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ANDRZEJ GAŹDZICKI

Megalodon limestones in the sub-tatric Rhaetian of the Tatra Mts

ABSTRACT: The *Megalodon* limestones of the sub-tatric Rhaetian, Tatra Mts, are composed mostly of the shells of *Conchodus infraliasicus* Stoppani. The preservation and ontogenetic variability of these megalodons, as well as the sedimentary environment and stratigraphical setting of the megalodon-bearing deposits are discussed.

INTRODUCTION

The *Megalodon* limestones are characteristic link in the Rhaetian of the sub-tatric (Križna) nappe in the Tatra Mts. They were reported for the first time by Goetel (1917) from Mt. Mała Świnica and Mt. Mały Kopieniec (cf. Figs 1—2). Similar limestones were noted on Mt. Wołoszyn (Głazek 1962, 1963).

In the course of the studies on the sub-tatric Rhaetian from Lejowa Valley (cf. Figs 1—2), a repeated occurrence of the *Megalodon* limestones was observed (Gaździcki 1968). This contribution deals with occurrences of such deposits in the whole sub-tatric unit of the Tatra Mts.

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The specimens of megalodons from Mt. Wołoszyn were made available through courtesy of Dr. J. Głazek. The megalodons from the collection of Professor W. Goetel were lent by the Museum of the Institute of Geological Sciences, Polish Academy of Sciences, Cracow.

GEOLOGICAL SETTING

Lejowa Valley

Megalodon limestones occur in two places within the Rhaetian profile exposed between Hala Huty — Mt. Spalenisko (beds *a* and *b* in Fig. 2*A*).

Bed *a:* gray, compact limestone, 0.8 m thick. Numerous typical cordate or hoof-like sections of megalodons are observable on the weathered surface (Fig. 3*a*; Pl. 2); particular sections vary from 10 to 25 cm in diameter. These sections correspond most probably to the species *Conchodus infraliasicus* Stoppani and are almost identical with those from the Dachstein limestones (cf. Zapfe 1957).

The limestones contain a small admixture of silty quartz and singular intraclasts, up to 1.5 mm in diameter; among bioclasts, fragments of trochites and brittle-star vertebrae, as well as foraminifers *Glomospira* sp., predominate.

Bed *b:* bluish, compact limestone, 0.9 m thick. Numerous cordate to occasionally less regular, up to 25 cm in diameter, sections of megalodons were recorded (Fig. 3*b*) which may represent the species *Conchodus infraliasicus* Stoppani or the genus *Rhaetomegalodon* Végh-Neubrandt.

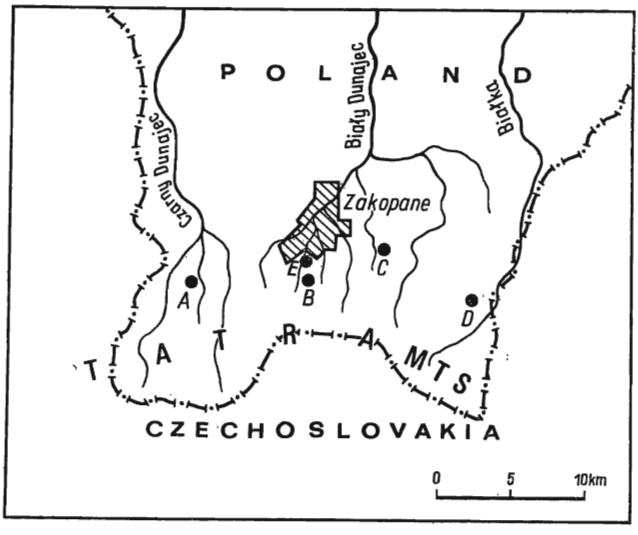


Fig. 1

Locality map of the sub-tatric Rhaetian profiles with *Megalodon* limestones in the Tatra Mts

A Lejowa Valley, *B* Mt. Mała Świnica, *C* Mt. Mały Kopieniec, *D* Mt. Wołoszyn, *E* Strążyska Valley

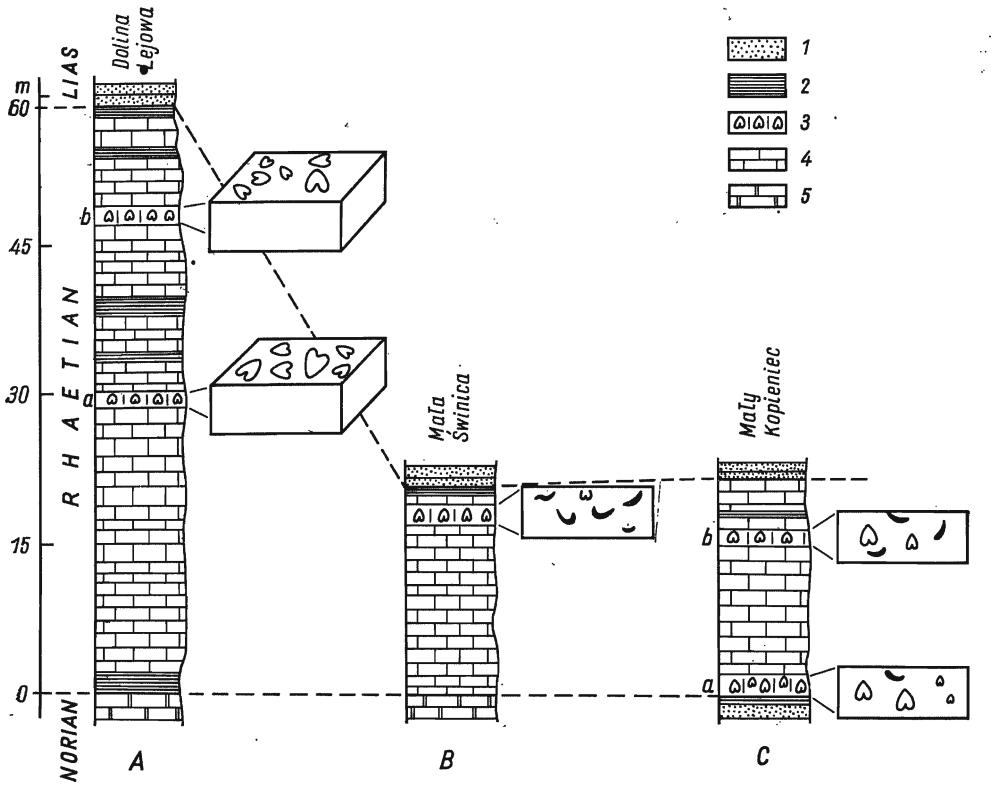


Fig. 2

Megalodon limestones in the sub-tatric Rhaetian profiles of the Lejowa Valley (*A*), Mt. Mała Świnica (*B*) and Mt. Mały Kopieniec (*C*) — cf. Fig. 1

1 sandstones, *2* shales, *3* *Megalodon* limestones, *4* other limestones (pelitic and grained, organodetrital), *5* dolomites

Occurrence of angular quartz grains, up to 0.6 mm in diameter, scarce sphaerical onkolites, up to 0.8 mm in diameter, as well as ooids with one or two envelopes, up to 0.2 mm in diameter, were noted. Bioclasts are represented by numerous fragments of trochites with onkolitic crusts and coatings, shell fragments of gastropods and brachiopods, echinoid prickles, brittle-star vertebrae and foraminifers *Glomospira* sp.

Mt. Mała Świnica

The Rhaetian deposits are twice exposed along the line from Czerwona Pass towards near-top parts of Mt. Mała Świnica (nearby the mountain path) in result of tectonic structure. Goetel (1917, Pl. 12)

presented the "lower" profile, begining just above Czerwona Pass, with *Megalodon* limestones directly overlying red shales of the "Keuper" (Norian). At present, those outcrops are obscured with waste.

A layer of *Megalodon* limestone, 1.8 m thick, was noted in top parts of the „upper" profile, close to the Rhaetian/Liassic junction (Fig. 2*B*). The layer consists of gray-blue, relatively compact zoogenic limestone with fragments of the megalodon shells. Occasionally, complete specimens of megalodons were noted. Usually, the megalodon shells are poorly preserved, strongly recrystallized, and their sections, variable in outline, are almost unidentifiable. Moreover, numerous brachiopods *Rhaetina gregaria* (Suess) and single spiriferins were found.

In the limestone, angular quartz grains, up to 0.3 mm in diameter, are scarce, whereas intraclasts and bioclasts are quite frequent. Bioclasts are represented by fragments of crinoids, echinoid prickles, brittle-star vertebrae and foraminifers *Glomospira* sp. and *Archaediscus* sp. Commonly onkolitic crusts and coatings are developed around bioclasts; some onkolites attain up to 4 mm in diameter.

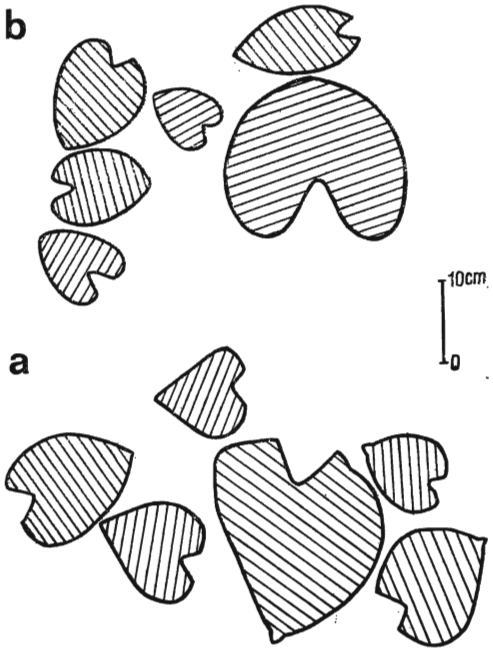


Fig. 3

Sections parallel to bedding planes of the *Megalodon* limestones from Lejowa Valley (cf. profile *A* in Fig. 2)

a section of the bed *a*
b section of the bed *b*

Mt. Mały Kopieniec

The *Megalodon* limestones occur twice within the Rhaetian sequence outcroping on SW slopes of Mt. Mały Kopieniec (beds *a* and *b* in Fig. 2*C* — cf. also Goetel 1917, Pl. 11).

Bed *a:* gray-blue, compact, thick-bedded limestones, up to 2.5 m in thickness, from the lowermost part of the profile, just above red shales and sandstones of the "Keuper" (Norian) (Fig. 2*C*). The megalodons are quite common here. Megalodon sections indicate the occurrence of individuals varying in size. Besides shells to 12 cm in diameter, there are smaller forms, some 5 cm in diameter. The assemblage includes specimens differing in degree of ontogenetic development, belonging presumably to the species *Conchodus infraliasicus* Stoppani. Moreover, some small bushy colonies of corals, *Thecosmilia clathrata* Emmrich, were occasionally noted. Numerous fragments of gastropod and brachiopod shells, crinoid trochites, brittle-star vertebrae, echinoid prickles, and foraminifers *Glomospira* sp. and *Frondicularia* sp. were noted in thin sections. Onkolites, up to 2 mm in diameter, are developed around some bioclasts.

Bed *b:* layer of sandy limestone, 0.7 m thick, with fragments of megalodon shells, unidentifiable as a result of strong recrystallization (Fig. 2*C*).

Besides numerous angular quartz grains (up to 0.5 mm in diameter), the limestones contain ooids, onkolites and significant amount of bioclasts represented by fragments of gastropods, brachiopods and echinoderms. Foraminifers *Glomospira* sp. and *Archuediscus* sp. are common.

Other exposures

The *Megalodon* limestones are also known from the Rhaetian of Mt. Wołoszyn (Fig. 1), when exposed in the course of field works (Głazek 1962, 1963). The megalodons are relatively common here. Traces of strong scouring of layers, distinctly marked, indicate changes in hydrodynamic conditions in the sedimentary environment (cf. Fig. 4 and Pl. 1).

Moreover, the megalodon sections were also reported in Rhaetian limestones in the area of the Ku-Dziurze Valley, and Strążyska Valley (Fig. 1); however, they are rare, strongly recrystallized and very dificult to identify (cf. Goetel 1917).

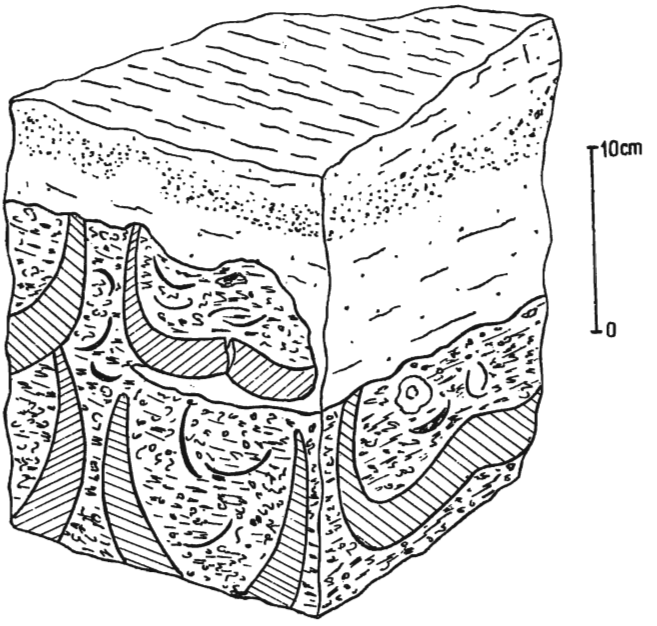


Fig. 4

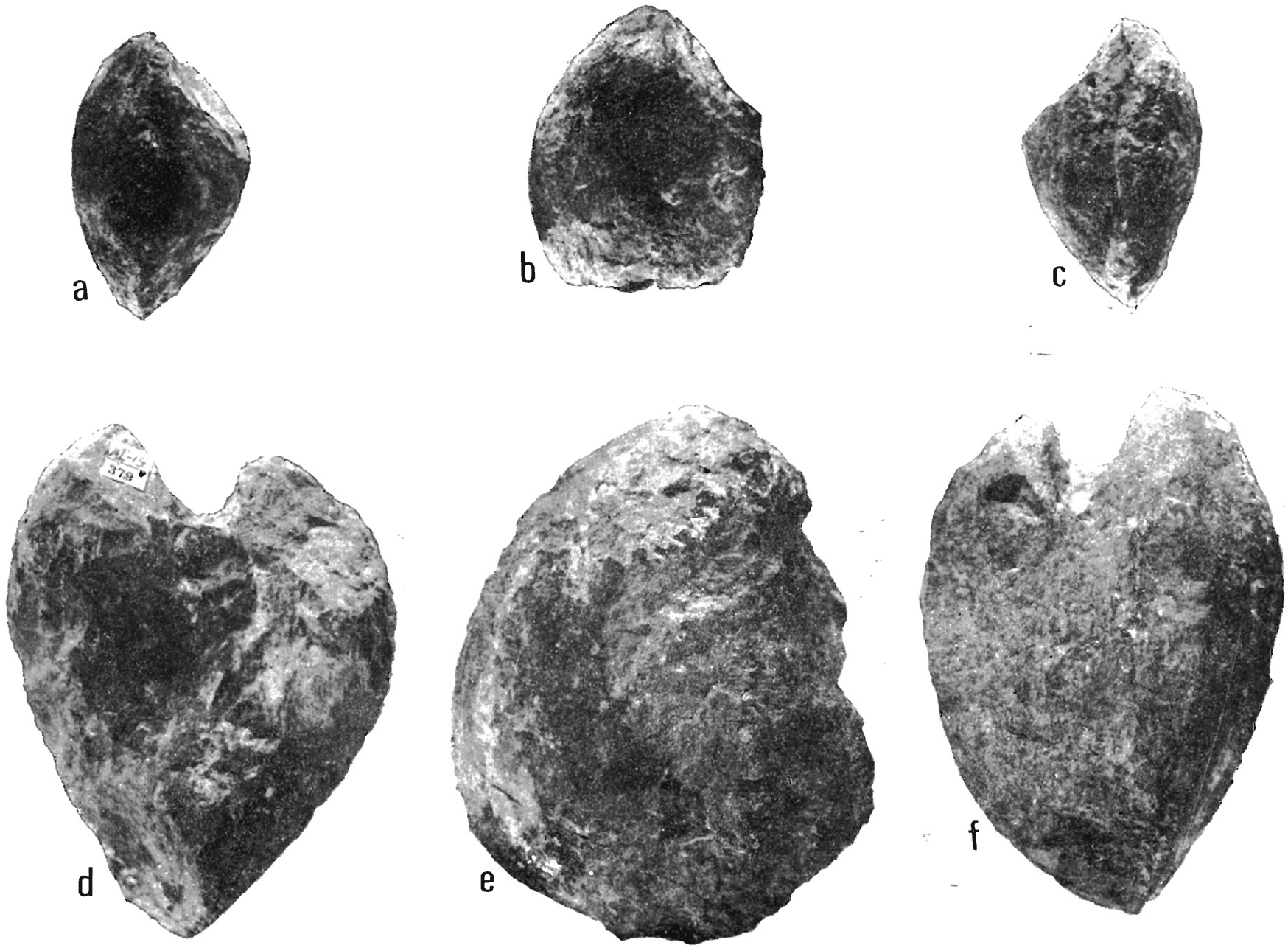
Fragment of the *Megalodon* limestone from Mt. Wołoszyn; visible are erosion surfaces at the middle and top part of the bed (cf. Pl. 1)

PRESERVATION AND TAXONOMY

The megalodon shells occurring in Rhaetian sediments under discussion are very difficult to extract from limestone matrix because of their strong recrystallization. The specimens obtained are poorly preserved, incomplete and difficult to be identified.

Two specimens from Professor Goetel's collection, were of great help here; they come from Mt. Mały Kopieniec (bed *a* in Fig. 2*C*; cf. Goetel 1917, Pl. 11).

The larger specimen (Fig. 5*d*—*f*) was previously assigned by Goetel (1917) to the species *Lycodus cor* Schafhäutl which really corresponds (cf. Kutassy 1934, Müller 1963, Cox & LaRocque 1969) to the species *Conchodus infraliasicus* Stoppani. The smaller specimen (Fig. 5*a*—*c*) was identified by Goetel (1917) as *Megalodus* cf. *scutatus* Schafhäutl. However, as it results from recent studies on the specific variability of *Conchodus infraliasicus* Stoppani (cf. Zapfe 1957, 1964; Végh-Neubrandt 1968), this



Megalodons *Conchodus infraliasicus* Stoppani from Mt. Mały Kopieniec

a—c smaller specimen in anterior (*a*), side (*b*) and posterior (*c*) views; *d—f* bigger specimen in anterior (*d*), side (*e*) and posterior (*f*) views. The specimens are from the collection of Professor W. Goetel, and housed at the Institute of Geological Sciences, Laboratory in Cracow, Polish Academy of Sciences
All figures of natural size; taken by B. Drozd, M. Sc.

specimen should be identified as belonging to this very species, being its juvenile form.

The megalodon shells from Lejowa Valley (Fig. 2*A*) were unextractable because of a strong recrystallization, therefore a detailed analysis of their cross-sections was performed. This analysis indicates the occurrence of specimens of the species *Conchodus infraliasicus* Stoppani, differing in size (Figs 3*a*, *b*; Pl. 2), and confirming the preservation of forms at a different stage of their ontogenetic development. The smaller sections are a result of growth variability of that species (cf. Zapfe 1964). The area, shallow and flat in juvenile forms, becomes wide and deeply incised in adults (Fig. 3 and Pl. 2). Bending of the beak is also variable (cf. Zapfe 1964), generally increasing with age of the individual (cf. Figs 5*b*, *f*).

However, it seems that not all the sections agree with the variability outlined above, since the size and shape of the sections depends, primarily on the position of the section plane as well as on the height of the section through the shell. It is also very probable that some of the sections (cf. the largest one in Fig. 3*b*) correspond to the genus *Rhaetomegalodon* Végh-Neubrandt (cf. Végh-Neubrandt 1970). However, the material is insufficient to solve this problem definitely.

On the vertical section of bed *a* from Mt. Mały Kopieniec (Fig. 2*C*), individuals differing in size may be also observed; they most likely also belong to the species *Conchodus infraliasicus*.

ECOLOGY AND SEDIMENTARY ENVIRONMENT

The megalodons were the pelecypods inhabiting in groups the regions of the shallow and quiescent marine basins, commonly close to coral reefs (Zapfe 1957).

Within the sedimentary basin, in which the discussed Rhaetian sediments were deposited, a differentiation in energy conditions is distinct. In the region of Lejowa Valley (Fig. 2*A*) the sedimentation was quiet; shells of megalodons are usually preserved with both valves tightly closed (Pl. 2), due to strong and adherent hinge, contracting both valves. It may be therefore assumed that in spite of shallowness of the Rhaetian basin, the currents were not strong enough to move the specimens out of their natural position. Cordate sections (Figs 3*a*, *b*; Pl. 2) indicate that individuals embedded in the rock are arranged in a similar pattern. Their symmetry planes are as a rule almost normal to the bedding. Deeper-cut sections are also cordate proving that particular specimens are more or

less in the same position in which they were burying themselves in muddy bottom (cf. Zapfe 1957). This arrangement of sections indicates the life position of particular individuals, what together with their occurrence in groups and preservation of individuals varying in their ontogenetic development, allow to assume that the whole community must have been burried in a calcareous deposit, a remarkable thickness of which has most probably caused a sudden death of the community (cf. Ager 1963).

The way the shells were filled up with sediment is also characteristic, as some evident changes in grain size of sediment filling up the shells and composing the associated deposit can be seen (Fig. 6). This proves that in most cases the shells were enough closed at the time of covering with sediments that after decay of soft parts only fine-grained material could penetrate their interiors.

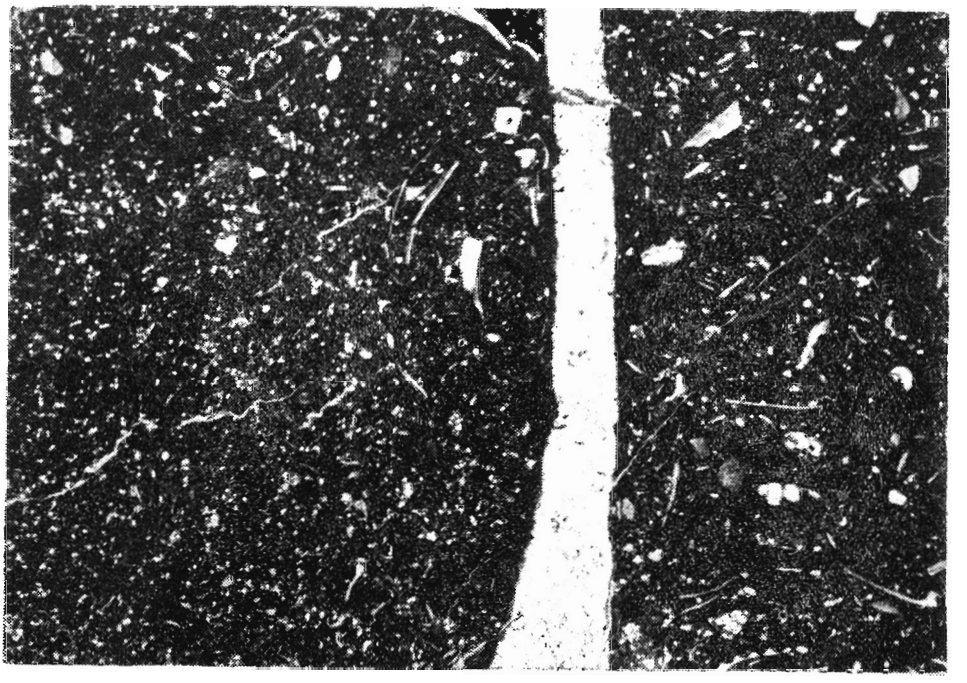


Fig. 6

Section parallel to the bedding plane of the *Megalodon* limestone from Lejowa Valley (bed b); visible is finer fraction of the organodetrital material inside the megalodon shell (left in the photo) than in the associated sediment; × 4

The profiles of Mt. Mały Kopieniec and Mt. Wołoszyn bear traces of periodical strong scouring of layers (Fig. 4 and Pl. 1), which may be connected with rapid changes in hydrodynamic conditions. Some megalodon shells here were not closed after death of individuals which

is confirmed by their infill consisting of the same organodetritical material as matrix (Fig. 4 and Pl. 1).

Microfacial analysis of the megalodon-bearing sub-tatric Rhaetian deposits (Gaździcki 1969, 1970) point to their deposition in relatively shallow, marine environment. It is evidenced both by chemical (ooids) and biosedimentary (onkolites) components, and mostly by organic remains. Among the latter, benthic forms attached to the bottom (corals, brachiopods, pelecypods, crinoids), as well as vagile (foraminifers, gastropods and echinoids) are present. Within communities formed by these organisms, the megalodons had a very individualized position due to their abundant occurrence in some areas and development of bigger groups in places.

It is interesting to note that within the high-tatric Rhaetian of the Tatra Mts, studied in detail by Radwański (1968), megalodons have not been found, what may be due to different facial conditions and smaller depth of water which gives the high-tatric Rhaetian a character of a peculiar facies in the Tethyan geosyncline (cf. Radwański 1968).

FINAL REMARKS

The megalodons are quite common forms in the Upper Triassic sediments of the Tethyan geosyncline (cf. Zapfe 1963, 1964; Végh-Neubrandt 1964; Allasinaz 1965). These pelecypods, small and diversified in genera during the Carnian and Norian (Végh-Neubrandt 1964, Allasinaz 1965), in the Rhaetian are at the peak of their development, although the number of genera is smaller. In the latter stage there occurred forms of a very large size, occasionaly up to 40 cm in diameter (Végh-Neubrandt 1968).

In carbonate sediments of the geosynclinal Rhaetian, the genera *Conchodus, Megalodus* and *Rhaetomegalodon* are the most common, and their occurrence in Europe is known mainly from Hungary — Bakony Forest, Gerecse and Vértes Mts (Vadász 1960; Végh-Neubrandt & Oravecz 1960; Végh-Neubrandt 1963, 1964, 1968), from Nothern Alps (Zapfe 1950, 1957, 1963, 1964), Lombardian Alps (Allasinaz 1962, Gnaccolini 1965) and Apulian Alps (Nardi 1963). From the Slovakian part of the Tatra Mts, apart from Goetel (1917), the occurrence of megalodons was reported by Andrusov (1959) and Kochanova (1967).

The recent studies on the Upper Triassic of Hungary (Végh-Neubrandt 1968, 1970), the Northern Alps (Zapfe 1969) as well as the Lombardian Alps (Allasinaz 1962, Gnaccolini 1965) made it possible to define the stratigraphic range of the megalodons of the genera *Conchodus*

and *Rhaetomegalodon* as Upper Rhaetian. Because of the lithostratigraphic character of that stage in the Tatra Mts, which is also characteristic for other areas of Europe (cf. Pearson 1970), it is difficult to decide whether profiles of the sub-tatric Rhaetian of the Tatra Mts correspond to the whole chronostratigraphical range of that stage or to its upper, *i.e.* megalodon-bearing part only.

Institute of Geology
of the Warsaw University
Warszawa 22, Al. Żwirki i Wigury 93
Warsaw, April 1971

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A. GAŻDZICKI

WAPIENIE MEGALODONTOWE RETYKU REGLOWEGO TATR

(Streszczenie)

Wapienie megalodontowe, będące charakterystycznym ogniwem litologicznym retyku reglowego (kriżniańskiego) Tatr (*por.* Goetel 1917, oraz fig. 1—2), zbudowane są głównie z muszli megalodontów (fig. 3—6 oraz pl. 1—2) należących do gatunku

Conchodus infraliasicus Stoppani, który jest kosmopolityczny w obrębie utworów retyku geosynkliny alpejsko-karpackiej. W rozważanych wapieniach megalodonty występują miejscami gromadnie, przy czym pewne nagromadzenia, w których reprezentowane są osobniki o różnym stopniu rozwoju ontogenetycznego (fig. 3*a*, *b* oraz pl. 2), mają charakter zespołów zasypanych w pozycji przyżyciowej.

Instytut Geologii Podstawowej
Uniwersytetu Warszawskiego
Warszawa 22, Al. Żwirki i Wigury 93
Warszawa, w kwietniu 1971 r.

Vertical section of the *Megalodon* limestone from Mt. Wołoszyn (the specimen collected by Dr. J. Głazek); visible are erosion surfaces at the middle and top part of the bed (cf. Text-fig. 4)

Section parallel to the bedding plane of the *Megalodon* limestone from Lejowa Valley (bed *a*, cf. Text-fig. 3*a*)