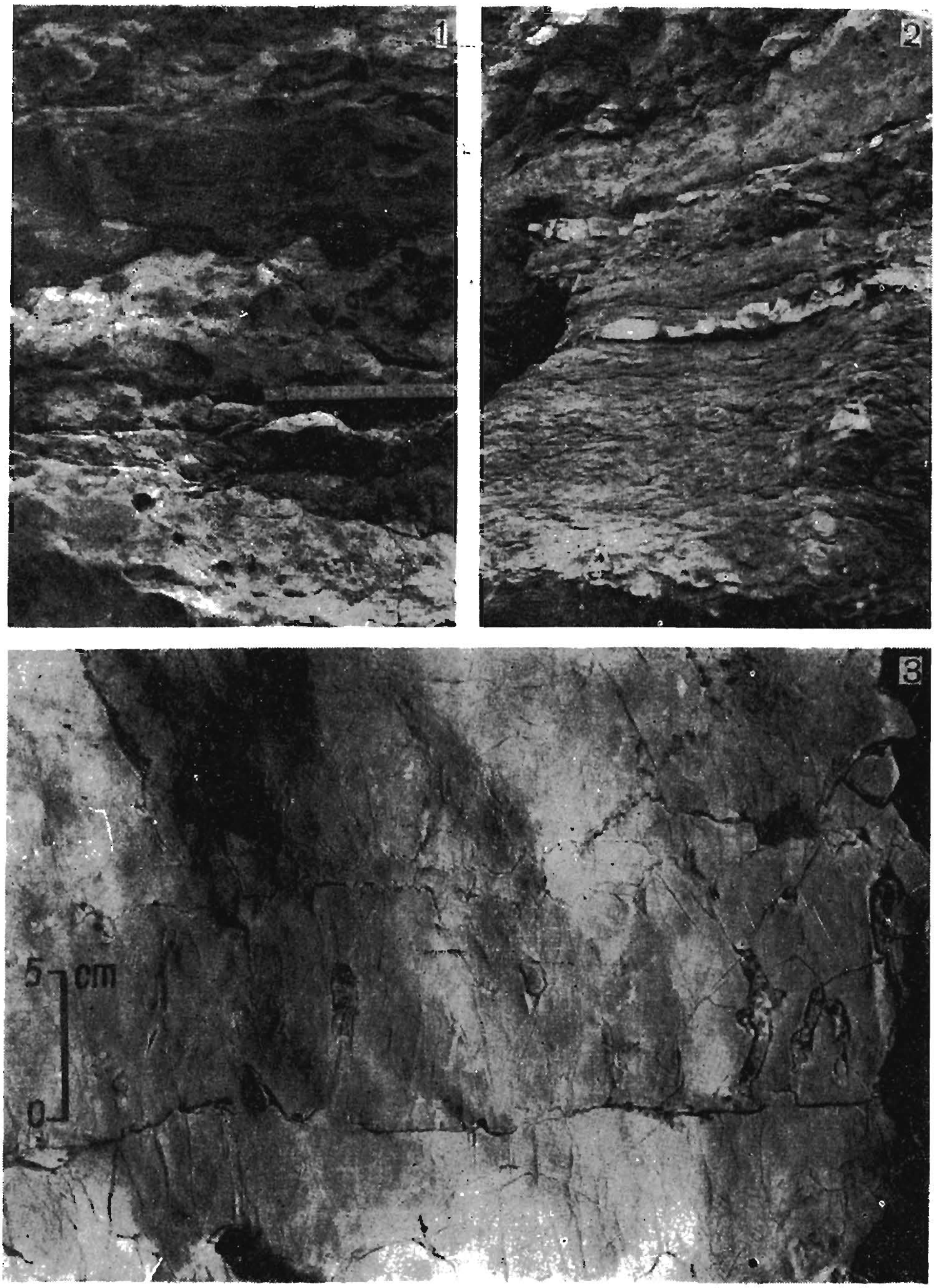
1 — Parallel-bedded grained limestone; Wolica, Łukowa Beds.

2 — Diagonal-bedded layer of grained limestone; Obice, Łukowa Beds.

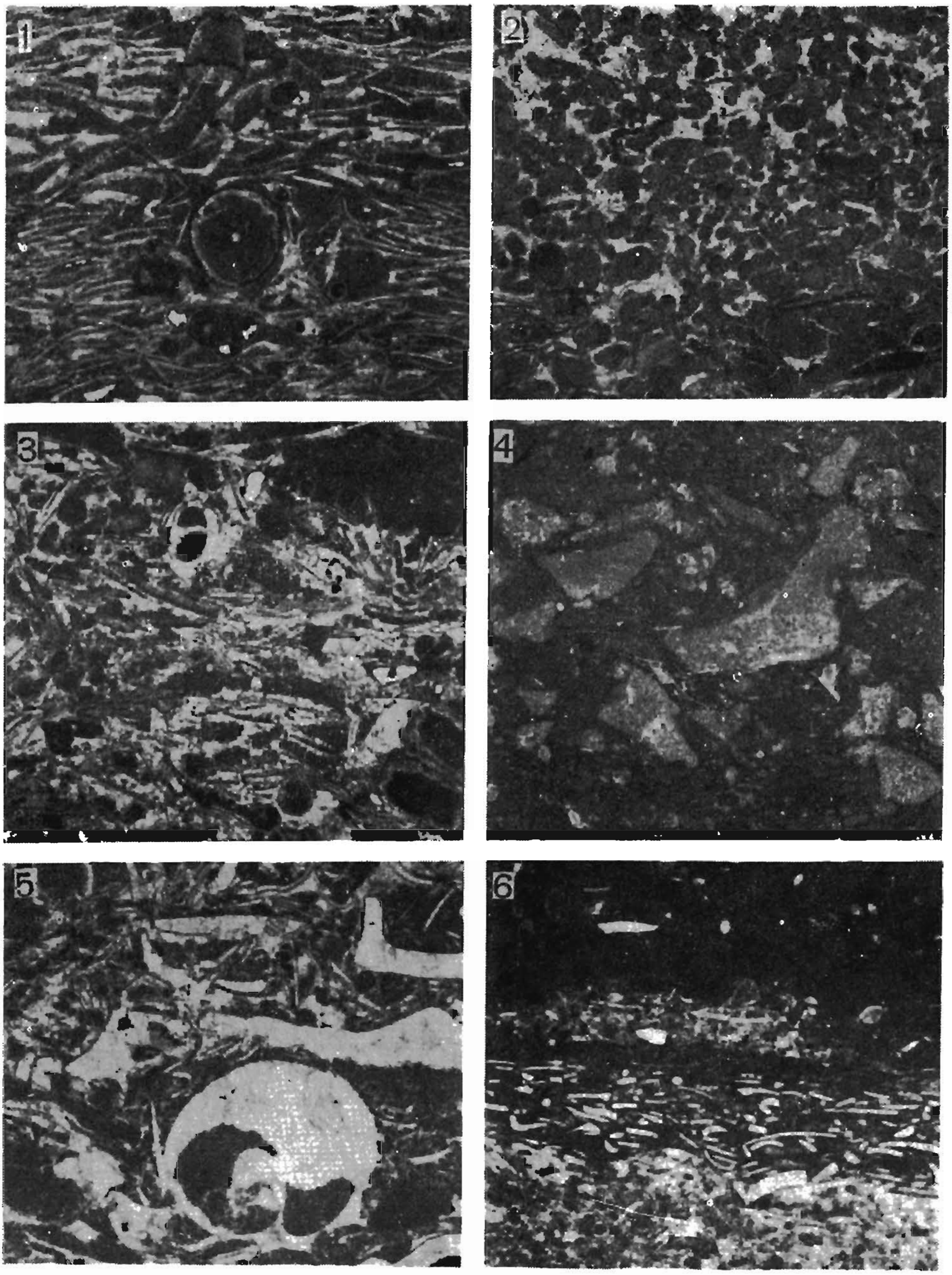
3 — Flat intraclasts formed of a plastic deposit (topside view); Polichno, Łukowa Beds.



1 — Enteropneustan burrows in a micritic layer (section): Polichno, Łukowa Beds.
2 — Topside of a micritic layer with numerous outlets of enteropneustan burrows and of *Trypanites* borings; locality the same.
3 — Enteropneustan burrows modified by Recent karst processes; locality the same.



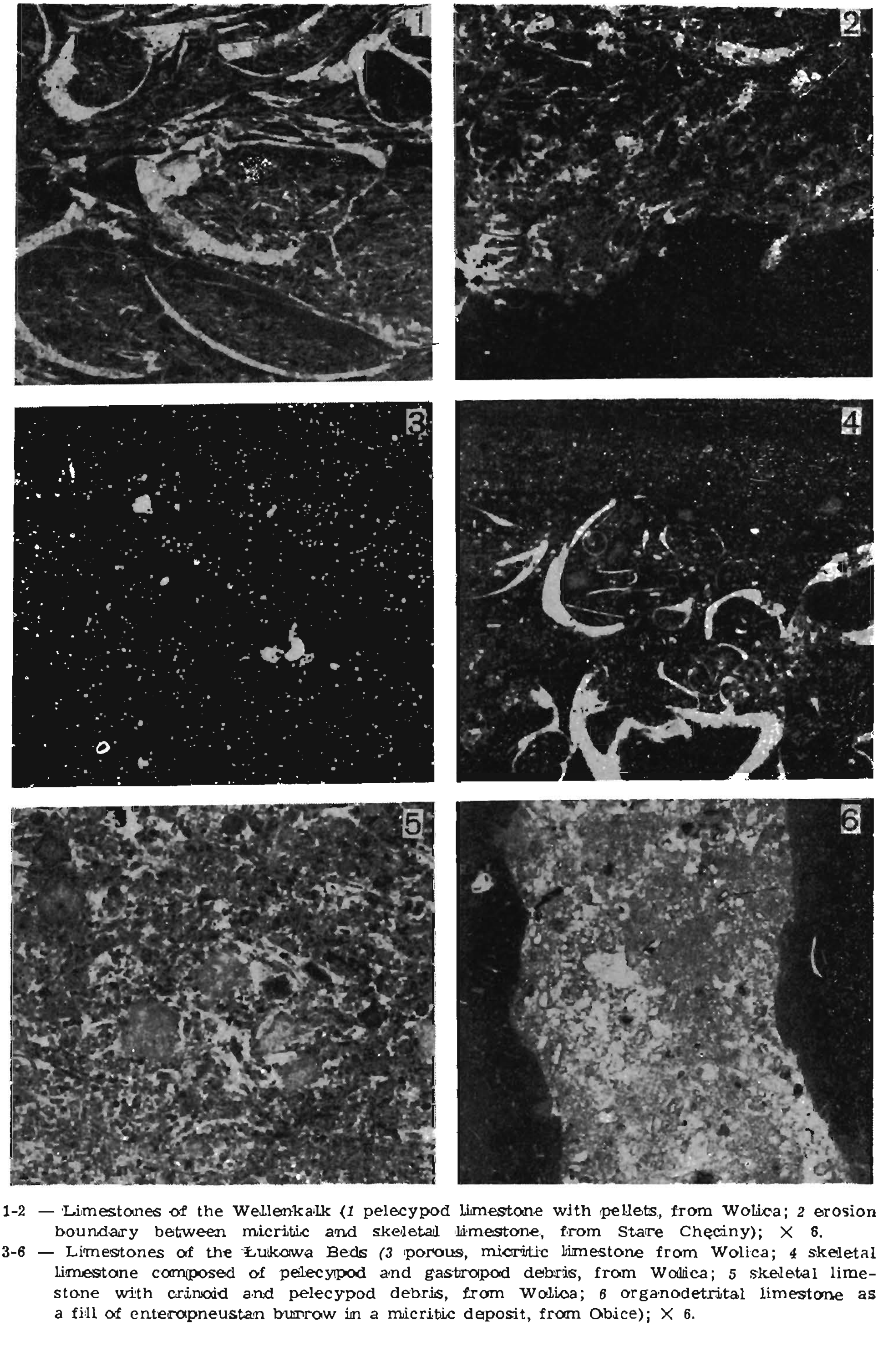
1 — Non-bedded calcirudite layer overlying an erosional surface of the micritic layer; Wolica, Łukowa Beds.
2 — Flint layers; Wolica, *Lima striata* Beds.
3 — Enteropneustan burrows in a reversed layer (section); Polichno, Łukowa Beds.



1 — Skeletal limestone with trochites, and hashed shells of gastropods, pelecypods and ostracodes; Stare Chęciny, uppermost Röt; × 6.

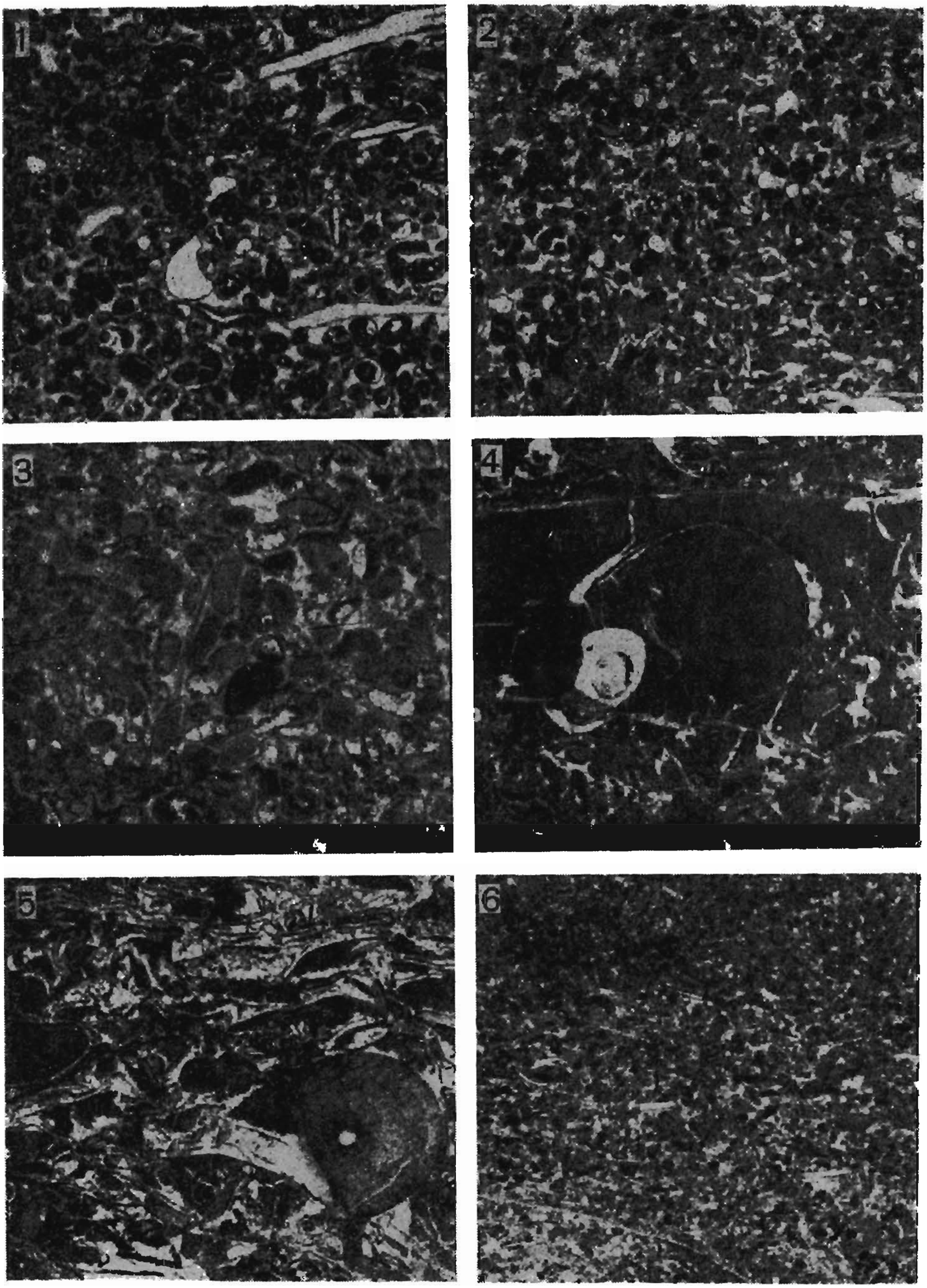
2-4 — Grained limestone of the Wolica Beds (*2* encrinite with pelecypod and gastropod shell detritus, from Pierzchnica; *3* skeletal limestone with pellets, trochites and pelecypod and gastropod shell detritus, from Łukowa; *4* detrital limestone composed of various intraclasts, from Łukowa); × 6.

5-6 — Limestones of the Wellenkalk from Wolica (*5* skeletal limestone composed of gastropod and pelecypod debris; *6* boundary between skeletal and micritic limestone); × 6.

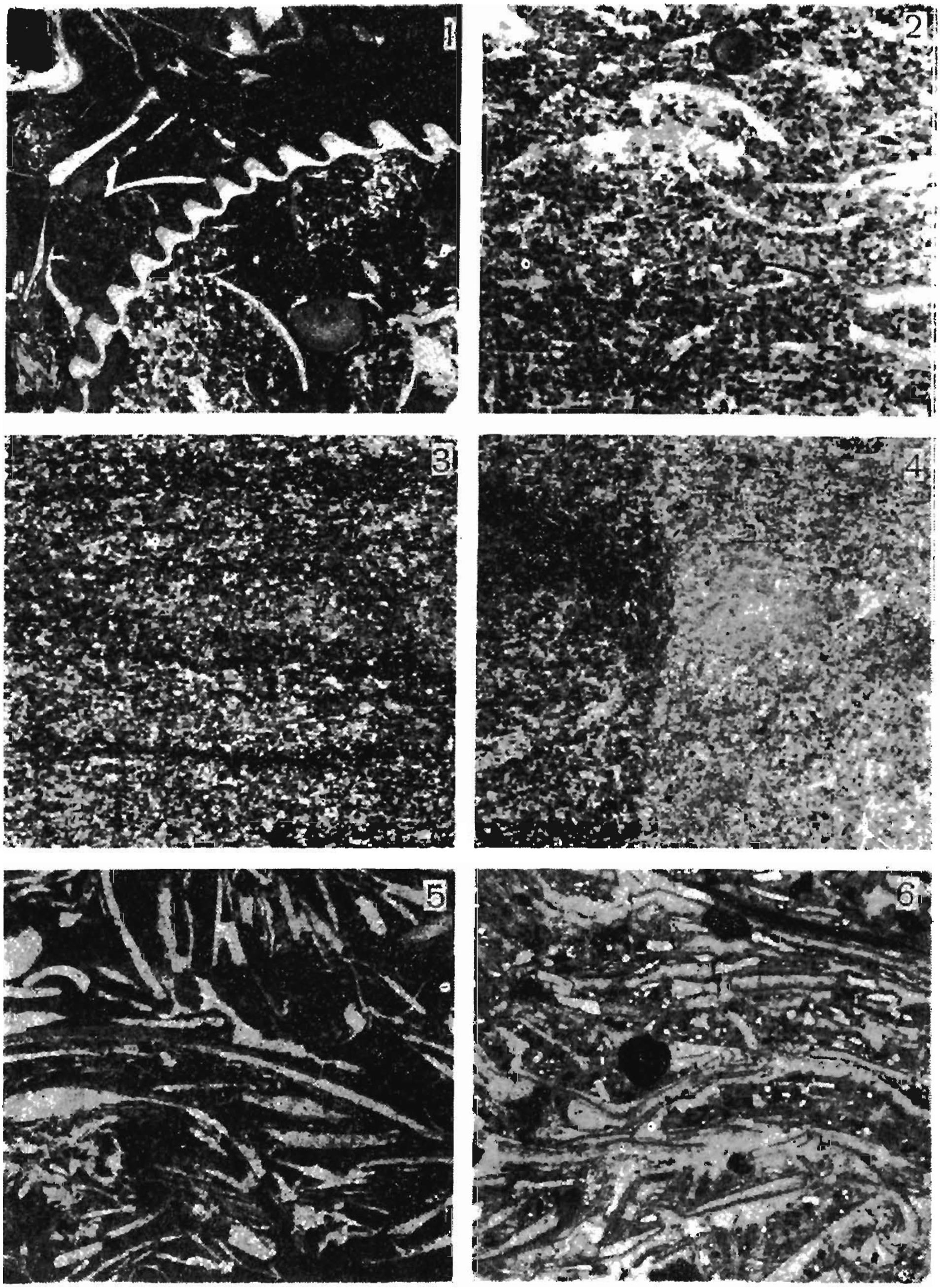


1-2 — Limestones of the Wellenkalk (*1* pelecypod limestone with pellets, from Wolica; *2* erosion boundary between micritic and skeletal limestone, from Stare Chęciny); × 6.

3-6 — Limestones of the Łukowa Beds (*3* porous, micritic limestone from Wolica; *4* skeletal limestone composed of pelecypod and gastropod debris, from Wolica; *5* skeletal limestone with crinoid and pelecypod debris, from Wolica; *6* organodetrital limestone as a fill of enteropneustan burrow in a micritic deposit, from Obice); × 6.

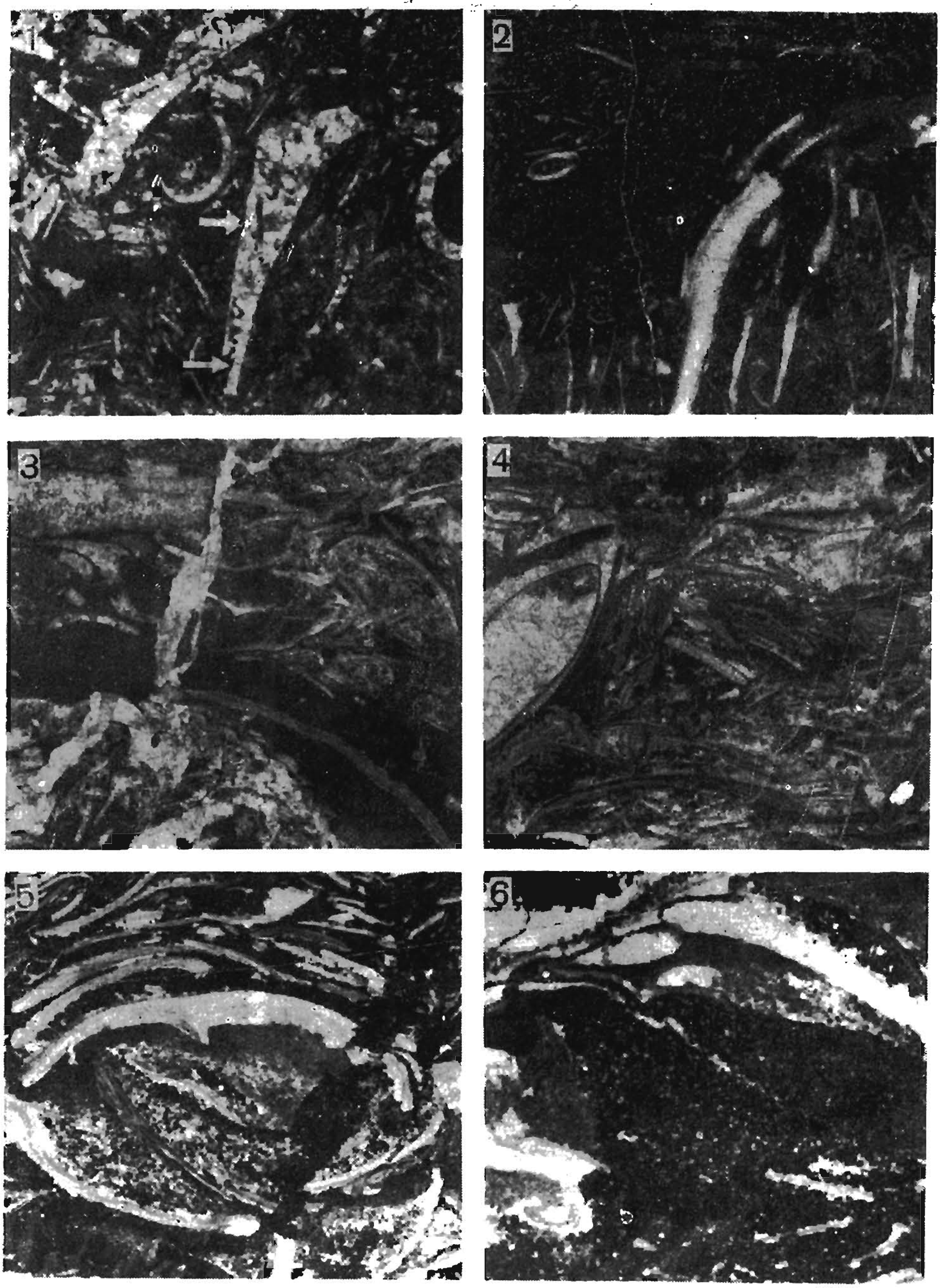


1-6 — Limestones of the Łukowa Beds (*1* lump limestone with microonkolites and shell detritus, from Polichno; *2* encrinite with lumps, shell detritus and foraminifers, from Polichno; *3* encrinite with shell detritus, from Łukowa; *4* pelletal limestone with shell detritus and intraclasts, from Stare Chęciny; *5* skeletal limestone composed of crinoid and pelecypod debris, from Wolica; *6* skeletal limestone with foraminifers and pellets, from Wolica); × 6.



1-4 — Limestones of the *Lima striata* Beds (*1* skeletal limestone with pellets, from Wolica; *2* pelletal limestone with detritus, pelecypod and gastropod shells, trochites and foraminifers, from Wolica; *3* pelletal limestone with detritus of pelecypod, brachiopod and ostracode shells and sponge spicules, from Wolica; *4* flint composed of chalcedony aggregates (right), and occurring in limestone as presented in Fig. 3; Wolica); × 6.

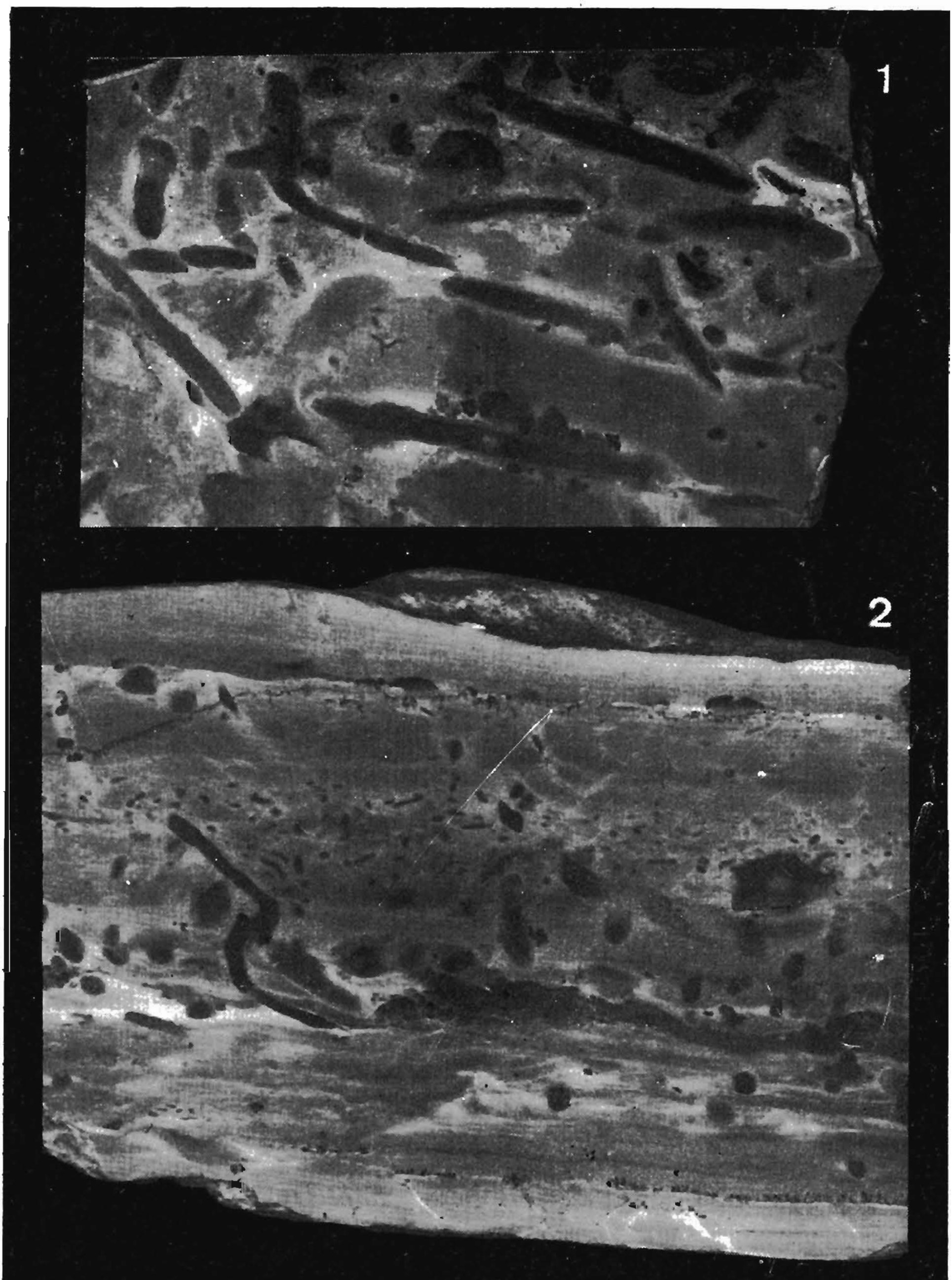
5-6 — Limestones of the *Pecten discites* Beds (*5* micritic, pelecypod limestone with pellets, from Stare Chęciny; *6* sparry, pelecypod limestone with pellets and intraclasts, from Stare Chęciny); × 6.



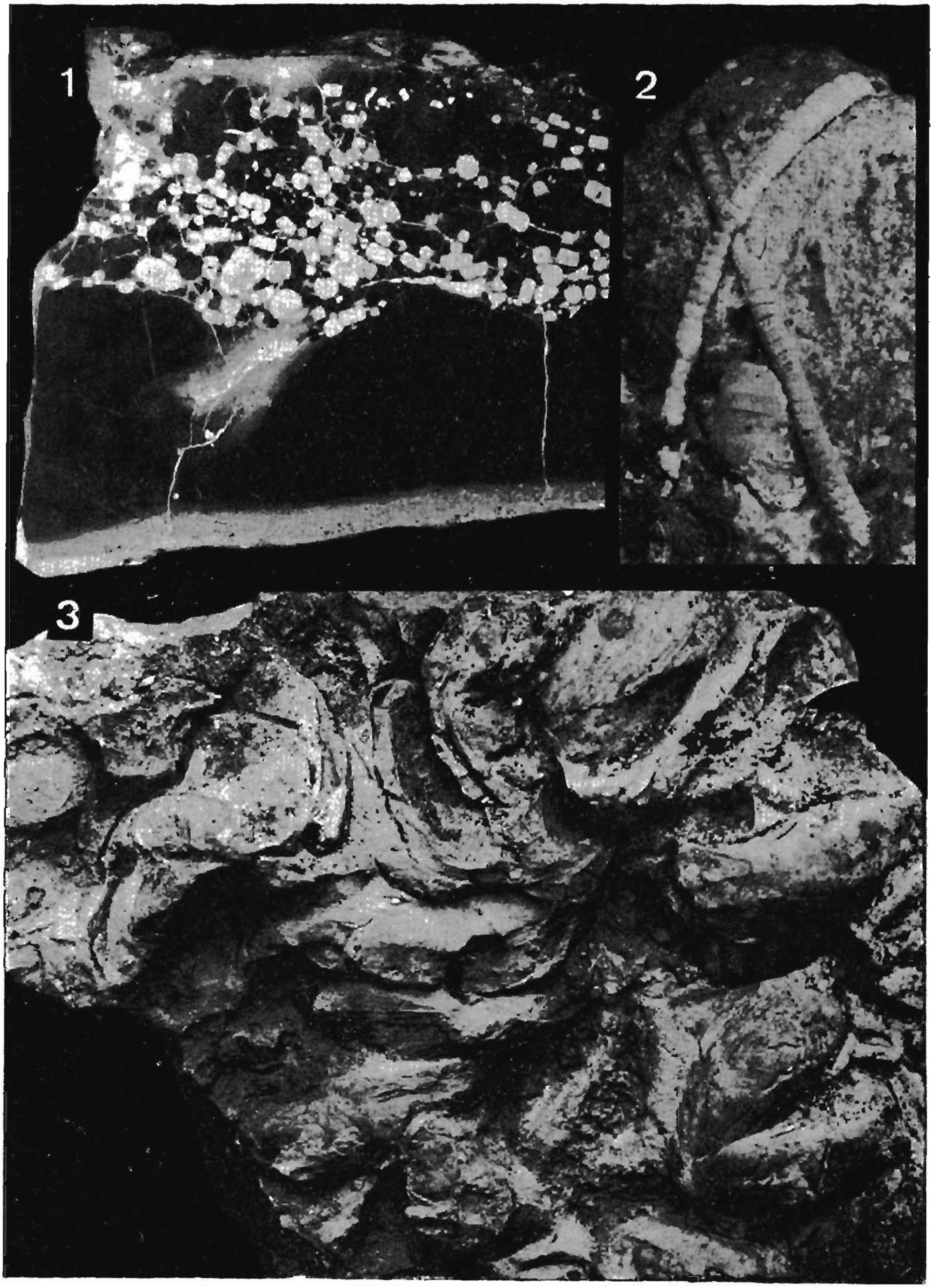
1-2 — Limestones of the *Pecten discites* Beds (*1* pelecypod limestone; arrowed are borings in the shell; Pierzchnica, × 10; *2* pelecypod limestone with shell detritus arranged vertically; Pierzchnica, × 4.

3 — Skeletal limestone with detritus of pelecypod, brachiopod and ceratitid shells; Zajączków, *Ceratites* Beds (4th conodont zone), × 5.

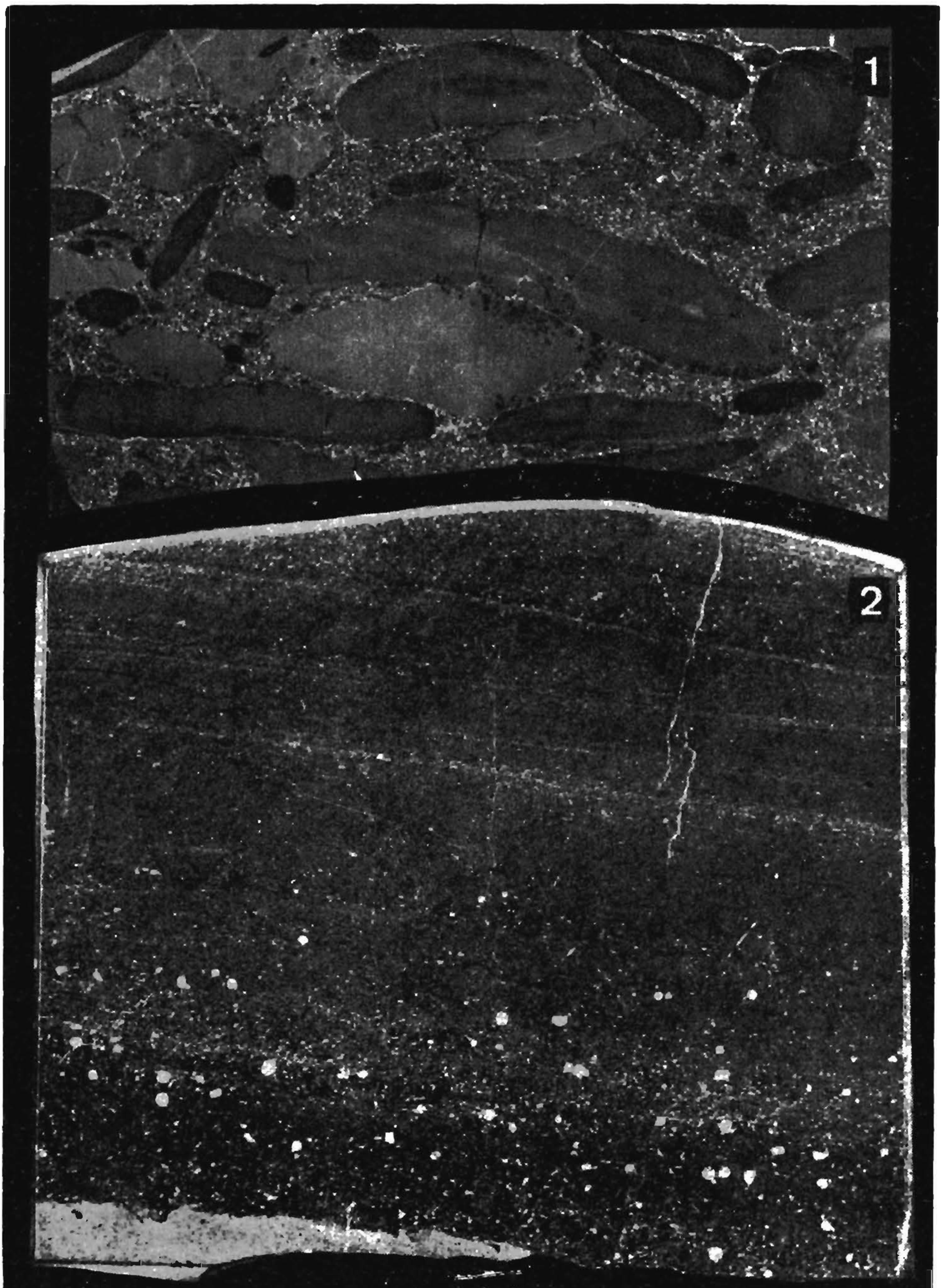
4-6 — *Terebratula* Lumachelle (*4* sparry, brachiopod limestone, from Pierzchnica, × 5; *5* micritic-sparry, brachiopod limestone, from Stare Chęciny, × 5; *6* close-up view from the same sample; dolomite grains are visible; × 10).



1-2 — Unrecognizable burrows from the uppermost Röt at Wolica (*1* section parallel to the bedding, *2* vertical section); nat. size.

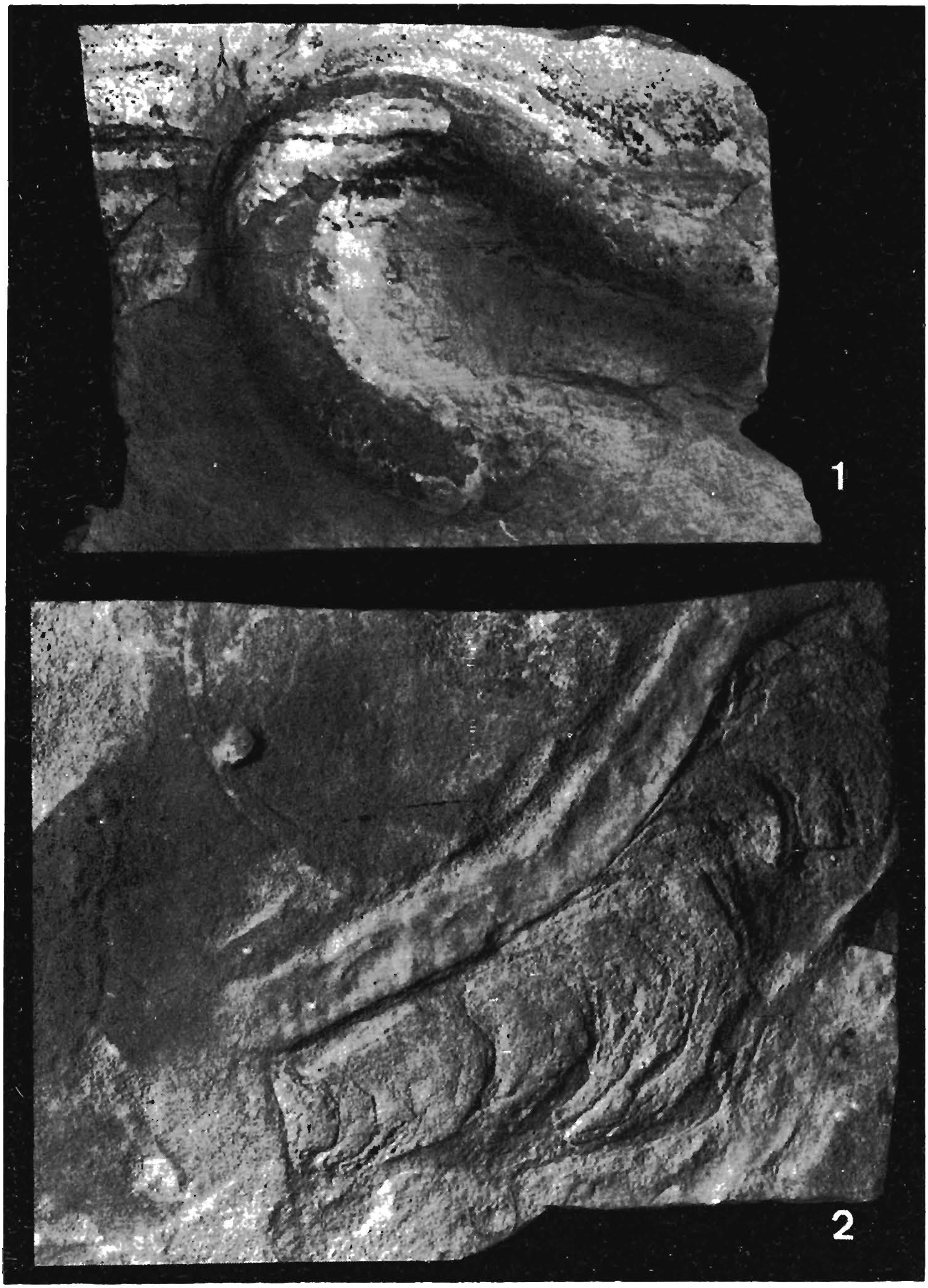


1 — Contact between crumpled and encrinitic limestone; Zajączków, Wellenkalk; × 1.5.
2 — Crinoid stems and detritus in encrinite; Łukowa, Wolica Beds, × 1.5.
3 — *Gervilleia* lumachelle, topside view; Zajączków, Wellenkalk; nat. size.

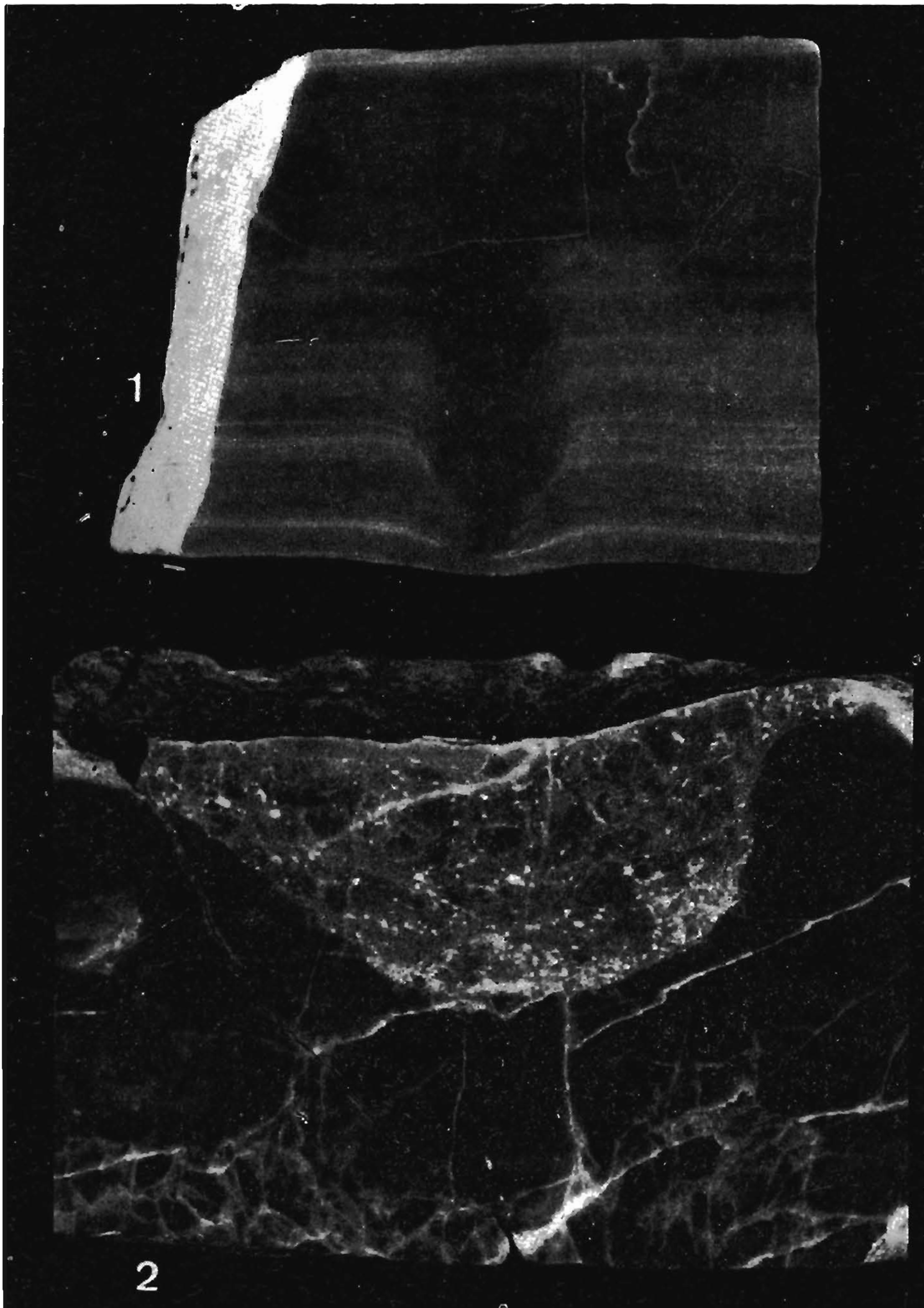


1 — Intraformational conglomerate; Wincentów, Wellenkalk, nat. size.
2 — Turbidite layer with ripples at the topside; Wincentów, Wellenkalk, × 1.5.

Lumachelle composed of isolated valves of *Lima striata* (Schlotheim), topside view; Wolica, Wellenkalk, nat. size.

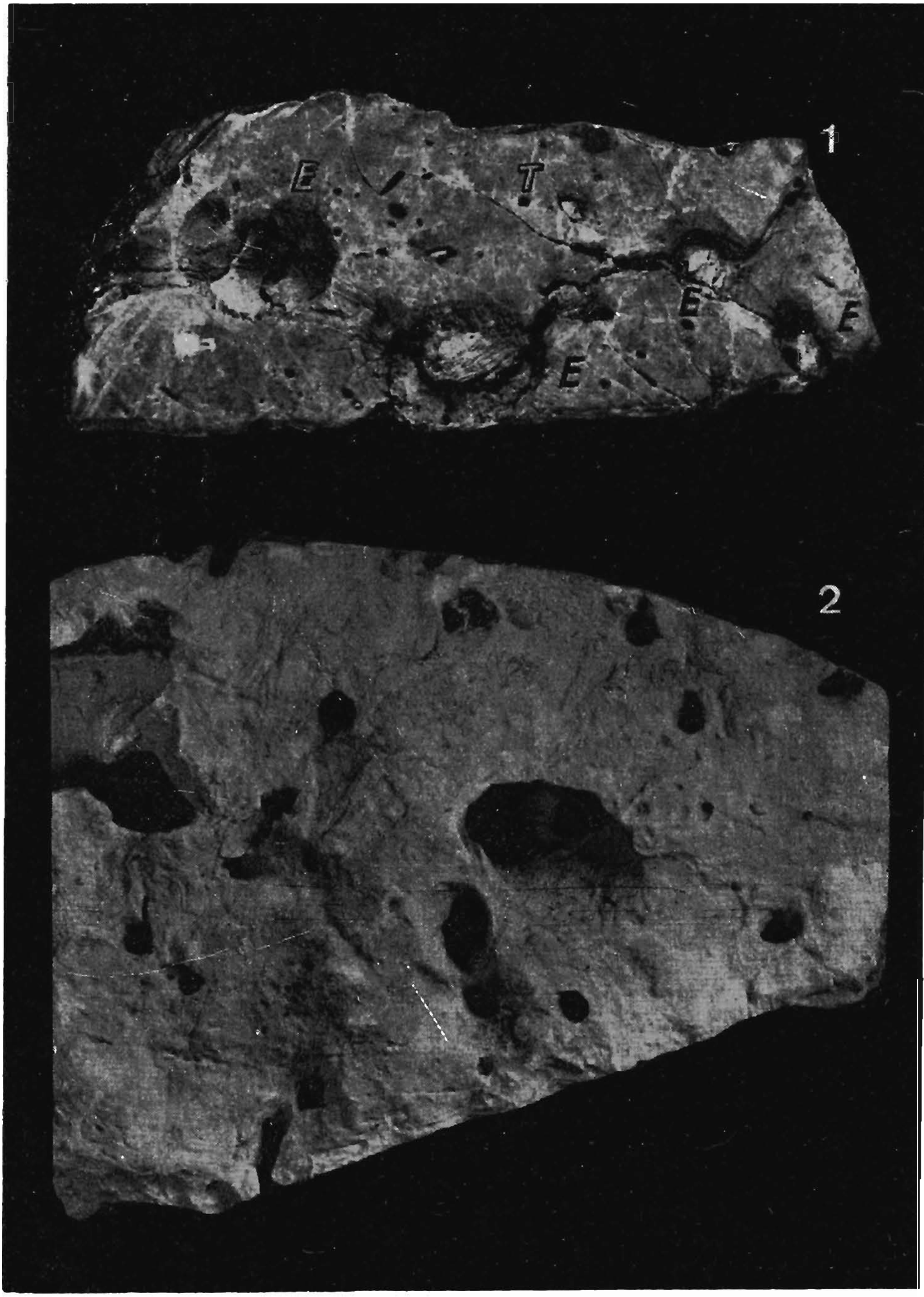


1-2 — Trace fossils *Rhizocorallium* sp. on topsides of layers; Wolica, Wellenkalk, nat. size.



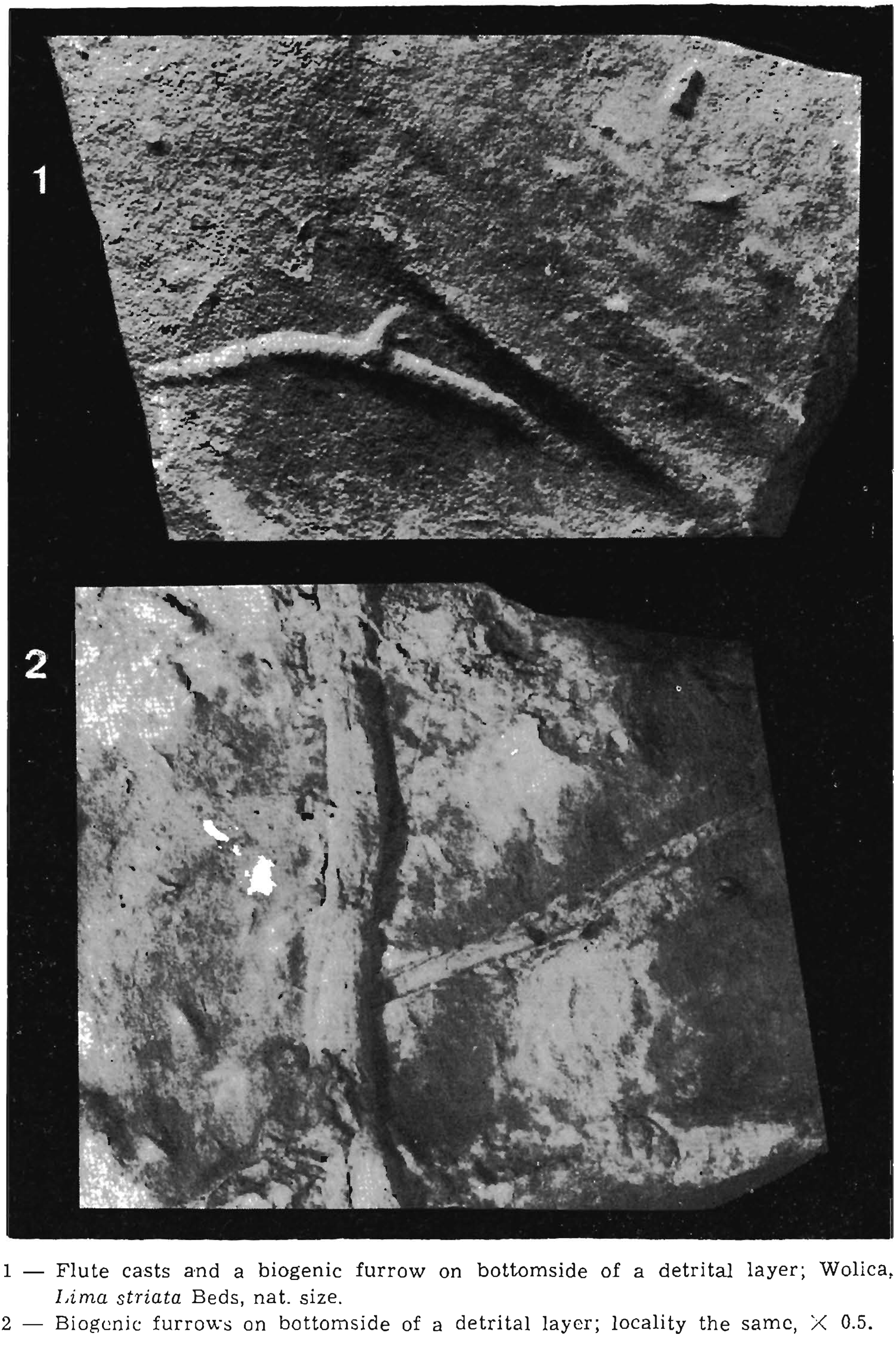
1 — Burrow attributable to a sea anemone; Zajączków, Łukowa Beds (*coll.* W. R. Kowalski), nat. size.

2 — Erosional furow in a micritic layer, filled with organodetrital deposit; Polichno, Łukowa Beds, nat. size.



1 — Outlets of enteropneustan burrows (*E*) and *Trypanites* borings (*T*) on topside of a layer; Polichno, Łukowa Beds, × 1.5.

2 — Outlets of enteropneustan burrows; locality the same, nat. size.

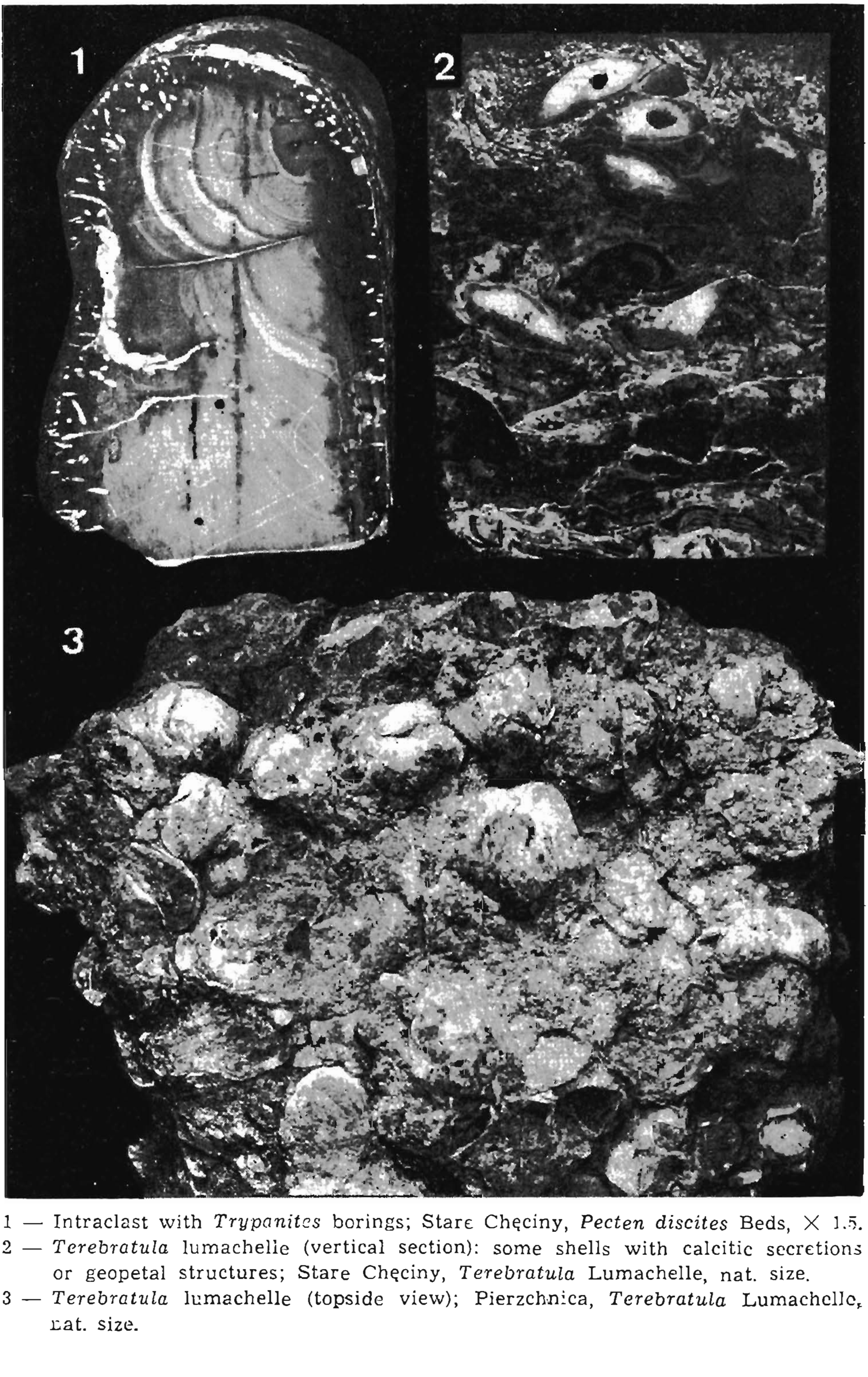


1 — Flute casts and a biogenic furrow on bottomside of a detrital layer; Wolica, *Lima striata* Beds, nat. size.

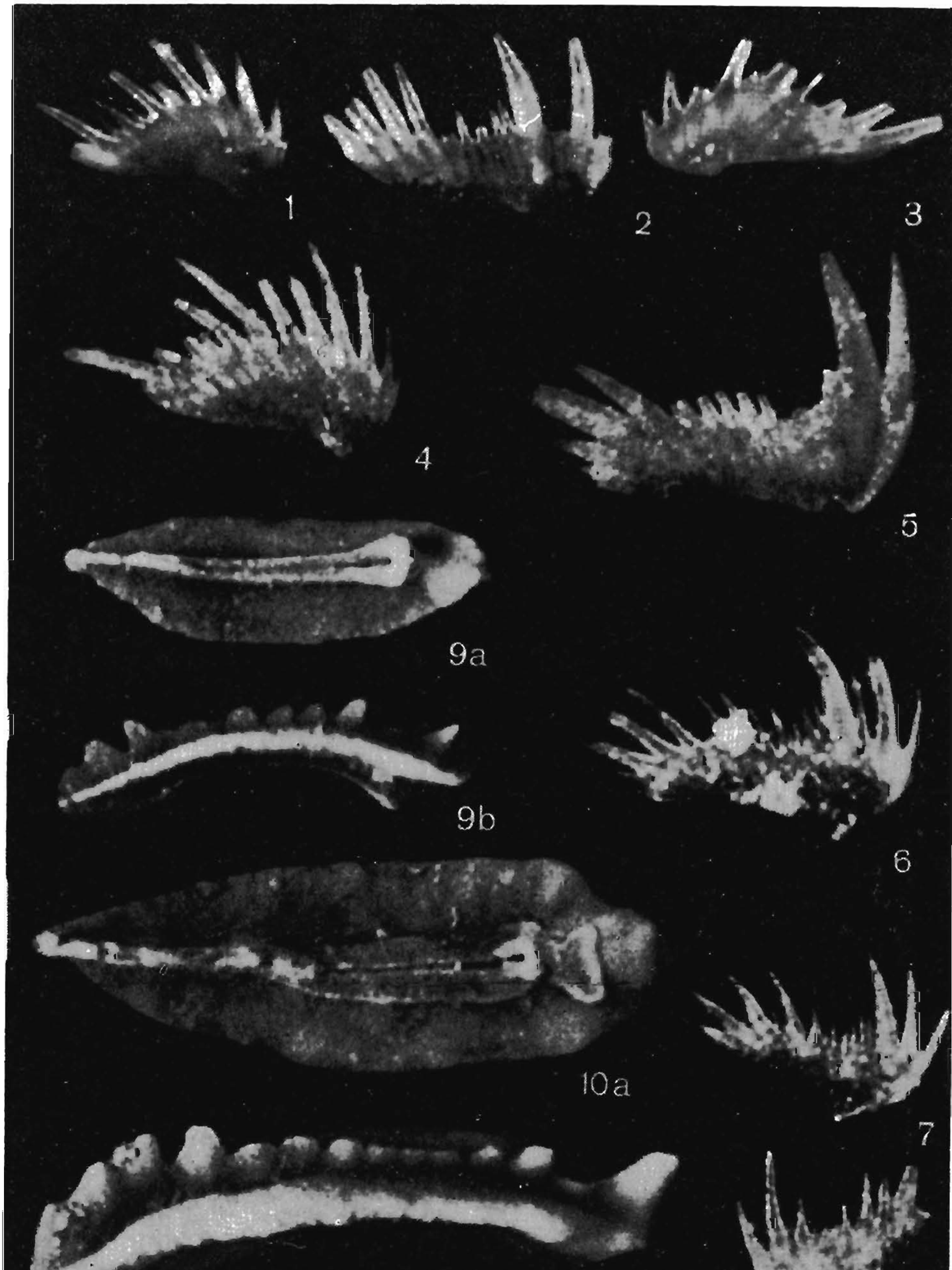
2 — Biogenic furrows on bottomside of a detrital layer; locality the same, × 0.5.

1 — Fragment of ceratitid mould: topside (*1a*) corroded, underside (*1b*) with preserved sculpture; Lesica, *Pecten discites* Beds, nat. size.

2 — Corrosion topside of crumpled limestone: corroded mould of a ceratitid is visible; Stare Chęciny, *Pecten discites* Beds, × 0.6.

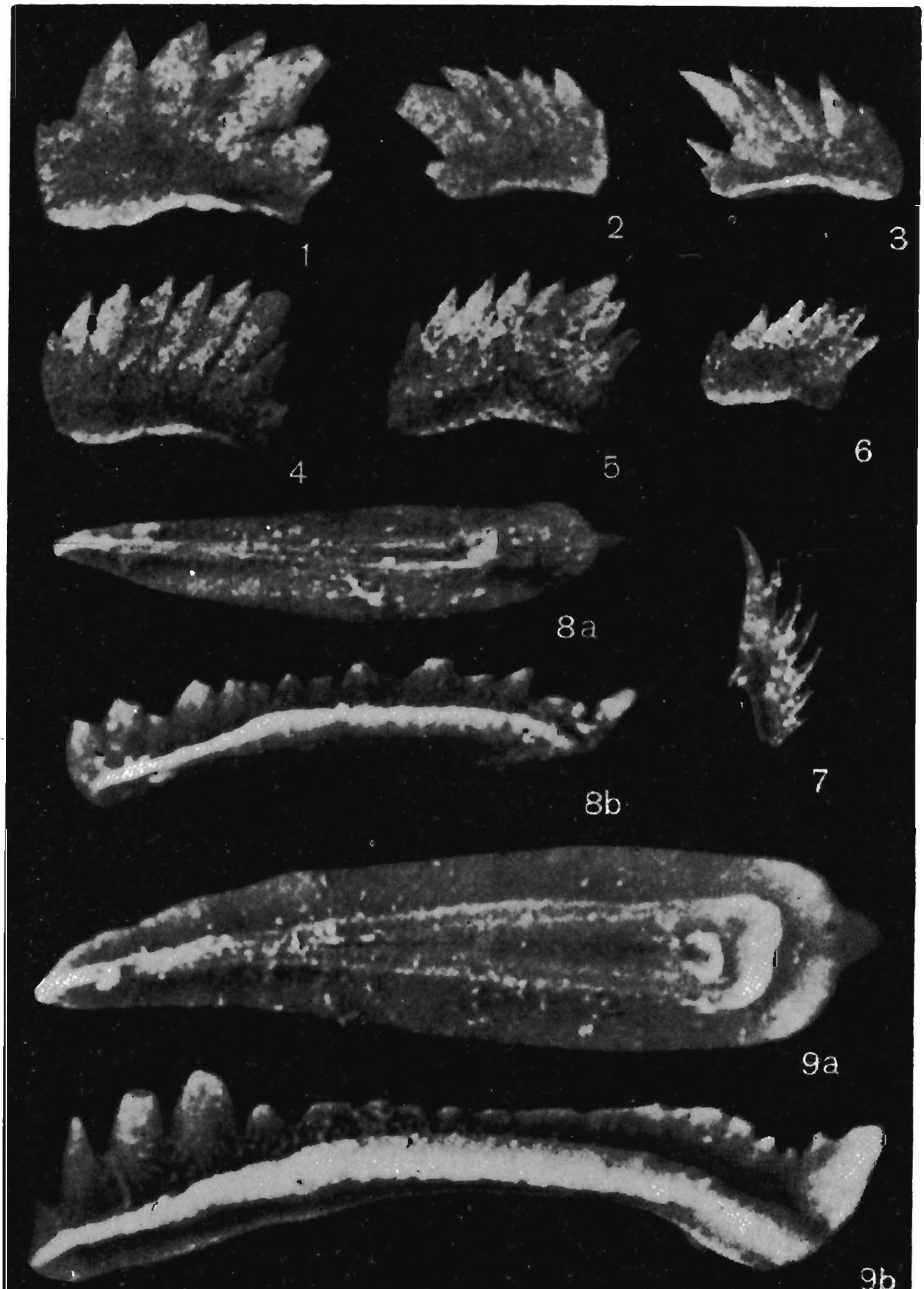


1 — Intraclast with *Trypanites* borings; Stare Chęciny, *Pecten discites* Beds, × 1.5.
2 — *Terebratula* lumachelle (vertical section): some shells with calcitic secretions or geopetal structures; Stare Chęciny, *Terebratula* Lumachelle, nat. size.
3 — *Terebratula* lumachelle (topside view); Pierzchnica, *Terebratula* Lumachelle, nat. size.



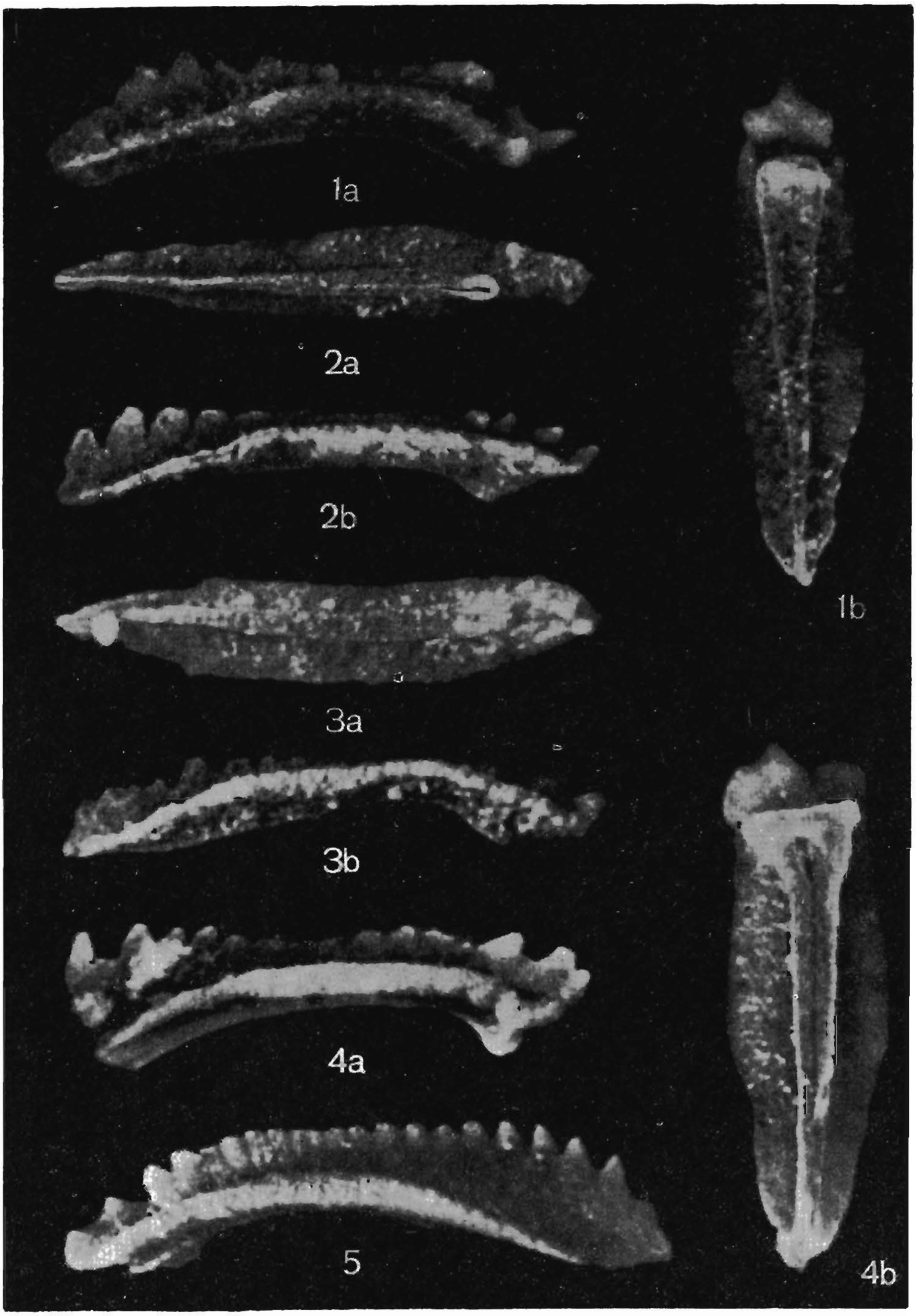
1, 3-4 — *Neohindeodella riegeli* (Mosher); Wolica, *Lima striata* Beds.
2 — *Neohindeodella aequidentata* Kozur & Mostler; Pierzchnica, *Ceratites* Beds.
5-8 — *Diplododella bidentata* (Tatge); Wolica, *Lima striata* Beds.
9 — *Gondolella suhodolica* (Budurov & Stefanov) — *a* bottom view, *b* side view; Stare Chęciny, *Pecten discites* Beds.
10 — *Gondolella suhodolica* (Budurov & Stefanov) — *a* bottom view, *b* side view; Lesica, *Ceratites* Beds.

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



1-3 — *Neospathodus kockeli* (Tatge); Obice, Łukowa Beds.
4-5 — *Neospathodus germanicus* Kozur; Stare Chęciny, Łukowa Beds.
6 — *Neospathodus germanicus;* Kozur, Obice, Łukowa Beds.
7 — *Chirodella polonica* (Kozur & Mostler); Wolica, *Lima striata* Beds.
8 — *Gondolella cornuta* (Budurov & Stefanov) — *a* bottom view, *b* side view; Lesica, *Ceratites* Beds.
9 — *Gondolella cornuta* (Budurov & Stefanov) — *a* bottom view, *b* side view; Lesica, *Pecten discites* Beds.

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



1 — *Gondolella* cf. *basisymmetrica* (Budurov & Stefanov) — *a* side view, *b* bottom view; Stare Chęciny, *Ceratites* Beds.

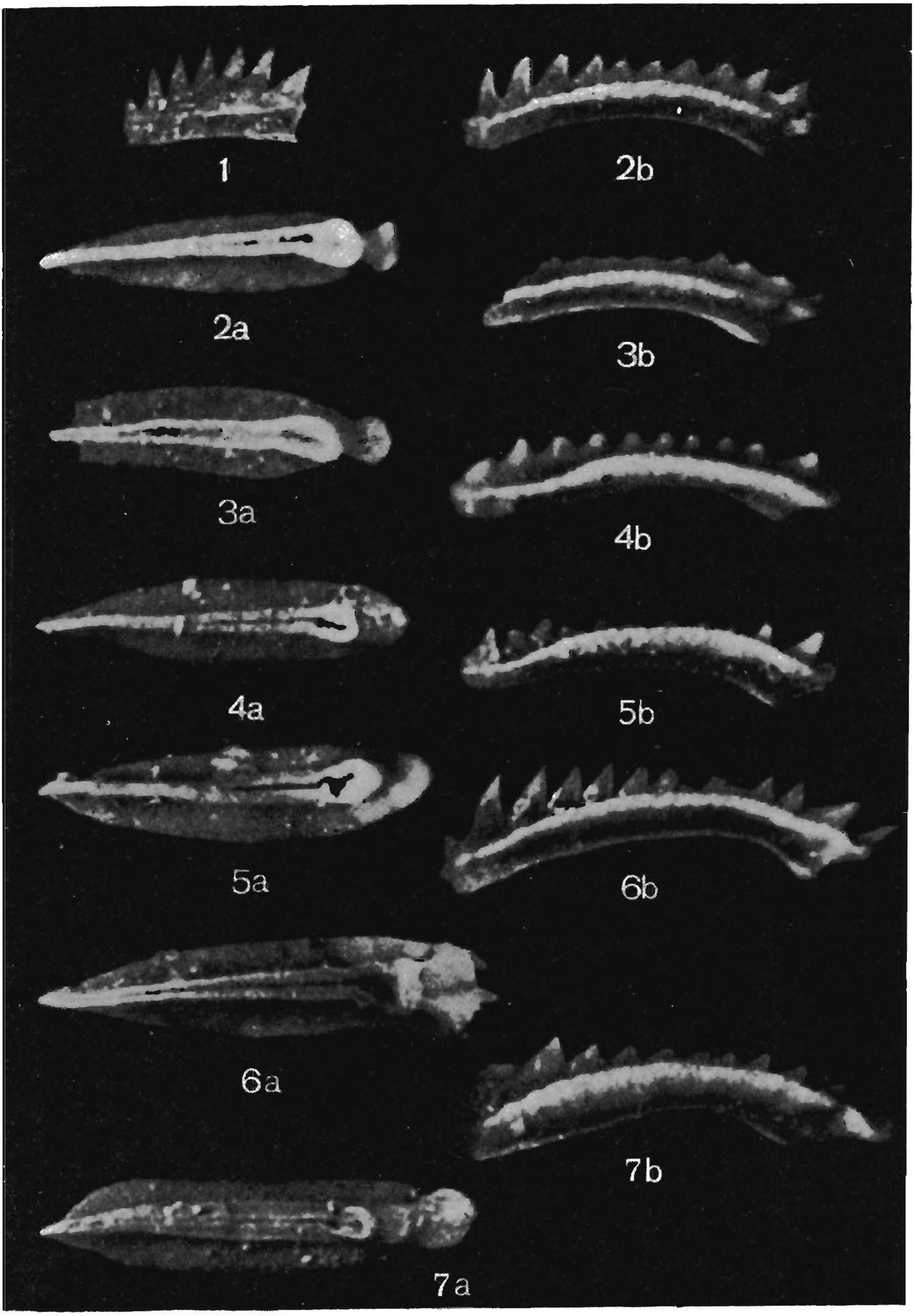
2 — *Gondolella longa* (Budurov & Stefanov) — *a* bottom view, *b* side view; Stare Chęciny, *Ceratites* Beds.

3 — *Gondolella longa* (Budurov & Stefanov) — *a* bottom view, *b* side view; Lesica, *Pecten discites* Beds.

4 — *Gondolella navicula* Huckriede, transitional to *G. bifurcata* (Budurov & Stefanov) — *a* side view, *b* bottom view; Pierzchnica, Łukowa Beds.

5 — *Gondolella navicula* Huckriede; Wolica, *Lima striata* Beds.

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



1 — Juvenile form of *Gondolella navicula* Huckriede; Wolica, *Lima striata* Beds.

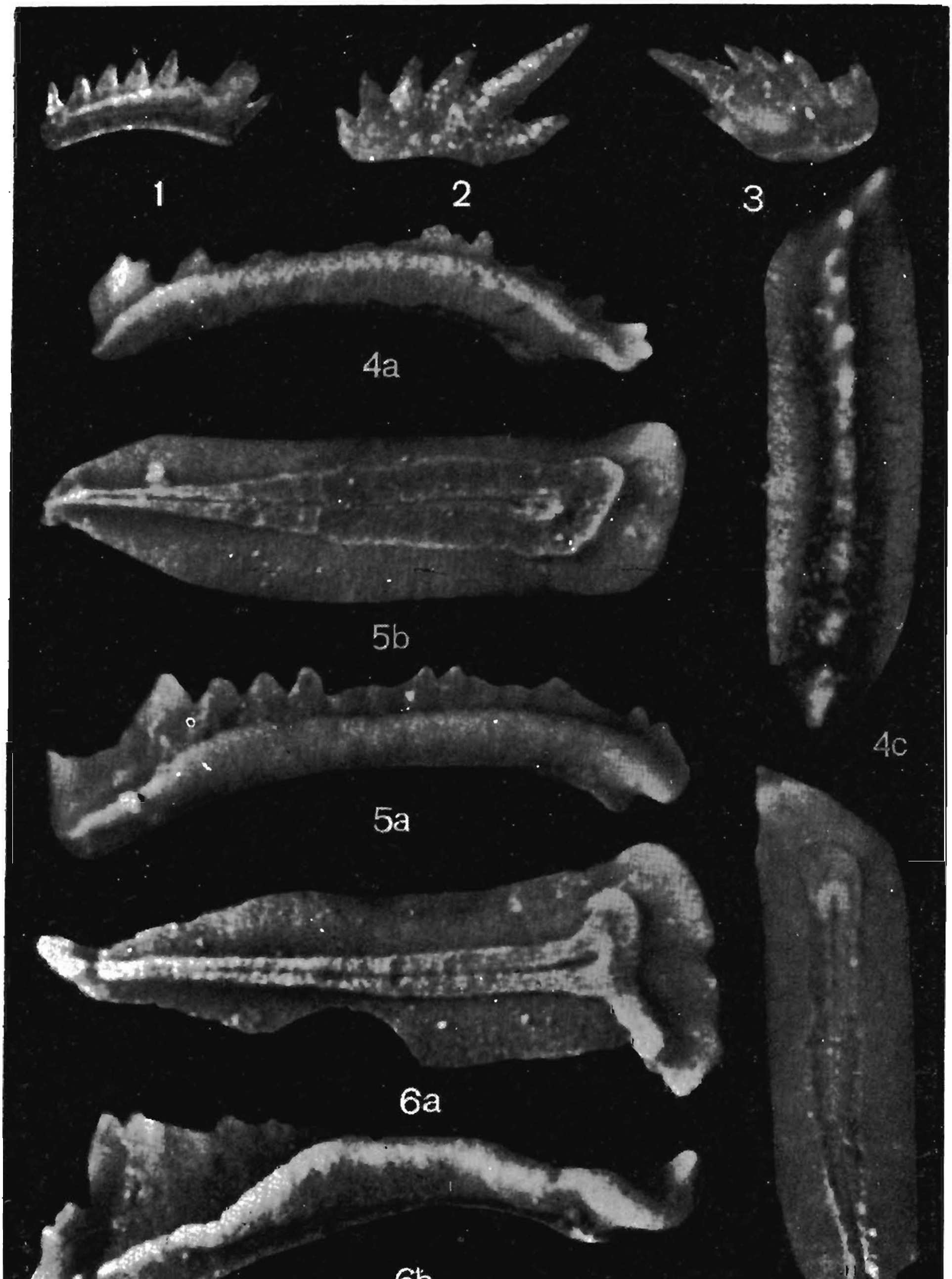
2, 7 — *Gondolella constricta* Mosher & Clark — *a* bottom view, *b* side view; Stare Chęciny, *Pecten discites* Beds.

3 — *Gondolella constricta* Mosher & Clark — *a* bottom view, *b* side view; Stare Chęciny, *Ceratites* Beds.

4-5 — *Gondolella acuta* Kozur — *a* bottom view, *b* side view; Stare Chęciny, *Pecten discites* Beds.

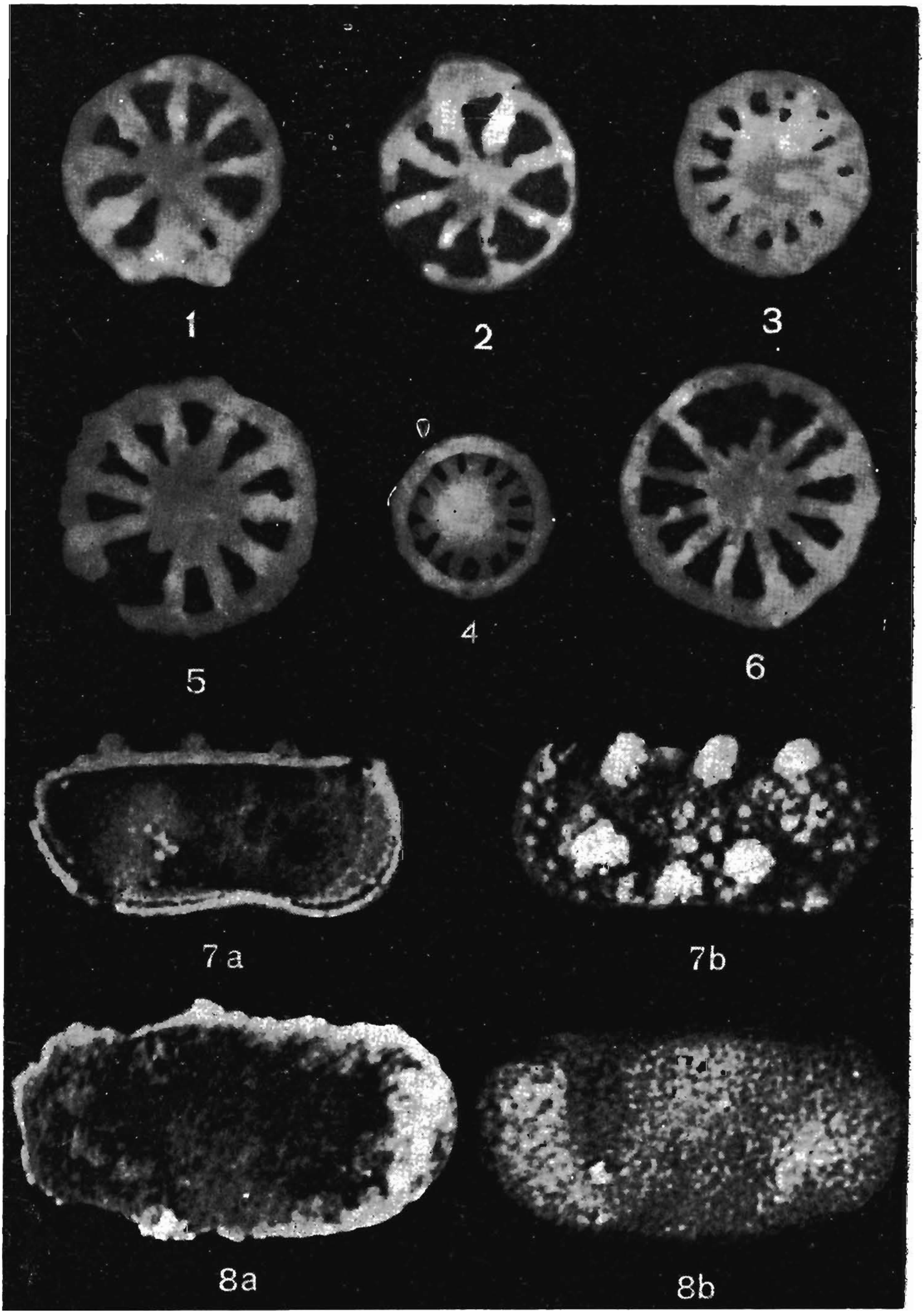
6 — *Gondolella* cf. *basisymmetrica* (Budurov & Stefanov) — *a* bottom view, *b* side view; Stare Chęciny, *Pecten discites* Beds.

All figures X 100; taken by L. Łuszczewska, M. Sc.



1 — *Gondolella haslachensis trammeri* Kozur; Pierzchnica, *Ceratites* Beds.
2 — *Cornudina* sp.; Wolica, Łukowa Beds.
3 — *Cornudina latidentata* Kozur & Mostler; Wolica, Łukowa Beds.
4-5 — *Gondolella excentrica* (Budurov & Stefanov) — *a* side view, *b* bottom view, *c* top view; Stare Chęciny, *Pecten discites* Beds.
6 — *Gondolella bifurcata* (Budurov & Stefanov) — *a* bottom view, *b* side view; Wolica, *Lima striata* Beds.

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



1-2 — *Theelia* cf. *subcirculata* Mostler; Stare Chęciny, Łukowa Beds.
3-4 — *Theelia* cf. *zapfei* Kozur & Mostler; Stare Chęciny, Łukowa Beds.
5-6 — *Theelia zapfei* Kozur & Mostler; Stare Chęciny, Łukowa Beds.
7 — *Judahella pulchra multinodosa* (Kozur) — *a* interior view, *b* exterior view; Wolica, Łukowa Beds.
8 — *Ussuricavina* cf. *rakovkensis* Gramm — *a* interior view, *b* exterior view; Wolica, Łukowa Beds.

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