

## CORRESPONDENCE AND NOTES

## Micropalaeontological evidence for the age of the Borrowdale Volcanic Group

SIRS – In a recent letter to the Geological Magazine, Dr N. J. Soper (1987) quoted me, stating that ‘new micropalaeontological evidence... suggests that most of the (Borrowdale) volcanic pile was erupted during Caradoc time’. The micropalaeontological evidence comprises acritarchs from sediments of the Borrowdale Volcanic Group in Holehouse Gill [SD 182 926]. A fuller discussion of the acritarchs and their position in the Borrowdale sequence is currently in preparation (with Dr E. W. Johnson), but in the meantime I would like to respond briefly to Dr Soper’s letter indicating precisely how I now interpret their age.

The acritarchs are poorly preserved and sparse but they occur in one third of the samples collected. Nearly twenty taxa have been recorded but most are either long-ranging species or are determined only at generic level. The Caradoc (as opposed to pre-Caradoc) age relied principally on the occurrence of one species, *Veryhachium irroratum* Loeblich & Tappan. In Britain, this species has been recorded only from the Caradoc (Turner, 1984). Outside Britain, most records are also from rocks which have been assigned a Caradoc or younger age. These include:

(1) Mountain Lake Member, Bromide Formation, Oklahoma, USA (including the type material, Loeblich & Tappan, 1969). According to Sweet & Bergström (1976), most of the member is of Caradoc age but a Llandeilo age cannot be discounted for the lowermost part; Ross *et al.* (1982), however, place the base of the member at a level which they correlate with the base of the Caradoc Series.

(2) Djeffara Formation, north-west Libya (Deunff & Massa, 1975).

(3) Quartzite Beds of the Diabase–Phyllite Group, Berkovitsa Anticline, Bulgaria (Kalvacheva, 1978).

(4) Subsurface, north-east Libya (Molyneux & Paris, 1985).

(5) Orphan Knoll, offshore Canada (Legault, 1982).

(6) Ouaougout Member, Lower Ktaoua Formation, Morocco (Deunff *in* Destombes, Hollard & Willefert, 1985, p. 197).

Two records are from rocks of pre-Caradoc age. It is difficult to comment on one of these, from the Šárka Formation (Llanvirn) of Bohemia (Vavrdová, 1976, 1977), because the material was neither figured nor described; it did, however, seem to me to be anomalously early, given the more extensive Caradoc records mentioned above and the views of other workers (Diez & Cramer, 1977; Cramer & Diez, 1979, p. 129) that the species appeared in the Caradoc. In my earlier assessment, I gave less weight to Vavrdová’s record than I perhaps should have done. Unfortunately, I had overlooked the second, apparently rare, occurrence in the Laval Formation of Quebec (Martin, 1983). This formation is assigned to the Chazy Group, which strongly suggests a pre-Caradoc age and strengthens the argument that *V. irroratum* first appears in pre-Caradoc rocks.

On stratigraphical evidence, the Borrowdale Volcanic Group has long been restricted to the Llandeilo–early Caradoc (see, for example, Wadge, 1978). Taking all the records listed above into account, the stratigraphical range of *V. irroratum* may span the whole of this interval. As there is no evidence to indicate that the species occurs in rocks of pre-Caradoc age in Britain, and since it occurs more

frequently in rocks of Caradoc or younger age worldwide, I still favour a Caradoc age for the acritarch assemblage from the Borrowdale Volcanic Group; but the evidence is not conclusive and a Llandeilo age cannot be discounted. I regret that I may have led Dr Soper to believe that the micropalaeontological evidence was stronger than it now appears.

Acritarchs have a widespread distribution in British Lower Palaeozoic rocks. Much of the work published until now has concentrated on the well preserved floras from the Welsh Borderland, but these microfossils also occur in Wales, the Lake District and the Southern Uplands of Scotland; in some cases, for example in parts of the Skiddaw Group in the Lake District, they are among the most commonly occurring and stratigraphically useful fossils. However, much remains to be done in both taxonomy and biostratigraphy so that sound biostratigraphical standards may be established. Future work needs to be directed towards these aspects as a matter of some urgency.

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