

A GUNFLINT-TYPE MICROBIOTA FROM THE DUCK CREEK DOLOMITE, WESTERN AUSTRALIA

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Abstract. Two billion year old black chert lenses from the Duck Creek formation, northwestern Western Australia, contain abundant organically preserved microorganisms which are morphologically similar to fossils of approximately the same age from the Gunflint formation, Ontario. Entities include: a relatively small (5–15 μm) coccoid taxon morphologically comparable to *Huroniospora* Barghoorn, a larger coccoid form comparable to an apparently planktonic alga from the Gunflint, *Gunflintia* Barghoorn, and *Eoastrion* Barghoorn (*Metallogenium* Perfil'ev). Gunflint-type assemblages had a wide geographic distribution in middle Precambrian times, and these assemblages may eventually prove useful as biostratigraphic indices.

1. Introduction

The extent to which a fossil assemblage is representative of the evolutionary level of its time is a problem which continually confronts paleontologists, particularly those who study the record of Precambrian life. Not long ago, the microfossil assemblage found in stromatolitic cherts of the Gunflint formation near Schreiber, Ontario, provided the sole basis for interpreting the biological world of 2000 m.y. ago (Barghoorn and Tyler, 1965; Cloud, 1965). In broad terms, the Gunflint flora seemed to represent a reasonable evolutionary intermediate level between the simple organic spheres of the 3200 m.y. old Swaziland System (Schopf and Barghoorn, 1967) and the essentially modern algae of the 900 m.y. old Bitter Springs formation (Barghoorn and Schopf, 1965; Schopf, 1968; Schopf and Blacic, 1971); however, the discovery of modern blue-green algal taxa in other formations which are as old as (Hofmann, 1976; Golubic and Hofmann, 1976) or even older than (Nagy, 1974) the Gunflint chert has given cause for reconsideration of the first described diverse Precambrian biota.

Fortunately, we now have additional information on the distribution of Gunflint-type organisms in the form of two fossil assemblages from Australia: an oncolitic flora from the Nabberu Basin (Walter *et al.*, 1976) and the new assemblage reported here from the Duck Creek dolomite of northwestern Australia.

2. Geological Setting

The Middle Precambrian sedimentary accumulation of the Hamersley Basin lies in the northwestern corner of Western Australia, cropping out over a wide area roughly centered about the town of Wittenoom (Figure 1). Its geological history, as recorded in the rocks of the Mt. Bruce Supergroup (Figure 2), has been well summarized by MacLeod (1966). Briefly, some 2190 ± 100 m.y. ago (Compston and Arriens, 1968), a zone of crustal downwarping developed between the Archean Pilbara and Yilgarn cratonic blocks. The Fortescue Group (which forms the base of the Mt. Bruce sequence) is characterized by rapid vertical and horizontal facies changes and extensive evidence of volcanic activity, indicating instability in this zone of subsidence. As the basin gradually became tectonically quiescent, as well as somewhat restricted, chemical sedimentation greatly increased in importance, culminating in the deposition of the vast banded iron and shale formations of the Hamersley Group. In time, rapid subsidence was renewed, leading to the development of a true geosyncline in which accumulated the thick and lithologically varied sediments of the Wyloo Group. Wyloo sedimentation was terminated by regional orogenesis which tilted and folded, but in many places did not significantly metamorphose, the Mt. Bruce sequence.

Among the units of the Wyloo Group is the Duck Creek dolomite. In the vicinity of our fossiliferous outcrop (24 km east of Mt. Stuart Station, 3 km south of the Duck Creek Station road), the formation has a measured minimum thickness of 1100 m and consists throughout of thin-bedded to massive dolomite, often silicified or marked by thin chert lenses or beds (Daniels, 1970). Although the formation is frequently abundantly stromatolitic (Walter, 1972), all microfossils thus far discovered come from chert lenses within a conspicuously flat-bedded carbonate member. In outcrop this chert ranges in color from black to red, reflecting the localized preservation or oxidation of organic matter. As is the case for other fossiliferous Precambrian formations (e.g., Barghoorn and Tyler, 1965; Schopf, 1968), it is only in the jet-colored microcrystalline silica that the organically preserved algae and bacteria occur.

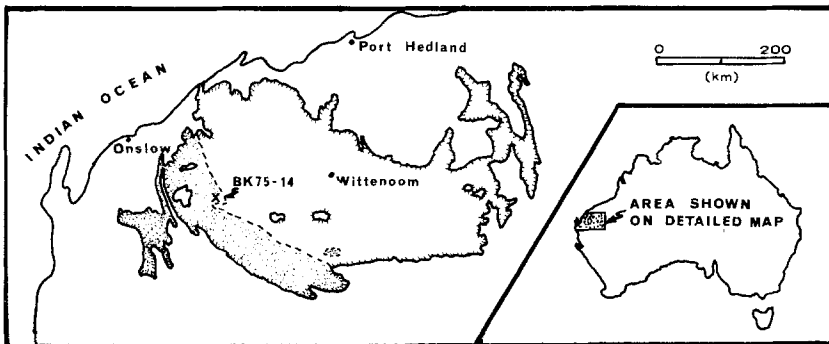


Fig. 1. Location Map of the Duck Creek Microbiota: Outcrop area of the Mt. Bruce Supergroup is defined by the black boundary line. The extent of the Wyloo Group is shown by stippling. 'X' marks fossiliferous outcrop (Locality BK75-14).

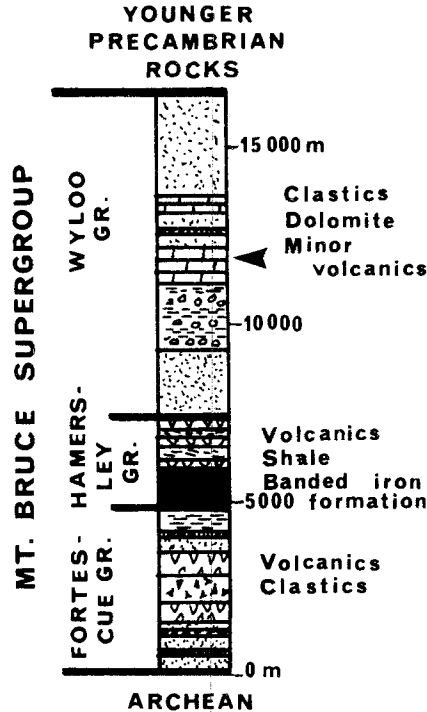


Fig. 2. Generalized stratigraphic column of the Mt. Bruce Supergroup (after Trendall, 1973). Arrow points to the stratigraphic level of the preserved microfossils.

From geological considerations, one can infer that the Duck Creek organisms lived in a shallow marine environment, below the zone of wave action. Analogy with modern environments suggests that the presence of dolomite may indicate some degree of basin restriction. The intercalated chert beds corroborate this inference because, in the absence of organisms such as diatoms, radiolaria, and sponges (which keep dissolved silica concentrations in the modern oceans well below saturation levels (Siever, 1957)), opaline silica may well have been a normal early precipitate from evaporitic seas (Siever, 1977). It should be noted, however, that in Duck Creek times, prior to the evolution of shell forming organisms, the oceans must constantly have been saturated (or supersaturated) with respect to both dissolved silica and dissolved carbonate. Under such conditions, very little basin restriction might be necessary to initiate precipitation.

Walter (1972) has compiled all the isotopic geochronometric data relevant to establishing an age for the Duck Creek fossils, and from this data it seems apparent that the microorganisms are approximately 2000 m.y. old. Particularly important is a Rb-Sr whole rock determination on layered igneous rocks interbedded with Wyloo sediments which yielded an age of 2020 ± 165 m.y. (Compston and Arriens, 1968). The significance of this is that it shows the Duck Creek dolomite to be approximately contemporaneous with the fossiliferous Gunflint formation of Ontario.

3. Microbiota

The microbiota of the Duck Creek formation consists of bacteria and algae which are morphologically comparable to taxa which are well-known from the Gunflint formation of Canada. Like the Gunflint sediments, the Duck Creek cherts are profusely fossiliferous, although in the latter formation, preservation is not as good as in the former. Two entities are co-dominant in the non-stromatolitic Duck Creek cherts – a small (5–15 μm) coccoid form (Figure 3-3,4,7,8) comparable to *Huroniospora* Barghoorn (Barghoorn and Tyler, 1965) and a budding bacterium referable to the genus *Eoastrion* Barghoorn (Barghoorn and Tyler, 1965). This assemblage is specifically similar to the Frustration Bay* flora of the Gunflint (Figure 4), a fossil community of bottom-dwelling microbes which lived in the stagnant muds in the

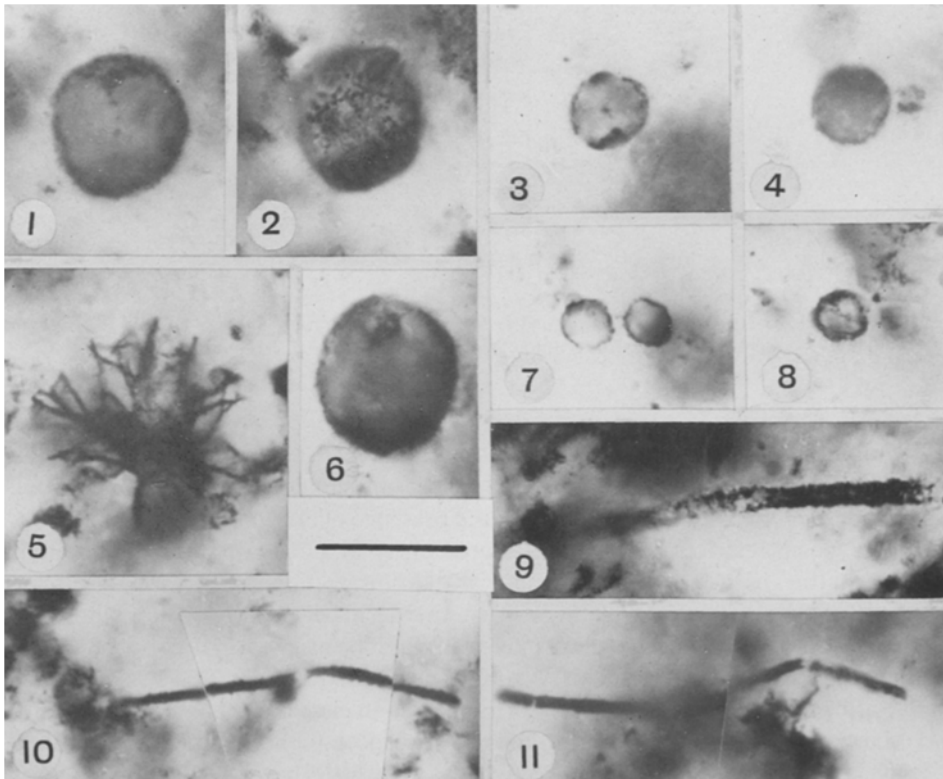


Fig. 3. Duck Creek microfossils (Bar = 20 μm): 1,2,6. Large coccoid algae. 1 and 2 show the same specimen in section and surface views. 3,4,7,8. Small coccoid algae, morphologically comparable to *Huroniospora* Barghoorn. 5. *Eoastrion* Barghoorn. 9–11. *Gunflintia* Barghoorn.

* In 1964, one of us (E.S.B.) and J. W. Schopf experienced great difficulty in finding an outcrop of the upper Gunflint chert-carbonate facies which was known to exist near the northern-most tip of Thunder Bay (Lake Superior). When the elusive locality was found, it was appropriately dubbed 'Frustration Bay', and this name seems to be as good as any for differentiating the microbiota of this facies from that of the basal algal chert facies exposed at Schreiber, Ontario.

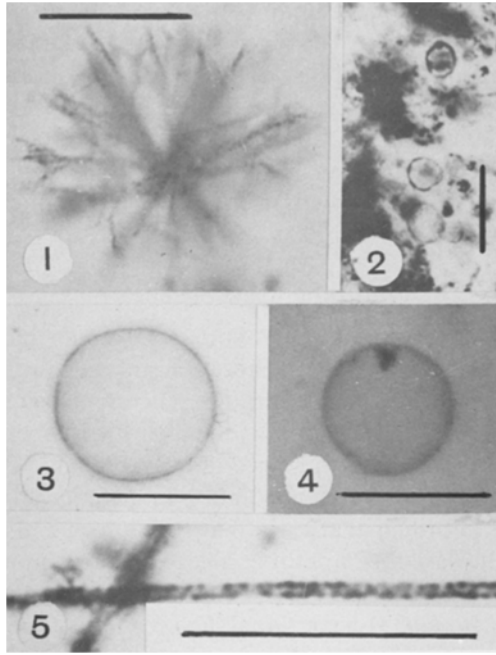


Fig. 4. Gunflint taxa which are morphologically comparable to Duck Creek fossils (Bar = 20 μm in each case): 1. *Eoastrion* Barghoorn. 2. *Huroniospora* Barghoorn. 3,4. Unnamed, apparently planktonic, algae. 5. *Gunflintia* Barghoorn.

deeper portions of the restricted Gunflint basin (Barghoorn *et al.*, 1976). A large (up to 31 μm in diameter), apparently planktonic coccoid alga occurring sporadically in the Frustration Bay facies (Knoll *et al.*, 1977) is also recognizable in the Duck Creek material (Figure 3-1,2,6).

A further association between the assemblages can be found in the relatively large size of the budding bacteria occurring in each. In both the Frustration Bay and the Duck Creek cherts, the rosette-shaped bacteria have diameters which often exceed 20 μm and may reach 40 μm or more. In contrast, both the originally described *Eoastrion* specimens from the shallow water algal facies of the Gunflint and the accepted living counterparts of these bacteria, the genus *Metallogenium* (Perfil'ev and Gabe, 1969), have smaller diameters (Kline, 1976).

The major difference between the two floras under discussion lies in the relative abundance of filamentous algae. These filaments, referable to the genus *Gunflintia* Barghoorn (Barghoorn and Tyler, 1965), are virtually absent in the Frustration Bay assemblage, but are fairly common, comprising up to 5% of the flora, in the Australian biota (Figure 3-9,11). The random orientation and the generally short length of preserved *Gunflintia* filaments suggests that they did not live in this community, but were deposited allochthonously, following transportation over an unknown distance.

As suggested in the introduction to this paper, the primary importance of the Duck Creek flora lies in what it reveals about the Gunflint assemblage. It

demonstrates that although the Gunflint microbiota may have been ecologically specialized, it nevertheless occurred in widely separated geographical localities during middle Precambrian times, an observation that is corroborated by the work of Walter *et al.* (1976) on a Gunflint-type assemblage found in rocks of similar age from the Nabby Basin of Western Australia. Although three occurrences are too few to justify the drawing of firm conclusions, they do suggest that assemblages of the type first discovered in various facies of the Gunflint formation may have been common in environments of 2000 m.y. ago.

4. Stratigraphic Significance

The occurrence of several coeval microfloras of similar biological constitution inevitably leads to considerations of Precambrian biostratigraphy. Stromatolite morphology has proven useful in the stratigraphic subdivision and correlation of Middle and Late Proterozoic (Riphean) sediments (Raaben, 1969; Cloud and Semikhatov, 1969; Walter, 1972), and since time-correlatable changes in these sedimentary structures imply concomitant evolution in the microbial assemblages which built them, it is likely, in principal at least, that Precambrian microorganisms should be biostratigraphically useful. Planktonic algae are of demonstrated value in the correlation of latest Precambrian rocks (Timofeev, 1959; Navmova, 1961; Downie, 1967), and Schopf *et al.* (1973) have noted *Eomycetopsis*-type filaments in several probably contemporaneous late Precambrian cherts; however, the relative paucity of older Proterozoic microorganisms has generally made possible correlative utility untestable.

Considerations of the Duck Creek, Gunflint, and Nabby floras suggest two points:

(1) The biostratigraphic utility of individual taxa is dubious. As an illustration of this, the *Metallogenium-Eoastrion* bacterium has been found not only in 2000 m.y. old rocks, but also in 1650 m.y. old cherts (Kline, 1975), 100 m.y. old chert pods (Plaza, 1975), and, of course, in modern lake sediments (Perfil'ev and Gabe, 1969). The coccoid and filamentous forms which these floras have in common are also sufficiently general in structure to have morphologically comparable counterparts in younger strata.

(2) Considered as assemblages, however, these biotas may well be representative of a particular period in time. If Precambrian biostratigraphy is ultimately to prove practicable, it is likely that it will depend on assemblage associations and not individual taxa.

Comparison of the aforementioned floras with that of the coeval Belcher Group, Canada, (Hofmann, 1976) adds complexity to the situation. Although the Belcher fossils are approximately the same age as the Gunflint biota, their biological affinities lie much closer to the 900 m.y. old Bitter Springs flora (Schopf, 1968; Schopf and Blacic, 1971) – not to mention extant mat communities of the Persian Gulf and Shark Bay, Australia (Golubic and Hofmann, 1976). These facts clearly demonstrate the limits of any biostratigraphic scheme. In spite of obvious difficulties, however, the discovery of the Duck Creek microbiota does lend further support to the recently expressed optimistic views (Schopf, 1975; Awramik and Barghoorn, 1976) of the ultimate future of Precambrian microfossil biostratigraphy.

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