Reports

Precambrian Age of the Boston Basin: New Evidence from Microfossils

Abstract. *A Vendian (Late Proterozoic Z) age has been determined for the Boston Basin by comparison of a microflora from the Cambridge Argillite with other late Precambrian assemblages. The microfossils, which include* Bavlinella *cf.* faveolata, *are preserved as petrifactions in pyrite. This age designation for the sedimentary rocks of the Boston Basin should allow for the reinterpretation of the structure of the basin and its regional correlations.*

The discovery of microfossils in the Cambridge Argillite, Boston Bay Group, resolves a century-long controversy concerning the age of the Boston Basin. Depending on the structural interpretation, age estimates for the Boston Basin have ranged from Precambrian to Permian (*1*). Based primarily on a sedimentary structure interpreted as fossil wood (*2*), the prevailing view has been that the age of the basin is late Paleozoic. This interpretation implied that there was an unconformable separation between the Boston Bay Group, which consists of the Cambridge Argillite and the synsedimentary Roxbury Conglomerate, and fossiliferous Cambrian rocks on the northern and southern margins of the basin. Recent geologic mapping of the Boston area (*3*) indicated that the Boston Bay Group may conformably underlie and would, therefore, be older than adjacent Cambrian strata. Radiometric dating of rhyolites at the base of the section (*4*) supports this interpretation. We propose a Vendian (Late Proterozoic Z) age for the Boston Bay Group on the basis of the diagnostic microfossil assemblage found in the Cambridge Argillite.

During a petrographic study of Cambridge Argillite collected from the newly excavated subway tunnel north of Harvard Square, Cambridge, Massachusetts, one of us (C.A.K.) noted opaque subspherical bodies interspersed with organic laminae in thin section. Suspecting that these structures might be microfossils, we collected additional samples of dark gray argillite from near Davis Square, Somerville, and well-stratified argillite, with light and dark gray layers and laminae, from beneath the intersection of Massachusetts Avenue and Lancaster Street, Cambridge. All samples contained organic matter; however the latter locality yielded the best preserved microfossils.

Cleaned and crushed 30-g samples were macerated in hydrofluoric acid which caused the release of organic matter associated with the opaque structures that resembled those noted in thin section. Upon treatment with warm, concentrated nitric acid, the opaque structures appeared as a suite of three-dimensionally preserved microfossils and amorphous organic matter. This result suggested that pyrite was the agent of preservation. Organic residues were mounted in glycerin jelly and studied with transmitted light microscopy.

Three classes of organic structures are preserved: (i) solitary or clustered spheres, (ii) filaments, and (iii) spherical colonies (*Bavlinella* sp.). The microfossils are not fragmented or broken and do not show other evidence of having been reworked from a sediment. The walls of the microfossils are composed of coalified (black), granular organic matter.

Simple spherical cells are the most common microfossil, comprising 65 percent of the fossils found. Some cells are empty vesicles; others contain an internal granular body of organic matter, roughly spherical in outline, which is either dense and homogeneous or hollow (Fig. 1a). Maximum diameters of cells range from 4.0 to 14.0 μm. A histogram of cell size is unimodal, leptokurtic, and slightly skewed to the right (Fig. 2); the size frequency distribution is similar to that of extant unialgal cultures (*5*) and suggests that the fossils are derived from a single biological population. Spherical cells are occasionally clustered in linear or globular groups of two to eight or more cells (Fig. 1b). In many clusters the outer walls of the individual spheres are fused; however, internal bodies, where

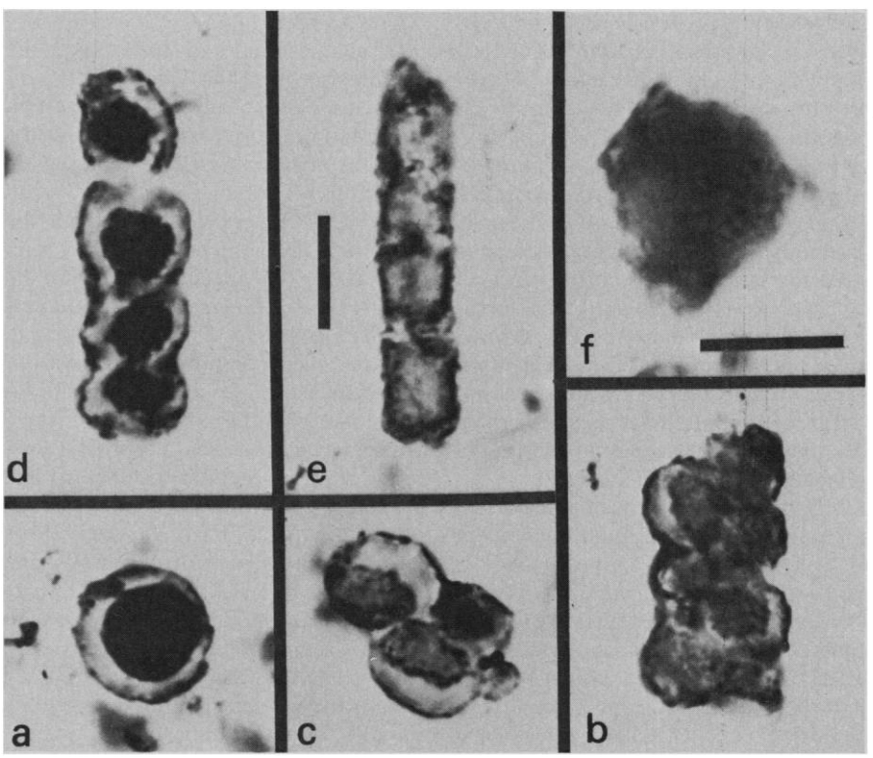

Fig. 1. (a) Spherical cell with internal structure of organic material. (b) Cluster of cells with internal granular structures. (c) Cluster of cells with internal granular structures and small budlike cell. (d) Filament of spherical cells with internal structures. (e) Cylindrical tube with crosswalls. (f) *Bavlinella* cf. *faveolata*. Scale bar in (e), which applies to (a) through (e), represents 10 μm; bar in (f) also represents 10 μm.

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present, are discrete entities. The sizes of cells in a cluster vary, and the smaller cells often look like buds (Fig. 1c).

Several filamentous morphologies occur in the population, including cylindrical tubes without crosswalls, chains of cylindrical cells with crosswalls, and chains of both cylindrical and spherical cells (Fig. 1, d and e). Filaments often contain condensed bodies similar to those found in spheres. The occurrence of both cylindrical and spherical cells in the same filament suggests that final cell shape may be in part the result of diagenesis and that differences in morphology do not necessarily connote different taxa. Lengths of filaments range from 11.0 to 27.5 μm. Cylindrical paired cells are the most common filaments; however, there are filaments with as many as six cells.

The most significant observation is the presence in the assemblage of *Bavlinella* (Shepleva) Vidal (Fig. 1f), a presumed colonial cyanophyte. These microfossils account for 20 percent of the fossils found. *Bavlinella* has spherical cells (spherulae), which are 0.2 to 1.0 μm in diameter and are packed uniformly and densely throughout the colony. Maximum diameters of the colonies range from 5.0 to 15.0 μm, averaging 8.5 μm (N = 103). Our specimens are smaller than *B. faveolata*, as described by Shepleva (*6*) and Vidal (*7*); however, they are the same size as *Sphaerocongregus variabilis* Moorman (*8*), which Vidal (*7*) synonymized with *B. faveolata*. Therefore, the designation *Bavlinella* cf. *faveolata* is appropriate.

All fossils are preserved as petrifactions in pyrite but without the complete replacement of organic matter. The cells apparently acted as nucleating sites for pyrite formation. Pyrite crystals formed during diagenesis encased the organisms, but cellular morphology and some organic matter are preserved. This form of microfossil preservation has apparently not been reported for palynomorphs, with the possible exception of those described by Tynni and Siivola (*9*).

Bavlinella faveolata has an age distribution from Late Riphean to Early Cambrian; however, it is most abundant in middle to upper Vendian deposits (*7, 10*). Shepleva (*6*) described the fossil from argillites in the Bavlinskaya Series of the Volga-Ural oil province. *Bavlinella* has since been isolated from a variety of lithologies, in particular, tillites and shales from Vendian glacial deposits, including the Tillite Group, eastern Greenland (*11*); the Biri-shale, Upper Proterozoic Hedmark Group, southern Norway (*12*); the Mineral Fork Tillite, Utah (*13*); and the Gotia Group, Svalbard (*14*).

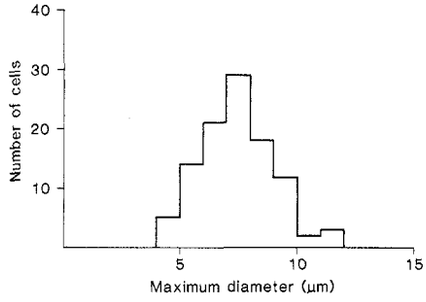

Fig. 2. Size frequency distribution of spheroidal cells (N = 104, $\bar{X}$ = 7.2 μm).

Because of the nature of the preservation, in which form but not fine detail is retained, generic designations of the microfossils other than *Bavlinella* are not appropriate, but microfossils resembling our assemblage have been noted in upper Precambrian palynofloras. Konzalova (*15*) described a microflora from the upper Precambrian of Bohemia which contained "spherical bodies" ranging from 7 to 11 μm in diameter. Some of her illustrations [plate II, No. 7, in (*15*)] show clusters of spherical cells with granular walls similar to clusters from the Cambridge Argillite. Moorman (*8*) isolated microfossils from the Hector Formation, Alberta, which included *Bavlinella* as well as spherical cells and clusters which resemble palynomorphs in the Cambridge Argillite.

In composition and appearance the microfossils from the Cambridge Argillite are similar to the Biri-shale assemblage described by Manum (*12*). All the forms he described from shaly facies are present in our samples. He reported linear rows of spherical cells but not the cylindrical filaments present in our samples. Also, the specimens Manum labeled "type A" (*Bavlinella faveolata*), which ranged from 15 to 24 μm in diameter, are larger than our *B.* cf. *faveolata*.

Manum placed his microfossils in different morphotypes, rather than taxonomic categories. His "type B" conforms in all respects to the spheres and clusters we found in the Cambridge Argillite. Thus, color, size, structure of the internal bodies, granularity of walls, and the budlike cells of some clusters are indistinguishable in the two assemblages. Manum reported microfossils from conglomeratic facies at Moelv which are not present in our argillite samples. Whether the coeval Roxbury Conglomerate contains similar microfossils is not known.

A Vendian age for the Cambridge Argillite is suggested by the presence of *Bavlinella* and the overall similarity of our microfossil assemblage to other latest Proterozoic assemblages. The absence of diagnostic Early Cambrian acritarchs, in a sediment which contains well-preserved *Bavlinella*, supports this conclusion. In addition to resolving a local dating problem, the establishment of a Vendian age for the Boston Basin opens up the possibility of new interpretations for large-scale regional correlations. For example, the correlation of the Boston Basin with strata of the Avalon Peninsula of southeastern Newfoundland and the Caledonides of southern Norway may now be possible.

CECILIA LENK
PAUL K. STROTHER
Paleobotanical Laboratories,
Harvard University,
Cambridge, Massachusetts 02138
CLIFFORD A. KAYE
U.S. Geological Survey,
Boston, Massachusetts 02114
ELSO S. BARGHOORN
Paleobotanical Laboratories,
Harvard University

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