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THE SIGNIFICANCE OF INVESTIGATIONS UPON DIATOMS FOUND IN THE PRZEWORNO MARBLES

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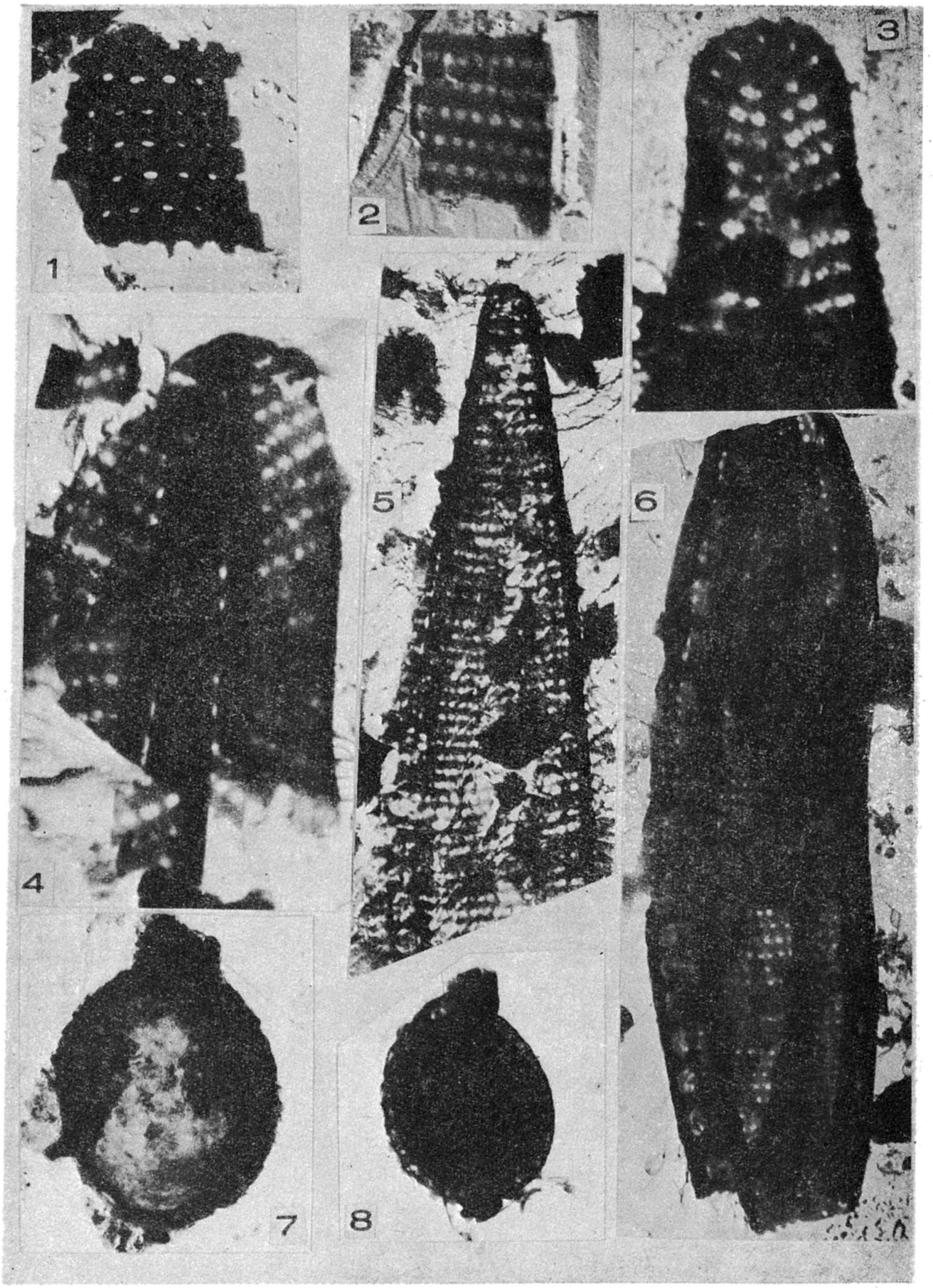
Heated discussions upon the existence of diatoms older than Jurassic were closed by Pia (9) who authoritatively refuted the reliability of all records published so far. It has lately been generally agreed (2, 11, 13) that the oldest documented finds derive from Middle Cretaceous, since Rothpletz's (10) two Early Jurassic *Pyxidicula* species were included by Deflandre (4) into *Schizosphaerellidae* containing calcareous nannofossils incerte sedis. Vyekshina's (14) Late Jurassic *Compositus evgenii* and *Stephanopyxis parentes*, according to Stryelnikova (13), need confirmation. A few years ago, however, diatom remnants were found in Przeworno in Poland (5, 6, 12) in two layers of graphitic marble, the age of which was established by Oberc (7, 8) as Proterozoic (they were formerly (1) treated as Middle or Lower Devonian); this fact brings down the lower diatom age limit ca 450 milion years. The diatoms of Przeworno are, then, contemporaneous with Proterozoic acritarchs, as well as with the already fairly highly differentiated blue-green and green algae, and perhaps chrysophites (11, 3).

The discovered fragments of diatom frustules are very small (ca 1—4 × 1—12 μm), and have so very dense and delicate an ornamentation that one is unable to see them with the light microscope — even when using an immersion objective — either in very thin microsections, or in the deposit remaining after the dissolving of the marble in hydrochloric acid. It appeared later that they are also extremely fragile, easily breaking and distintegrating. It was only by chance that the first, verly small, perforated fragment of a frustule was noticed in the transmission electron microscope, picked up on the replica film detached from the marble surface. It required indeed great patience and much time to find and to photograph only 39 remnants of diatoms in specially collected marble samples, taking all precautionary measures to avoid contamination during the investigations.

Applying a magnification of ca 7000 x, about 150 preparations were examined, each covering an area of ca 0,4 mm². The distribution of diatom remnants appeared to be very uneven: they were found in 16 preparations out of 134 studied. The majority of remnants were found in the thin layer (thickness up to 18 cm) of black marble containing large tremolite crystals, there being far fewer in the thick layer (ca 40 cm) of the grey-black one. No diatom remnants were found in the white marble layers of the same age separating those mentioned above or in those lying underneath and above.

Figs 1—8. Nannofossils from Przeworno marbles. 1, 2 — fragments of diatom frustules; 3 — fragment of a diatom valve belonging to Araphideae; 4 — remnants of the epi- and hypovalve of a diatom Navicula; 5, 6 — fragments of diatoms Nitzschia; 7, 8 — Flagellata incerte sedis. (Magnifications: figs 1, 2, 7 ca. 20 000 ×, figs 3—6 14 000 ×, fig. 8 7200 ×) (Photographed by B. Kwiecińska).



Ryc. 1—8. Nannofosylia z marmurów Przeworna, 1, 2 — ułomki skorupek okrzemek; 3 — fragment walwy okrzemki z grupy Araphideae; 4 — szczątki epi- i hypowalwy okrzemki Navicula; 5, 6 — szczątki okrzemek Nitzschia; 7,8 — Flagellata incerte sedis. (Powiększenia: ryc. 1, 2, 7 ok. 20 000 ×, ryc. 3—6 14 000 ×, ryc. 8 7200 ×) (Fot. B. Kwiecińska).

All the layers of marble are located in the northern wall of the marble quarry et Przeworno, in its lower part. They are not in contact with the layers in which the fossil caves occur or other karst forms filled with clay and rich Miocene fauna; these layers are situated in the southern and western parts of the quarry. The migration or infiltration of Tertiary or younger diatoms into the investigated pieces of marble was and is impossible because of the very early mineralization and extremely low porosity of these rocks. According to the analyses made by Dr. J. Dziewański the grey-black marble has: total porosity 2.15%, actual porosity 0.21%, specific density 2.86 g/cm³, volume density 2.80 g/cm³.

It was possible to determine the taxonomic position only for 20 remnants of diatom frustules; the others are just tiny, perforated fragments (figs 1, 2). One remnant derives most probably from a valve of a cell belonging to *Centrophycidae*, and nineteen to *Pennatophycidae*, one of which belongs to *Araphideae* (fig. 3), and the rest to *Biraphideae:* here two remnants may be included to the *Navicula* genus (fig. 4), while no less than thirteen belong to the *Nitzschia* genus (figs 5, 6). These facts contradict the current opinions as to the course of evolution in diatoms and prove that the beginning of diatom occurrence, as well as the differentiation to the centric and the pennate form of the valves, and of the development of the raphe and the canal-raphe in frustules, is to be sought in the still older geological epochs. All the remnants found in Przeworno have the same primitive features, and above all: very small size of cells (probably 7—25 μm), very weakly and almost uniformly silicified frustules perforated by minute pores (not areols) arranged in single, very dense rows (3—6 rows in 1 μm). In all this the Proterozoic diatoms differ from those of Cretaceous and Tertiary which have large and coarse frustules with a highly differentiated construction and ornamentation.

Together with the diatoms some other nannofossils were found in Przeworno (also under the electron microscope): two tests which might have belonged to flagellates, four shells of a so far unknown organism, and one undetermined organic structure. It may be presumed that they all provide evidence of the existence of organisms from which also come the silica occurring in minerals and graphitic substance in the same marble layers.

This was the very first discovery of organic remnants in the Proterozoic calcitic marble, which proved a possibility of the survival of very scarce and tiny remains of organisms in old metamorphosed limestone. Certainly this is a very rare event, since in thousands of rocks already investigated under the electron microscope they were noticed only in Przeworno. One may, however, suppose that the graphitic marbles of Przeworno are not a perfect exception and that diatoms and other nannofossils will also be found in the future in some other rocks metamorphosed in more favourable conditions. If so, at least some old metamorphic rocks will be subjected to micropaleontological investigations.

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STRESZCZENIE

Kilka lat temu znaleziono szczątki okrzemek w Przewornie na Dolnym Śląsku (5, 6, 12) w dwu warstwach marmurów grafitowych, których wiek został ustalony przez J. Oberca (7, 8) na proterozoik. Wskutek tego obniżona została dolna granica wieku okrzemek o około 450 mln lat, licząc od środkowej kredy (2, 11, 13).

Spośród 39 znalezionych szczątków 19, to nieoznaczalne ułamki skorupek okrzemek, jeden można zaliczyć do *Centrophycidae*, 19 do *Pennatophycidae*, przy czym jeden należy do *Araphideae*, inne do *Biraphideae:* dwa do rodzaju *Navicula*, aż 13 do rodzaju *Nitzschia* (ryc. 1—6). Mimo tak dużego zróżnicowania schematu budowy, wszystkie okazy mają wspólne prymitywne cechy w postaci bardzo małych wymiarów (prawdopodobnie ok. 7—25 μm), cienkich skorupek słabo i prawie jednolicie wysyconych krzemionką, maleńkich porów (nie areol) ustawionych w pojedyncze, bardzo gęste rzędy (3—6 rzędów do 1 μm). Początków występowania okrzemek i różnicowania się budowy skorupek trzeba zatem szukać w jeszcze starszych epokach geologicznych.

Wraz z okrzemkami znaleziono dwa domki wiciowców (ryc. 7, 8) i kilka innych maleńkich skorupek. Są to skąpe ślady po organizmach, z których prawdopodobnie pochodzi krzemionka wchodząca w skład minerałów i grafit, występujące obficie w tych warstwach marmuru.

Jest to pierwsze odkrycie szczątków organicznych w proterozoicznych marmurach kalcytowych dokonane dzięki przeglądaniu wprost w transmisyjnym mikroskopie elektronowym cząstek oderwanych wraz z błonką repliki napyloną na powierzchni świeżych przełamów skały. Stosowanie tej metody wymaga wiele czasu i cierpliwości, jednak stwarza możliwość objęcia, przynajmniej niektórych, starych skał metamorficznych badaniami mikropaleontologicznymi.

РЕЗЮМЕ

Несколько лет тому назад в местности Пшеворно в Нижней Силезии в двух слоях графитовых мраморов были найдены остатки диатомей (5, 6, 12). Ю. Оберц (7, 8) относит эти мраморы к протерозою. Этот факт передвигает возрастную границу диатомей на близко 450 млн. лет, считая с раннего мела (2, 11, 13).

Из числа 39 найденных остатков 19 представляет неопределимые остатки диатомей, один можно отнести к Centrophycidae, 19 к Pennatophycidae, причем один принадлежит к Araphideae, другие же к Biraphideae: два к роду Navicula и 13 к роду Nitzschia (фиг. 1—6). Несмотря на сильно дифференцированное строение, все экземпляры характеризуются общими примитивными признаками как весьма небольшие размеры (очевидно около 7—25 μм), тонкие раковинки, слабо и однообразно пропитанные кремнезёмом, небольшие поры, распределенные в виде одинарных, очень густых рядов 3—6 на 1 μм). Таким образом, появление диатомей и дифференцирование их раковинок относится еще более древним геологическим эпохам.

Вместе с диатомеями были найдены два экземпляра флагеллят (фиг. 7, 8) и несколько других маленьких раковинок. За счет немногочисленных организмов в упомянутых слоях мрамора появились кремнезём и графит.

Описанные организмы являются первой находкой органических остатков в протерозойских кальцитовых мраморах. Они были выявлены путем непосредственного наблюдения под электронным микроскопом частиц, оторванных вместе с пленкой реплики, повлеченной на поверхности свежего излома породы. Этот метод требует больших затрат времени и скрупулезности, однако он позволяет производить микропалеонтологический анализ по крайней мере некоторых древних метаморфических пород.