

bility is much more likely to have been the principal controlling factor, as I discuss at some length in a recent article (Hallam, 1972).

As regards Reid's suggestion that a simple lowering of temperature away from the tropics was in itself unlikely to have been the most significant environmental control for the Mesozoic faunas, as has been widely assumed, I can only agree wholeheartedly. I am strongly in accord with his view that increased seasonal effects towards the poles, as in illumination and plankton productivity, are likely to have been far more potent in the comparatively equable Mesozoic climate. Attention ought perhaps to be drawn here to the somewhat similar views expressed by Valentin (1971), who argues for the importance of trophic resource stability as the prime factor controlling latitudinal faunal distributions even at the present day. Certainly it seems that the old simplistic notions of temperature control, which have hitherto dominated discussion of the topic of Mesozoic faunal provinces, must be abandoned in the light of modern ecological knowledge.

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A. HALLAM

Department of Geology and Mineralogy
University of Oxford
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On some highest Llandovery red beds and graptolite assemblages in Britain and Eire

SIR,—Graptolite assemblages strongly indicative of the *crenulata* Zone have recently been collected by the writer and others from two localities associated with highest Llandovery marine red beds. These are at Doon Rock, Kilbride Peninsular, Co. Mayo, Eire, and Hebblethwaite Hall Gill (SD 69109313), Howgill Fells, Northern England. On Swindale Beck in the Cross Fell inlier, Burgess, Rickards & Strachan (1970) established for the first time the age of the Llandovery red mudstones as belonging to the *crenulata* Zone, although elsewhere it had been shown that this formation is underlain by a *greistoniensis* assemblage and overlain by a *centrifugus* Zone assemblage (Rickards, 1967, 1970).

The Hebblethwaite Hall Gill locality has been recently exposed following the removal by gales of a large tree rooted on the red beds outcrop. Three cm of dark grey graptolitic mudstone (*sensu* Rickards, 1964) are exposed in the core of the anticline depicted by Rickards (1967, pl. 12) and are positioned approximately in the middle of the 12 m of red beds exposed on this section. The following fauna was obtained with some difficulty: *Monoclimacis* sp., *Monograptus ?marri* (Perner), *M. priodon* (Bronn) common, *M. sp. nov.* (Hutt species), *M. spiralis* (Geinitz), *M. tullbergi* Bouček, *M. ex gr. nodifer* Törnquist *sensu stricto*, *Petalograptus* sp. and retiolitid fragments (specimen nos. Sedgwick Museum A81980–81999). The red beds on this section are underlain by graptolitic mudstones yielding a *greistoniensis* assemblage and are overlain by slightly coarser mudstones with a rich *centrifugus* Zone (Wenlock) fauna. Some elements of this undoubted high Llandovery red beds fauna are not very diagnostic zonally, but the abundance of *M. priodon* in this position, and the general nature of the assemblage strongly suggests a *crenulata* Zone age, and indicates that the red beds are of the same

age as the Llandoverly red beds of Cross Fell. The lithologies of the red mudstones and associated rocks, and the sequence of rock types, is identical in both areas.

Figure 1 illustrates the stratigraphy of a part of the Doon Rock area of the Kilbride Peninsula. Some 18.5 m of red mudstones (Tonalee Formation) are poorly exposed south of the fell road and these are overlain by approximately 33 m of mostly fine-grained, greenish mudstones (Benbeg mudstone unit of Piper, 1972, p. 44) but including dark graptolitic mudstone between 28.6 and 30.0 m above the base. This thick unit (locality 2) has yielded the brachiopods *Orbiculoidea* sp. and *Pentlandella pentlandica* (Haswell) in addition to numerous well-preserved graptolites referable to the following species: *Retiolites geinitzianus geinitzianus* (Barrande), *Monoclimacis* cf. *linnarssoni* (Tullberg), *M. vomerina* cf. *vomerina* (Nicholson), *Monograptus priodon* (Bronn), *M.* aff. *nodifer* Törnquist, *M.* 'Spirograptus' sp. and 'Diversograptus' *inexpectatus* (Bouček & Přibyl) (Specimen nos. Sedgwick Museum A74942-75011). The last three species, particularly, suggest a Llandoverly age whilst '*D.* *inexpectatus*' is a *crenulata* Zone species in Czechoslovakia. The other species are in accord with this assignation, the absence of cyrtograptids in such a rich assemblage indicating Llandoverly rather than Wenlock rocks, and the presence of abundant *M. priodon* indicating very high Llandoverly.

Elsewhere the Tonalee Formation has been dated as C6, or *crenulata* Zone (e.g. Cocks *et al.* 1971, fig 8) and the Benbeg mudstone unit at the base of the Lettergesh Formation should also be placed here.

Stratigraphically above locality 2 are 3 m of fine-grained, greenish mudstone similar to the beds below the graptolitic horizon. Approximately 6.5 m of dolerite sill then intervenes between the Benbeg mudstone and the coarser, sandy greywacke of the succeeding

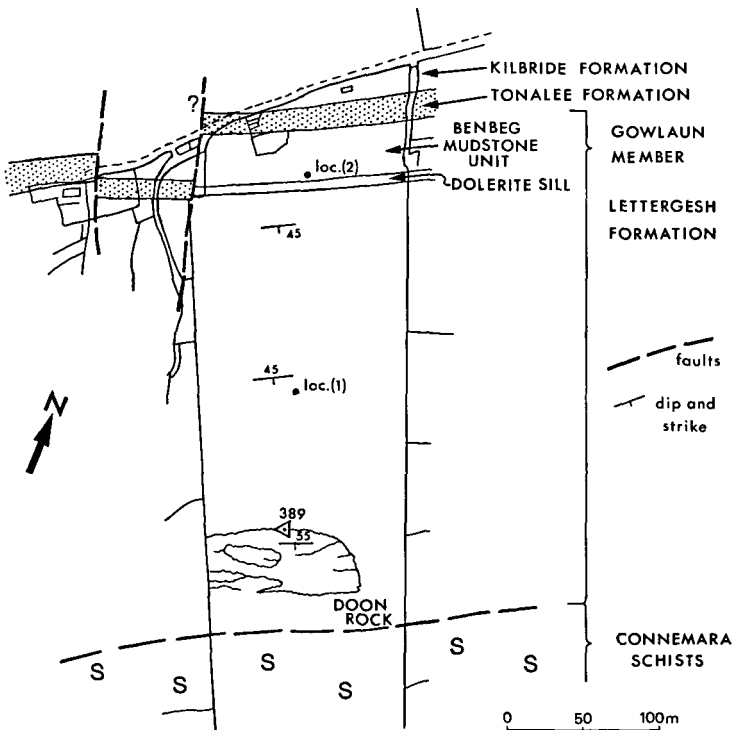


Figure 1. Geology in the region of Doon Rock, Co. Mayo, showing the graptolite localities mentioned in the text.

Gowlaun Member of the Lettergesh Formation (in terms of older usage: the Upper Owenduff Group). 115 m stratigraphically above the top of locality 2 are a few cm of graptolitic mudstone between coarser greywackes (locality 1, Fig 1) which yielded rare specimens of *Retiolites geinitzianus geinitzianus* (Barrande). The upper limit of this species in Britain is, so far as the writer is aware, about the top of the *centrifugus* Zone (Wenlock). Thus the lowest part of the Lettergesh Formation, above the Benbeg mudstone unit, is not older than upper *crenulata* Zone or younger than basal Wenlock. This broadly agrees with the observations of Rickards & Smyth (1968) who recorded a *murchisoni* Zone fauna from low in the Lettergesh Formation near Clonbur, although at that locality the base of the formation was not seen.

Thus the marine red beds of the Howgill Fells, Cross Fells, and Kilbride Peninsula are not only of similar thickness and lithology but are at least approximately the same age.

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Sedgwick Museum
Cambridge CB2 3EQ
20th October 1972

R. B. RICKARDS

From the Natural Environment Research Council

SIR, *Geochemical Maps*—The first of a series of geochemical maps at a scale of $\frac{1}{4}$ in. to 1 mile, based essentially on stream-sediment analyses, was placed on open file at Geochemical Division, 64–78 Gray's Inn Road, London WC1X 8NG, on the 11 September 1972. Copies are also available for consultation at the IGS offices in Edinburgh and Leeds. The map covers Sheet 6, Caithness (Central and Eastern) and part of Sheet 5, Sutherland and parts of Caithness, Ross and Cromarty, of the Geological Survey of Great Britain (Scotland) quarter inch geological map series. The area is also represented by Sheets 102, 103, 109, 110, 116 and the eastern part of Sheet 115 of the 1 in. to 1 mile geological maps of Scotland.

The geochemical data are unsmoothed and presented as proportional symbols at each sampling point, the minimum mean sample density being one sample per 2 km². The distribution of the following elements is shown: