# FOSSIL PROTOZOANS FROM THE KEEWATIN SEDIMENTS

KENNETH M. MADISON
*University of Illinois, Navy Pier, Chicago*

## Introduction

Sedimentary rocks interbedded with igneous pre-Cambrian rocks occur in the Schreiber-Nipigon district of Ontario, Canada. In the Lower Gunflint cherts, Tyler and Barghoorn (1954) discovered "... five morphologically distinct organic entities." They stated that "... these are the oldest structurally preserved organisms that clearly exhibit cellular differentiation and original carbon complexes which have yet been discovered in pre-Cambrian sediments." Their estimated age is nearly two billion years. Older sediments of Keewatin age occur near the town of Schreiber as lenses of conglomerate, quartzite, limestone or chert interlayered with magnetite embedded in lavas. The entire formation dips from 55° to 70° N to NW (Harcourt, 1939).

Embedded in the fine-grained quartz of the black Keewatin cherts are the fossilized remains of at least 15 separate species of primitive organisms. The individual fossils which appear as detailed brown stains, often with coalified internal structures, include three bacteria, two blue-green, two green and one red algae, two euglenoids, four flagellates and one heliozoan. Magnetite-helium ratios (Hurley, 1949) and $K_{40}/A_{40}$ (Goldich, *et al.*, 1956) date Algoman intrusives at 2.1 to 2.5 average 2.35 billion years. From this and from stratigraphic considerations, the estimated age of the Keewatin cherts appears to be from 2.6 to 2.8 billion years, with the higher value more probable.

This paper is concerned with the Keewatin protozoans, their morphology and possible systematic positions. In the Gunflint sediments, Tyler and Barghoorn (1954) found unicellular organisms which resemble *Discoaster,* a group of planktonic, calcareous marine flagellates of uncertain systematic position, probably related to the Coccolithophorides. No other information is available for protozoans of pre-Cambrian time.

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## Materials and Methods

The Keewatin cherts were collected during the summers of 1955 and 1956 from a large chert-magnetite outcrop on King's Highway 17 about one mile west of Schreiber, Ontario. As no earlier evidence indicated the presence of fossils, samples were collected at random along the face of the outcrop.

In the laboratory the cherts were sawed with a diamond saw into sections about 2 mm. thick. From these, standard thin sections were prepared and mounted on microscope slides.

## Results

Most of the thin sections of Keewatin chert showed coalified carbon structures with almost no internal detail. Some pieces of chert yielded thin sections with a different type of fossil material. These were brownish colored. Microscopic examination revealed that the dominant structures were probably the thallus and carposporangia of a red alga, most closely related to the modern Cryptonemiales. Between and on the fronds of the red alga were several bacterial and algal forms as well as protozoans. The bacteria and algae are being reported elsewhere.

The protozoans are represented by seven species, often fully as sharp and distinct as those seen in living protozoans; however, any conclusions must be tentative and subject to re-interpretation as more fossil material becomes available for study. Kudo (1954) and Hall (1953) were used in identifying these animals.

FAMILY EUGLENIDAE. — Genus *Euglena.* Two different species were found. The first (Fig. 1) is ovoid, 210 by 105 microns, slightly pointed at the anterior end, with a reservoir anteriorly. Within the reservoir is a dark granule, the blepharoplast; from it a long, slender filament, the flagellum, proceeds anteriorly out the cytostome and then posteriorly a short distance. The nucleus is round, dark, slightly anterior, and central. There are numerous fusiform chromatophores and round bodies with small coalified central granules.

The second species (Fig. 2) is an elongated cylinder with rounded ends, 210 by 67 microns. There is a large anterior reservoir with two peripheral granules, blepharoplasts (?). There is no evidence of a flagellum. The slightly posterior nucleus has two rounded bodies adjacent to it, paramylon bodies (?). Fusiform chromatophores are present as are numerous rounded bodies.

FAMILY OIKOMONADIDEA. — Genus *Oikomonas.* An ovoid form (Fig. 3), 46 by 28 microns, apparently uninucleate (the nucleus seems to be dividing). Anteriorly there is a small granule from which projects a short filament, the remains of a flagellum (?). Posteriorly, numerous granules outline several vacuoles. The cytoplasm is clear.

Genus *Ancyromonas.* Two distinct species were found. The first (Fig. 4) is small, triangular, and 8.5 by 8 microns. The remains of a flagellum from one of the apices may be present. Nucleus is vesicular, and there are several large vacuoles. This species most nearly resembles *A. contorta.*

The second form (Figs. 5 and 6) is larger, triangular, and 31 by 20 microns. There is evidence of a flagellum from the acute apex. The nucleus is uncertain. Numerous vacuoles were found, some with included coalified granules. This organism is not like any modern species known to the writer.

FAMILY AMPHIMONADIDAE.—Genus *Amphimonas.* A sub-spherical flagellate, 19 by 14 microns (Fig. 7). There is evidence of two flagella

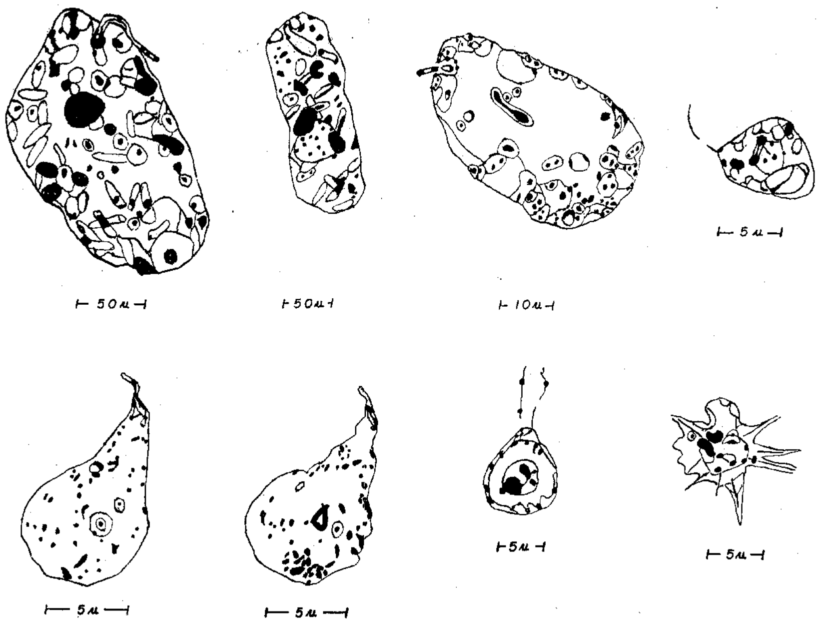


FIG. 1.—*Euglena* sp.; FIG. 2.—*Euglena* sp.; FIG. 3.—*Oikomonas* sp.; FIG. 4.—*Ancyromonas contorta* (?); FIG. 5.—*Ancyromonas* sp.; FIG. 6.—*Ancyromonas* sp.; FIG. 7.—*Amphimonas globosa* (?); FIG. 8.—*Sphaerastrum* sp. All thin sections.

projecting from the anterior end. The nucleus is large, central and coalified. The cytoplasm is dense. This form is similar to *A. globosa*.

FAMILY LITHOCOLLIDAE. — Genus *Sphaerastrum*. This heliozoan is small, 10 microns (Fig. 8). Numerous axopodia are covered with a gelatinous matrix. There is a central granule and a vesicular nucleus. This amoeboid species is smaller than the modern *S. fockei*, but resembles it.

## DISCUSSION

The presence of seven species of protozoans representing the subclasses Phytomastigina, Zoomastigina and Actinopoda, and living between the thalli of a red alga during Keewatin time, estimated to be 2.6 to 2.8 billion years ago, is significant for three problems in theoretical biology. These are: 1) the stability of protozoan forms; 2) the diversity of the Keewatin protozoan fauna; and 3) the age of the earth's crust and the origin of life.

1. *Stability of protozoan forms.* In general, the genera of multicellular animals are geologically short-lived, infrequently surviving unchanged for more than a single period. The identification of protozoan genera from the Keewatin with modern ones indicates that, from the morphological point of view at least, these organisms are more enduring than any other known animals.

2. *Diversity of the Keewatin protozoan fauna.* The presence of seven

protozoans representing two classes and three sub-classes on the fronds of a red alga 2.6 to 2.8 billion years old indicates that the Keewatin fauna was rich in number of species, at least with regard to Mastigophora and Sarcodina. Further, it suggests that animals separated from plants at some earlier time.

3. *Age of earth's crust and origin of life.* Rankama (1954) placed the formation of the earth's crust at 3.35 billion years, and Sagen (1957) used 4.5 billion years. Subsequently, life originated and organisms evolved. Two theories are current on the origin of life, the heterotrophic theory of Haldane (1933) and the autotrophic one of Madison (1953). Both of these require a long slow series of events. The flora and fauna in these cherts is the first morphological evidence that these events occurred prior to Keewatin time.

## Summary

The black Keewatin cherts from Schreiber, Ontario, dated at 2.6 to 2.8 billion years, contain the remains of 15 species of organisms belonging to the Schizomycetae, Cyanophyta, Chlorophyta, Rhodophyta, and Protozoa. These are the oldest morphologically preserved fossils that have been discovered to date.

The protozoans are represented by seven species belonging to five modern genera—namely, *Euglena, Oikomonas, Ancyromonas, Amphimonas,* and *Sphaerastrum.* Two of the species are similar to, if not identical with, living protozoans.

The significance of this discovery is discussed with regard to the stability of protozoan forms, the diversity of the Keewatin protozoan fauna, and the age of the earth's crust and the origin of life.

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