Acta Palaeobotanica 55(1): 115–117, 2015
DOI: 10.1515/acpa-2015-0007

DISCUSSION ARTICLE

# On the age of fossil diatoms

JADWIGA SIEMIŃSKA

Department of Phycology, W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland; email: sieminska.jadwiga@gmail.com

Received 22 April 2015; accepted for publication 29 May 2015

ABSTRACT. The finding of fossil freshwater diatoms in late Cretaceous chert in Mexico suggests – together with all the discoveries of fossil freshwater diatoms known from positions older than the Cretaceous – that the extinct marine Cretaceous diatom taxa cannot be considered to be the oldest.

KEYWORDS: fossil diatoms, Cretaceous, Upper Proterozoic, marble

The age of fossil diatoms remains a problem for study and debate. The Cretaceous diatoms, considered to be the oldest, belong to extinct marine genera, almost exclusively centric (Round et al. 1990). This opinion is supported by calculations based on the results of molecular studies indicating early Mesozoic origins for this group of algae (Koistra & Medlin 1996, Simms et al. 2006). During that period, diatoms occurred so abundantly that they formed deposits of diatomites.

The age of diatoms found in older sediments and rocks (Triassic, Permian, Carboniferous, Devonian, Silurian, Ordovician, and older; compiled by Siemińska 2000), described since the mid-nineteenth century from various parts of the world, is questioned (Simms et al. 2006, Crawford & Round 2002). Among these findings are single species and communities characteristic of freshwater habitats, and also some marine ones. In these communities there are representatives of recent types of diatoms from the Pennatae group, with or without a raphe. Sometimes they are accompanied by species of the centric genera. In addition to the species occurring nowadays, the presence of forms and even species that cannot be identified by currently known criteria has been noted; they were described as new taxa. The authors of these publications generally were experts on this group of algae (e.g. A. M. Edwards, J. Grüss, C. F. Castracane, A. Grunow, J. Pantocsek, A. Rothpletz, M. C. White, V. Zanon). Knowing the objections raised about the age of Palaeozoic diatoms, they endeavoured to use methods that would exclude contamination by modern material: they made preparations from the centre of the rock and not from the surface, viewed thin sections, and searched through ash of burned samples. The lively debate was summed up by Pia (1931), who did not recognize all these findings as reliable. Species of genera characteristic of freshwater communities were not known from Cretaceous sediments. That was the reason for negating their previous existence.

Thanks to information received from Dr. J.P. Kociolek, I have paid attention to Russian publications disclosing the presence of abundant remains of diatoms in Cambrian rocks. Vologdin (1962) saw and photographed (by LM) the remains of diatoms encountered in transparent thin sections taken from Middle and Lower Cambrian limestone from the Asian mountain range Tannu Ola in Tuva; he did not venture to call them diatoms although they do have features characteristic of diatoms. Ergaliev and Azerbaev (1986) mentioned that in siliceous horizons of the Great Karatau Mountains and Djebaglin Mountains they

found fragments similar to diatom frustules with longitudinal or rounded pores set up in parallel rows; they viewed them with an electron microscope on replicas from freshly broken rock. In thin sections made from early Cambrian siliceous minerals (with admixture of graphite) of the Little Karatau, Gapeev (1992, 1995) noted the outlines of forms similar to freshwater diatoms, and photographed (by LM) a cross section of the frustule, resembling the overlapping halves characteristic of diatoms. Allison and Hilgest (1986) published photographs of specimens similar to centric diatoms, found in thin sections of early Cambrian limestone of north-eastern Canada.

Forty years have passed since the finding of diatom remains in Upper Proterozoic black layers of white marble in Przeworno (Kwiecińska & Siemińska 1973). Kwiecińska, a minerologist specializing in the study of coal, found them while examining triafolic replicas of freshly broken rock by transmission electron microscopy at 7000–16 500×. The remains (measuring 1–25 × 1–10 μm) were very rare: among the 150 preparations examined during five years there were just 16. These were tiny pieces, and only a few in the form of heavily damaged frustules. Identifiable remains were described in several publications (summarized by Siemińska & Kwiecińska 2000). Three remains were classified as centric diatoms, including one described as a new genus, and the species *Bolewskia stanislai* resembling the extinct Miocene and Oligocene *Riedelia mirabilis* described from Pacific sediments. Nineteen specimens were classified as Pennatae: 2 of them belonging to Araphidae and resembling marine types *Rhaphoneis* and *Lickmophora*, 3 remains with a raphe resembling *Navicula sensu lato*, and 9 remains having characteristics of species of the genus *Nitzschia*. There are also spores belonging to the extinct Miocene genus *Xanthiopyxis*. These forms indicate a freshwater or brackish community. The Proterozoic age of the marble was established by Oberc (1966, 1975) on the basis of geology and tectonics; Professor Oberc maintained that opinion later as well. The Proterozoic age (Neoproterozoic) of the marble was confirmed by Oberc-Dziedzic (1999) and also by Szczepański and Józefiak (1999). Previously that marble was regarded as Middle or Lower Devonian because it was found below well-dated Middle or Lower Devonian layers.

More recently the discovery of freshwater diatoms in late Cretaceous lenses of chert in Mexico (Beraldi-Campesi et al. 2004) has attracted a lot of attention. Embedded in transparent silica, they are well visible in thin sections by LM. They belong to modern diatoms: centric (*Melosira*), without a raphe (*Tabelaria* and *Fragilaria*), and with a raphe (*Amphora*). Together with the accompanying filamentous blue-green algae and coccal green algae they formed a community typical for a shallow freshwater water body, similar to modern freshwater communities and to communities described from known positions older than the Cretaceous.

Consequently, Cretaceous marine diatoms cannot be considered to be the oldest. During the Proterozoic there were already diatoms very diverse in type and species, in both the Centricae and Pennatae groups, and the latter already had representatives with and without a raphe. This suggests that diatoms evolved much, much earlier. Very small, thin frustules with flat and very dense ornamentation (ca 3–4 rows of pores per 1 μm) can be considered ancestral. The occurrence of Proterozoic diatoms simultaneously with stomatocysts of golden-brown algae supports their relationship. Interesting is the occurrence of frustules referred to the genera *Coscinodiscus*, *Navicula s.l.* and *Nitzschia* from the Proterozoic to modern times.

## REFERENCES

ALLISON C.W. & HILGEST J.W. 1986. Scale microfossils from the Early Cambrian north-western Canada. J. Paleo., 60: 973–1015.

BERALDI-CAMPESI H., CEVALLOS-FERRIS S.R.S. & CHAKON-BACA E. 2004. Microfossil algae associated with Cretaceous stromatolites in the Tarahumana Formation, Sonora, Mexico. Cretac. Res. 25: 249–265.

CRAWFORD M.C. & ROUND F.E. 2002. Reviews. Diatom Res., 17(1): 267–270.

ERGALIEV G.CH. & AZERBAEV N.A. 1986. Kembryskaya Sistema Bolshoj Karatau. T. 1., Nauka, Alma Ata: 35–40.

GAPEEV A.P. 1992. Problematyki iz ranne kembryskikh otlozeny Malogo Karatau. Paleontologichesky Zhurnal, 1: 101–104.

GAPEEV A.P. 1995. Kembryskie formy diatomovykh vodorosley v otlozhenyakh Malogo Karatau? Litologia i poleznye iskopaemye: 236–261.

KOISTRA W.H.C.F. & MEDLIN L.K., 1996. Evolution of the diatoms (Bacillariophyceae) IV. Mol. Phylogenet. Evol., 6: 391–407.

KWIECIŃSKA B. & SIEMIŃSKA J., 1973. Diatoms (Bacillariophyceae) in the in the Przeworno marbles (Lower Silesia) Bull. Acad. Pollen. Sci., Ser. Sci. Terre, 20: 299–303.

OBERC J. 1966. Geology of crystalline rocks of the Strzelińskie Hills, Lower Silesia. Stud. Geol. Pol., 20: 1–197.

OBERC J. 1975. Metamorfik Przeworna i jego budowa. Przewodnik XLVII Zjazdu Polskiego Towarzystwa Geologicznego, Świdnica 1975. Instytut Geologiczny, Warszawa: 172–173. (in Polish)

OBERC-DZIEDZIC T. 1999. The metamorphic and structural development of gneisses and older schists series in the Strzelin crystalline massif (Fore-Sudetic Block, SW Poland). Mineral. Soc. Pol. Spec. Pap., 14: 10–21.

PIA J. 1931. Vorliassische Diatomeen. Neues Jahrbuch für Mineralogie. Stuttgart: 107–131.

ROUND F.E., CRAWFORD R.M. & MANN D.G. 1990. The Diatoms. Biology and Morphology of the Genera. University Press, Cambridge.

SIEMIŃSKA J. 2000. The Discoveries of Diatoms Older than the Cretacous: 55–74. In: Witkowski A. and Siemińska J. (eds), The Origin and Biogeographical Approaches. W. Szafer Institute of Botany Polish Academy of Sciences, Kraków.

SIEMIŃSKA J. & KWIECIŃSKA B. 2000. The Proterozoik diatoms from the Przeworno marbles: 97–122. In: Witkowski A. & Siemińska J. (eds), The Origin and Biogeographical Approaches. W. Szafer Institute of Botany Polish Academy of Sciences, Kraków.

SIMMS P.A., MANN D.G. & MEDLIN L.M. 2006. Evolution of the diatoms: insights from fossil, biological and molecular data. Phycologia, 45(4): 361–402.

SZCZEPAŃSKI J. & JÓZEFIAK D., 1999. Jegłowa beds – record of polyphase deformation and metamorphisms in the Strzelin crystalline massif (Fore-Sudetic Block, SW Poland). Mineral. Soc. Pol. Spec. Pap., 14: 33–37.

VOLOGDIN A.G. 1962. Diatomoobraznye organizmy kembria khrebta Tannu Ola – v Tuve. Doklady Akademii Nauk SSSR, 146(6): 908–912.