

OCCURRENCE OF FRESHWATER ALGA *PEDIASTRUM* IN CRETACEOUS MARINE SEDIMENTS

WILLIAM R. EVITT

Department of Geology, Stanford University, Stanford, California*

ABSTRACT. Fossils of *Pediastrum*, an alga that today lives exclusively in freshwater, occur in marine sediments in Pakistan (Lower Cretaceous) and California (Upper Cretaceous). Therefore, fossil *Pediastrum* does not (as has been assumed) establish the freshwater origin of its enclosing sediments. The genus ranges back at least to the Lower Cretaceous, and known Cretaceous forms closely resemble some modern ones.

INTRODUCTION

The purpose of this note is to call attention to the occurrence of the microscopic alga *Pediastrum* in marine deposits of Cretaceous age in California and Pakistan, and to consider the value of fossil *Pediastrum* as an independent indicator of a marine depositional environment for the strata in which it occurs.

Green algae of the genus *Pediastrum* are distinguished by disc-shaped coenobia or "colonies", composed of a variable number of cells (usually 8 to 64). The cells are arranged in basically concentric fashion, either closely packed or with intervening lumina, and those of the outer row commonly differ from the inner ones by possessing one to three projections. The cell wall is composed of highly resistant organic material capable of fossilization. Characters of taxonomic value are the number and arrangement of cells, the shape of the external cells, and the fine ornament of the resistant walls. The genus is cosmopolitan in freshwater ponds and lakes, but no marine representatives are known.

Fossil *Pediastrum* have been encountered in Pleistocene deposits by a number of workers (Borge and Erdtman, 1954, cite earlier references), and a few occurrences in older sediments have been noted. As far as I am aware, the oldest *Pediastrum* reported to date are those from the Green River Shale (Eocene) noted (but neither described nor figured) nearly a half-century ago by Davis (1916). Erdtman (1936) and Borge and Erdtman (1954) noted the genus in Oligocene strata on the Isle of Wight. Cookson (1953) identified specimens from "?Early Tertiary" shales in Australia with the common modern species, *P. boryanum*. Wilson and Hoffmeister (1953) described four new species from Eocene strata in Sumatra, all four having marked similarities to extant species.

These instances of *Pediastrum* in Tertiary sediments either certainly or probably represent freshwater deposits, although it is the presence of *Pediastrum* that is the principal basis for presuming a freshwater origin of at least one of them (Cookson, 1953). The exclusively freshwater habitat of modern *Pediastrum* has been interpreted to give it special significance as a paleoecological indicator. In this regard, Cookson (1953, p. 119) remarks:

* The observations reported here were made while the author was a member of the staff of Jersey Production Research Company, Tulsa, Oklahoma, and are published with the generous permission of that company.

Of the three microfossil types considered in this paper, *Botryococcus braunii* is of least importance in any paleoecological study since it can live in either salt or fresh water. On the other hand, *Pediastrum* being a freshwater alga and the Hystrichosphaeridae being components of the marine plankton are more valuable indices in this respect. Thus the occurrence of *Pediastrum* with *Botryococcus* in the Cootabarlow shale and Verona clay confirms that both are freshwater lake deposits.

The two occurrences reported below make suspect the premise on which Cookson's remark is based, although I do not mean to question the correctness of her ultimate conclusion as to the environment of the particular samples she was discussing.

PAKISTAN OCCURRENCE

During palynological study of core samples from several exploratory wells drilled by the Standard-Vacuum Oil Company east of Hyderabad in West Pakistan, coenobia of *Pediastrum* were encountered in marine shales in association with hystrichospheres, dinoflagellates, spores, and pollen. The strata that yielded the fossils had been deposited in part of the sedimentary basin that now underlies the great Indus plain. The clastics and the land-derived fossils in the samples studied apparently were derived from the Indian shield to the east. The other microfossils of organic composition associated with *Pediastrum* indicate a late Lower Cretaceous (probably Albian) age. Specimens of *Pediastrum* are reasonably common in one sample (about 10 being noted in scanning two prepared slides) and rare (14 in eight slides) in a second sample stratigraphically 850 feet below the first in the same well. Preservation of specimens is poor to fair, but leaves no doubt that the best represented species (if more than one is present) is similar to *P. boryanum*, with compact 8- to 64-celled coenobia and 2-pointed marginal cells.

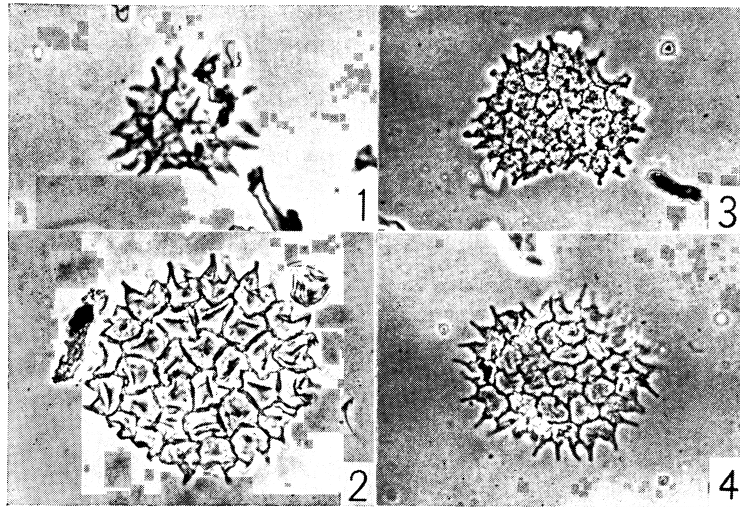


PLATE 1

Pediastrum spp. 1. A 16-celled coenobium from the Lower Cretaceous of Pakistan, $\times 500$. 2-4, Three 32-celled coenobia from the Upper Cretaceous of California, $\times 250$. The specimen in figure 2 is from a calcareous nodule, those in figures 3 and 4 from the higher limestone bed mentioned in text.

CALIFORNIA OCCURRENCE

Pediastrum coenobia are also conspicuously common in residues from two Late Cretaceous samples from California. These samples are from a belt of Cretaceous outcrops along the west side of the San Joaquin valley near Patterson, Stanislaus County; specifically: NE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 32, R.7E., T.5S. The area has not been mapped in detail, so exact stratigraphic relationships are unknown. However, the associated microfossils leave no doubt as to the approximate age. The sampled section consists of something under 20 feet of thin-bedded noncalcareous shale containing small (2- to 4-inch) flattened calcareous concretions, capped by a massive 2- to 3-foot bed of argillaceous limestone. Different microfossils dominate the assemblages from the nodules on the one hand and from the massive bed on the other, but many elements are common to both. The calcareous nodules contain a rich assortment of angiosperm pollen not precisely datable without local control. The most abundant fossil in the sample, but also one without established time significance, is a new species of the dinoflagellate genus *Deflandrea*. Other microfossils include Radiolaria (recovered from one nodule only) as well as rare and rather poorly preserved planktonic Foraminifera. The assemblage in the overlying massive limestone includes far fewer pollen, but a varied assemblage of well preserved dinoflagellates and hystrichospheres, as well as Radiolaria and a few Foraminifera.

The Radiolaria from the lower sample represent the same fauna as that from the Corral Hollow Shale described by Campbell and Clark (1944). Their material came from a separate outcrop belt about 20 miles to the west-northwest of the source of my material. A tentative date of Campanian for the sample they studied is based on an ammonite on the small block that yielded their Radiolaria. The Radiolaria that I recovered from the higher limestone sample constitute a markedly different and undescribed assemblage whose age significance cannot now be evaluated. However, the dinoflagellate-hystrichosphere assemblage from that higher sample compares closely with assemblages from the Lewis Shale in Wyoming and the Red Bank Formation in New Jersey, the former Campanian-Maestrichtian, the latter Maestrichtian in age. Thus, the Radiolaria from the lower sample and the dinoflagellates and hystrichospheres from the higher one indicate a Late Cretaceous age for these strata.

Abundance, preservation, and appearance of the specimens of *Pediastrum* differ between the two samples. Specimens from the upper limestone are fairly abundant (I counted 61 specimens in a slide prepared from one drop of concentrated insoluble residue) but small, extremely thin walled, and often folded or distorted. Specimens from the stratigraphically lower nodules are much better preserved and include some large individuals (to 125 microns diameter). However, they are not common (13 in three slides). All specimens from both samples whose morphology could be interpreted resemble *P. boryanum* and, like it, show wide variation in size of coenobia, number of cells, and the development of the points on the marginal cells. If they represent more than one species, more careful study than has been attempted will be necessary to distinguish them.

CONCLUSIONS

Three obvious conclusions derive from the observations reported above: (1) Fossil *Pediastrum* (even when individuals are common) is not, by itself, a reliable indicator of a freshwater depositional environment for the strata in which it occurs. Either some Cretaceous *Pediastrum* were marine, or, more likely, the resistant cell walls enabled the remains of the coenobia to be transported from the bodies of freshwater in which the organisms lived into bodies of marine water in whose sediments they were buried and preserved. (2) The geologic history of *Pediastrum* dates back to at least the Early Cretaceous. (3) The observed similarities of fossil *Pediastrum* (i.e., of the Cretaceous examples discussed here and Tertiary species described by other workers) to extant species point to a conservative evolution among known members of the genus since the late Mesozoic.

ACKNOWLEDGMENTS

I appreciate the kindness of Mrs. Virginia M. Page, Research Associate in Geology at Stanford University, in bringing to my attention the interesting material from California and for taking me to the locality near Patterson.

After this note was written, L. R. Wilson (personal communication) informed me that he has found many specimens of *Pediastrum* in preparations from the marine Upper Cretaceous Lewis Shale from the Rocky Mountains.

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