# CORRESPONDENCE

## THE GRAPTOLITIC MUDSTONES OF THE HOWGILL FELLS

SIR,—The Wenlockian and Ludlovian lithologies described by Dr. Rickards (1964) resemble those recognized in the south-eastern part of the Lake District.[1]

Dr. Rickards describes the Wenlockian rocks of the Howgill Fells as graptolitic mudstones. The Brathay Flags (Wenlockian) of the Lake District are similar, but may be more precisely defined as graptolitic, argillaceous siltstones. Their most characteristic feature is the abundance of compressed faecal pellets at all levels throughout the formation. These pellets appear as discoidal lenticules of silt, up to 1·0 mm. long and up to 0·5 mm. thick, densely packed in an argillaceous silt matrix and oriented to exhibit a faint parallel lamination. This lamination is accentuated by innumerable, irregular, carbonaceous, and pyritic films which are often closely grouped into blackish bands ; by very thin streaks of less pelleted silt ; and probably by a high degree of compaction.

Pelleting was first mentioned in connection with some Silurian mudstones in Wales and the Lake District by Jones (1954). It was later described in detail by Cummins (1959) from the Nantglyn Flags of Wales and by the present writer from the Wenlockian and Ludlovian of the Lake District. Soft, easily compacted faecal pellets are commonly produced by benthonic organisms in quiet water, neritic environments below wave base. In the case of the Brathay Flags it is envisaged that the abundant faecal pellets were probably produced by a soft-bodied benthonic fauna of which no skeletal traces remain. Dr. Rickards (p. 440) says, " It is clear that when bottom-working organisms [such as soft-bodied worms] are able to exist they obliterate, not cause, the carbonaceous banding. " There seems to be no reason at all to suppose that an extensively churned and pelleted sediment should not be subsequently burrowed by worms, with consequent destruction of pre-existing structures (as shown by his Pl. XVI). The existence of prior pelleting can still be accepted.

Dr. Rickards attributes the formation of these " graptolitic mudstones " to deposition " in what was clearly an anaerobic environment, devoid of benthonic life and preserving only those planktonic or pseudo-planktonic forms which sank into it ". The indications quoted of the existence of a flourishing benthonic fauna do not entirely support this conclusion.

Moore and Scruton (1957) showed that the degree of reworking of a sediment can be related to sedimentation rates and that when a certain critical rate is exceeded benthonic faunal activity is inhibited or even prohibited. The present writer would suggest that the more or less homogeneous shales and argillaceous siltstones of the Lower Ludlovian Bannisdale Slates (Rickards, 1964, p. 444–5—" Banded Unit Facies "), although locally exhibiting some worm burrowing, are not pelleted or otherwise reworked for this reason. The following comparisons serve as an illustration.

The Brathay Flags, about 1,000 feet (300 m.) thick, represent the whole of the Wenlockian period. They are almost entirely reworked. The Lower Ludlovian alone totals possibly more than 10,000 feet (3,100 m.) in the south-eastern Lake District, indicating a far greater overall rate of sedimentation. Even discounting the high proportion of this Lower Ludlovian stratigraphic sequence which is made up of sublithic-sandstone turbidites, the remaining siltstones and shales form an aggregate thickness about three times that of the Brathay Flags. The appearance of pelleted, argillaceous siltstones at some lower levels in the Lower Ludlovian suggests relatively slow deposition, but

[1] LLEWELLYN, P. G. The Middle and Upper Silurian Rocks between Longsleddale and the Shap Granite, Westmoreland. Ph.D. Thesis, University of Cambridge, 1960.

their replacement upwards by undisturbed or slightly burrowed sediments is thought to point to an increasing rate of sedimentation inhibiting benthonic faunal activity. There is, therefore, no necessity to invoke a " destruction of carbonaceous banding " (Rickards, p. 445). Furthermore, if the origin of the carbonaceous and pyritic films is accepted as being due to the reduction and preservation of organic matter within the pelleted sediments, the lower percentage of free carbon recorded by Dr. Rickards (p. 445) in the homogeneous sediments may be accounted for by a " dilution " of any organic matter present by increased sedimentation. There need, therefore, be no " loss of carbon " (Rickards, p. 445) due to reworking of the sediment.

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P. G. LLEWELLYN.

HENRIETTE ROLAND HOLSTLAAN 53,
RIJSWIJK (Z.H.),
HOLLAND.
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## *VERTICILLOPORA* AND *PHRAGMOPORELLA*, DESCRIBED AS CALCAREOUS ALGAE, ARE CRINOID STEMS

The two genera *Verticillopora* and *Phragmoporella* were described by Rezak (1959) as members of a new Tribe of Palaeozoic Dasycladaceae. Recently, in the course of an investigation of Palaeozoic algae, specimens of *Verticillopora* have been borrowed from the United States National Museum through the good offices of Dr. G. A. Cooper. These have been studied in section and by serial grinding. Patchy development of beekite and dolomite obscured the micro-structure, but on a polished surface it was possible to observe interlocking zig-zag junctions between the segments which must be cross sections of radially disposed ribs and sockets. Such a structure could serve no purpose in algae ; the radial grooves seen on the ends of segments of Tertiary genera such as *Neomeris* and *Larvaria* lie directly above similar grooves in the segment beneath and each is actually half of the external mould of a sterile secondary branch.

This, together with the undoubted pentamerous symmetry of these fossils, seen in Rezak's plate 3, figure 3, and plate 4, figure 5, strongly suggests that they are portions of crinoid stems. Two European groups of Silurian crinoids, the Crotalocrinidae and the Polypeltidae, display the most striking features of these American fossils—the large central cavity and the radially arranged perforations in the stem. The species *Crotalocrinus verrucosus* Schlotheim, 1826, was founded because of the wart like excrescences on the stem, which leave circular holes in the ossicles at their broken bases. The family Polypeltidae (Ubaghs, 1956) includes the genus *Trybliocrinus* with a radially arranged vessel system in its stem. The specimen of this genus shown on plate viii, figure 12 of Breimer's monograph (1962) is quite closely similar to that illustrated by Rezak on his plate 4, figure 3.