A NEW ALGA FROM THE CARBONIFEROUS FROSTERLEY MARBLE OF NORTHERN ENGLAND

by GRAHAM F. ELLIOTT

ABSTRACT. A new alga from the Frosterley Marble (Namurian; Carboniferous) of northern England is reconstructed from fragmentary material. It is compared with the Carboniferous genera *Kulikia* and *Sphinctoporella*, sharing with them the distinctive profusion of spherical cavities within the calcified axial surround or 'sleeve'. It differs from them in being formed of successional separate calcified discs or verticil units, which came apart after death, and is thus described as *Frosterleyella diaspora* gen. et sp. nov.

FROSTERLEY Marble was much worked in medieval and later times. The word 'marble', as with the better-known Purbeck Marble, is used in the popular and trade sense, not scientifically. It is in fact a hard limestone taking a good polish, in which the light-grey fossils, largely corals, stand out in section against the dark background to give an attractive pattern. Geologically it comes from the uppermost of three fossiliferous bands in the local Great Limestone of Namurian (Carboniferous) age in the northern Pennines of northern England (Johnson 1958). Mills and Hull (1976, p. 31) suggest from the lithology and from the mode of occurrence of the corals in the rock, that original deposition of the sediment was probably under the influence of strong currents or waves.

This is confirmed by thin-section study of the rock, which, where detail is not destroyed by diagenesis, shows a profusion of ill-sorted organic debris and microfossils. Debris of echinoderms (mostly crinoids), Bryozoa, brachiopod test and spines, and whole small foraminiferidids are common, and the original calcite is moderately well preserved. Less common are fragmentary remains of an obvious dasyclad alga, frequently seen as rings with smooth inner surface and very ragged exterior. The presumed original organic aragonite of the living plant has been converted to white calcite usually with near-complete obliteration of fine organic detail. The present study was made to see how much could be reconstructed from the unpromising abraded and diageneticized remains. Other algae are rare; noted were ?*Nanopora* (Wood 1964), the problematic *Hypocaustella* (Elliott 1980), and *Aphralysia* which was described as an alga, but later interpreted as a foraminiferidid (Garwood 1914; Belka 1981).

DESCRIPTION

Examination of the dasyclad rings reveals that those examples showing most of the calcite around the inner axial cavity, i.e. those less worn and not too ill-preserved, show the calcite to be full of close-set spherical cavities. Dimensions vary in random cut, but have been seen up to 73 μm in diameter, possibly the original maximum size. They correspond in appearance to 'sporangia' or reproductive cavities seen in other dasyclads. No traces of connecting branches between them are to be seen. Along one random radius, from axial cavity to outer worn edge, there is space for three cavities and also the serrated, broken-away edge of a fourth, so permitting a diameter to be postulated. It is such broken spheres, forming the outer edge of abraded rings, which give these their characteristic ragged appearance. The axial diameter can be measured; if a d/D ratio of 25–33% is postulated, this would give an estimated outer diameter of 1.1–1.5 mm. No vertical sections of dasyclad calcareous tube ('sleeve') have been observed, but two vertical sections of single rings indicate the plant to have been built up in life from consecutive discs or whorls which came apart after death, as is known in certain other dasyclads. Each disc (whorl, verticil) had a central axial cavity, keg-shaped, with maximum diameter equatorially, narrowing a little above and below. Numerous random oblique sections confirm this

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when the plane of section traverses above or below the aperture. Two specimens suggest that in life a very thin calcification may have joined the consecutive discs at the axial cavity surface.

The combined evidence suggests a plant built up of numerous successive calcareous whorls, each circular in outline, flattish, biconvex, and externally rounded, giving a deeply incised outline to the whole plant, somewhat like that of *Queenslandella* (Mamet and Roux 1983). The calcareous skeleton of the Frosterley alga contains numerous adjacent spherical cavities; the branch system connecting them is not known.

CLASSIFICATION

The key character in seeking to classify the Frosterley alga is the multitude of spherical cavities within the calcified discs. Two known Carboniferous genera show this: *Kulikia* (Golubtsov 1961) and *Sphinctoporella* (Mamet and Rudloff 1972). In the case of *Kulikia*, the author figured a selection of thin-section specimens, but managed to emphasize the spherical nature of the whorls at the expense of the continuous axial cavity, although several of his figures show this latter feature clearly. This led to the confusion of later authors. Mamet and Rudloff (1972) and Mamet and Roux (1975) in describing *Sphinctoporella*, and in describing a new species in a queried allocation to this genus, did not compare it with *Kulikia*. Not until later (Mamet *et al.* 1981) was this comparison made.

Skompski (1984) published an account of *Kulikia* from new, magnificently preserved pyritic material in Poland. He was able to develop both solid, detached, three-dimensional specimens and very clear thin-sections, better than any before. In particular, he described the branch system of *Kulikia*, not clearly preserved in the previous limestone matrices. He showed that the spherical cavities are occasioned by two kinds of branches, which he called active and passive. Active branches divide and produce many connected spheres, which he suggests are the assimilatory branches. Passive branches are single spheres or ovoids, immediately outside the axial cavity, which he suggests were reproductive in function. He re-defined *Kulikia*, transferring the queried species *rozovskaiae* from *Sphinctoporella* to *Kulikia*, because it has similar branch structures to the type-species *K. sphaerica*. The new generic diagnosis is in one respect a little restrictive; it includes tetragonal axial symmetry as a character. But, from the nature of dasyclad branching, polygonal axial symmetry is also likely to occur in other species if found. However, this is a minor point. Now that the *Kulikia* branch system is known, with important significance for our knowledge of dasyclad reproductive evolution, as Skompski emphasizes, how should *Sphinctoporella* be regarded? *Kulikia* and *Sphinctoporella* seem closely related; would the latter, known only in normal limestone preservation, show *Kulikia*-type branching if found better preserved?

There is here more than one taxonomic possibility. *Sphinctoporella* spp. could be transferred to *Kulikia*, assuming that they will be found eventually to have *Kulikia*-type branching. However, this is a character of more than generic importance, and it seems right to leave *Sphinctoporella* as a valid genus, for probable eventual 'tribal' grouping with *Kulikia*. It is against this background that the Frosterley alga must be considered. It is the worst preserved of them all, but shows the distinctive numerous calcified spheres of the other two. In one sense its separate whorl units are the final stage of the incised outline of *Sphinctoporella*, but this development occurs also in other dasyclad lineages.

I therefore describe it below as a new genus and species, clearly related to *Kulikia* and *Sphinctoporella*, and I hope that the incompleteness of our knowledge will be rectified in the future.

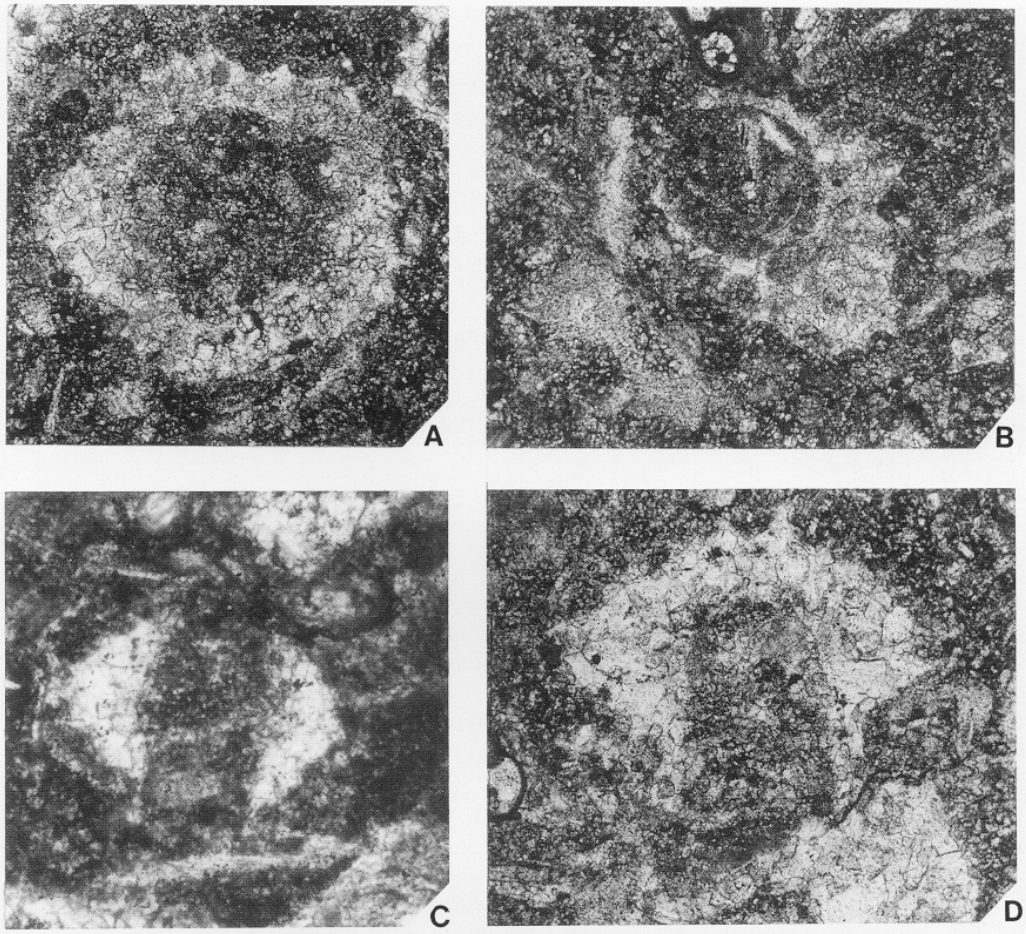
SYSTEMATIC PALAEONTOLOGY

Frosterleyella gen. nov.

Type species. Frosterleyella diaspora sp. nov. Carboniferous (Namurian) of northern England.

Derivation of name. After the type-locality of Frosterley, Weardale, County Durham, England.

Diagnosis. Calcified successional dasyclad verticil discs, biconvex in vertical section and circular in



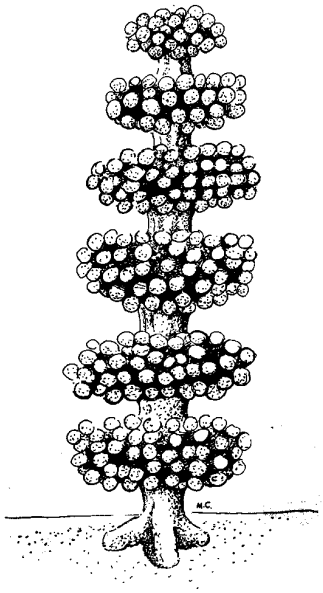
TEXT-FIG. 1. *Frosterleyella diaspora* gen. et sp. nov. Thin-sections of abraded examples from the Frosterley Marble (Namurian); Shittlehope Quarry, between Stanhope and Frosterley, Weardale, County Durham, England. British Museum (Natural History), Dept. Palaeontology, registered nos. V.62755*a* (A, B), V.62755*g* (C), V.62755*n* (D), all ×60. A, equatorial transverse section of uniformly worn example; biological detail poor but partly recognizable. B, transverse section showing central (inner periaxial) calcification, with incomplete area of 'sleeve' wall-calcite to right, showing clearly numerous spherical cavities. C, vertical section of single, small, much worn example, all biological detail destroyed by diagenetic calcification. D, oblique section, poorly preserved, but showing traces of cavities (ragged exterior, and interior of calcite), and possible thin 'below verticil' periaxial calcification.

outline, each with central keg-shaped axial cavity. Calcification full of spherical cavities, believed to be similarly organized to those of *Kulikia*.

Frosterleyella diaspora sp. nov.

Text-fig. 1A–D

Derivation of name. Diaspora or dispersal, a reference to the scattered occurrence of the broken fossil remains.



TEXT-FIG. 2. Reconstruction of living *Frosterleyella*, gen. nov. Basal regions conjectural, × 17 approx.

Syntypes. The specimens shown in text-fig. 1A–D. British Museum (Natural History), Department of Palaeontology, registered numbers V.62755*a*, *g*, *n*.

Horizon and Locality. Frosterley Band, in Great Limestone Formation (Namurian), Shittlehope Quarry, between Stanhope and Frosterley, Weardale, County Durham, England.

Diagnosis. As for genus; thickness of verticil discs up to 0·5 mm., estimated external diameter 1·1–1·5 mm.; diameter of axial cavity up to 0·366 mm.; diameter of spherical cavities up to 0·073 mm.

Other material. Numerous examples in thin-sections, registered nos. V.62755*a–z* inclusive.

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G. F. ELLIOTT
Department of Palaeontology
British Museum (Natural History)
Cromwell Road, London SW7 5BD

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Note added in proof: After submission and revision of this paper I learned of Dr S. Skompski's description of a poorly preserved dasyclad as Diploporeae gen. indet. Some random sections of his Form A of this Polish material appear very similar if not identical to those of *Frosterleyella*. There are slight differences in the features seen and in our interpretations, but we agree on general structure and on a close relationship to *Kulikia*.

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