Letter to the Editors

METAMORPHIC LIMESTONES OF THE GREAT GLEN AREA: COMMENTS

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Sirs—Rock et al. (1984) highlighted the problems of assigning the limestones of the Great Glen to the Lewisian, Moinian or Dalradian but preferred to leave them unaffiliated. Following Drever (1936, 1939, 1940) we consider these limestones to belong to the Dalradian and propose that at least the Ardgour and Glen Dessarry limestones are the diachronous “missing links” between the Vendian Middle Dalradian basinal succession to the SE and the early Cambrian shelf succession to the NW (Fig. 1). We agree that the limestones do not correlate with the Lower Dalradian both on the geochemical grounds advanced by Rock et al. (1984) and also because of the general absence of authigenic K-feldspars in the Lower Dalradian, a mineral found in both the Ardgour and the Glen Dessarry limestones (Rock et al. 1984) as well as in the anhydrite-bearing dolomitic Fucoid Beds of early Cambrian age (Bowie et al. 1966; Allison and Russell 1985). Barrow (in Flett 1907) had mapped a calc-silicate horizon in the Middle Dalradian Deeside limestone that contains alkali feldspar. These Deeside rocks are favoured by Drever (1940) as being most comparable to the Ardgour limestones. Again in the Middle Dalradian, barium-rich K-feldspar has been found in the Loch Tay Limestone (Scott, pers. com. 1984) and we have found K-feldspar in the Shira Limestone.

The barium feldspar, celsian, is also present in extraordinary concentrations in the Middle Dalradian barite deposit near Aberfeldy (Coats et al. 1980). Hyalophane and celsian have also been found at the same horizon near Loch Lyon (Coats et al. 1984).

Orthoclase is rare as a primary sedimentary or authigenic chemical precipitate and forms where K⁺ competes successfully with H⁺ in the feldspar molecule nucleating from solution, a condition realized only in environments of high pH (~10?) and high K⁺ molality (>10⁻⁷?) (Garrels and Howard 1959). Authigenic mica does not require such extreme conditions. We have argued that the source of aluminium and sulphate in the Aberfeldy celsian-barite deposit was alkaline, saline, shelf water lying to the NW of the Great Glen in Middle Dalradian times (Russell et al. 1984, Russell and Allison 1985). Limestones deposited in such a shelf sea should contain authigenic feldspar and evidence of evaporitic conditions. The Ardgour limestones contain feldspars and the calcic scapolite mizzonite (Drever 1936). It may be argued that the mineralogy is unreliable given the proximity of

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the metagabbro but against this we point out that (1) limestone is too reactive to allow diffusion of alkalis beyond its margins, i.e. it behaves as a chemically closed system; (2) a gabbro is not likely to emit alkalis; and (3) feldspar and mica are stable within the same hand specimen of limestone. We predict a high sulphate content of the scapolite.

We have identified the source of the alkaline ground waters as being the result of late Proterozoic/earliest Palaeozoic chemical weathering of the Lewisian to the palaeosaprolite agalmatolite in the Durness area (Russell and Allison 1985). Similar palaeosaprolites, comprising illite, pyrophyllite and residual quartz would have developed elsewhere on the Lewisian and on the Moine in the NW. Erosion and transport of these weathering products towards the SE, as well as the ‘in situ’ regoliths, provided the alumina-rich materials which now appear as highly metamorphosed, micaceous, alumina-rich rocks such as the sillimanite pelites alluded to by Rock et al. (1984).

Agalmatolite developed on the Moines would have provided a locus for decollement so adding to the difficulties of drawing a stratigraphic boundary between Moinian and Dalradian successions.
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References


DREVER, H. I. 1936. Symplectite-bearing nodules in the Ardgour Marble, Argyllshire. Geol. Mag. 73, 448-68.


— 1940. The geology of Ardgour, Argyllshire. Trans. R. Soc. Edinb. 60, 141-70.


SCOTT, R. 1984. Written communication. Department of Geology, University of Manchester.

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SIRS—We welcome the speculations by Russell et al. (1986), and are gratified that they reaffirm the critical position held by the Great Glen limestones for the understanding of Moine-Dalradian relationships. The model in their figure 1 is attractive, extrapolating ideas put forward by, for example, Gower (1972), and we in no way wish to deny it as one possibility. What follows should thus be taken in "ingenio advocati diaboli." Their model does, nevertheless, amount to a substantial reassessment of Moine-Dalradian relationships as summarised in, for example, Craig (1983), and we feel that more positive evidence than cited by Russell et al. (1986) is required before it can achieve equal weight with more traditional assessments. We excluded it from Rock et al. (1984), as we could only find negative evidence, as summarised below. We largely confine ourselves below to the Ardgour and Glen Dessarry limestones, since Russell et al. (1986) are most concerned with these.

Proposed correlation with the Deeside Limestone. Whilst we would not rule out a Dalradian correlation for the Great Glen limestones, the Deeside Limestone is by far the least likely Dalradian equivalent, on present petrographical and chemical data. All available descriptions of the Deeside Limestone imply it to be both very impure and dolomite-poor: Hutchinson (1933), for example, describes it as a "feldspathic facies of the Loch Tay Limestone". We know of only 4 analyses (Muir et al. 1956), which have SiO₂ contents of 20, 23, 29 and 46%, and correspondingly high contents of elements concentrated in non-carbonate minerals (e.g. Cu, Y, Zr), but MgO contents <2.5%. For a Deeside-Great Glen correlation to be seriously considered, the occurrence within the Deeside Limestone of equivalents for the abundant pure (<5% SiO₂) limestones and dolostones in the Great Glen must be demonstrated. We did not include the Deeside Limestone in table 6 of Rock et al. (1984) precisely because we know of no such equivalents.

Proposed correlation with other Middle Dalradian limestones. Table 6 of Rock et al. (1984) outlined the chemical mismatch between the major Middle Dalradian carbonate formations and the Ardgour and Glen Dessarry ‘limestones’. Middle Dalradian carbonate formations are in fact almost exclusively calcitic (e.g. Gower 1972; Rock 1985), showing no equivalents of the Glen Dessarry dolostones; moreover, most of them are interbedded with quartzites, grits or metavolcanics,
Fig. 1. Trace element discrimination between 41 Middle Dalradian and 19 Ardgour/Glen Dessarry carbonate rocks. Middle Dalradian data (from Rock 1985) are for the Boyne, Deeside, Loch Tay, Tayvallich, and Culdaff formations. Both data-sets include limestones, dolostones, and 'skarns' (as defined by Rock et al. 1984), and cover similar ranges of major element composition. Trace element data are not available for the Bonahaven Dolomite. Values below detection limits are calculated as real values of zero. N.B. Data acquired since.

whereas the Ardgour and Glen Dessarry carbonates are associated with Al-rich pelites only. Conversely, the only Middle Dalradian dolostone formation (the Bonahaven Dolomite; Spencer and Spencer 1972; Fairchild 1985) contains no equivalents of the pure Ardgour limestones, and is associated with quartzites and tillites. Furthermore, excellent discrimination is possible on simple plots, between available analyses of Middle Dalradian (Tayvallich Subgroup) and the Ardgour/Glen Dessarry carbonate rocks (Fig. 1). Notwithstanding similarly wide ranges of SiO₂ (1–60%), Al₂O₃ (0–16%), CaO (2–53) and MgO (0–20%) in both groups, formal discriminant analysis consequently separates them with efficiencies of about 90% (Mahalanobis D² c.5; F ratios >99.5% significant), using various combinations of major and trace elements. Such differences are scarcely less than those demonstrated between the Great Glen and Lower Dalradian limestones in table 5 of Rock et al. (1984)—which Russell et al. (1986) have accepted.

Whilst Russell et al. (1986) may argue that the Ardgour/Glen Dessarry and Middle Dalradian limestones are diachronous, and thus not necessarily exact compositional equivalents, any long-range correlation across the Great Glen Fault must surely be based on some factual foundation, given the fundamental significance still attached to this Fault. Yet Russell et al. wish to correlate the Durness, Ardgour/Glen Dessarry and Middle Dalradian carbonates—rocks which cannot be correlated by normal stratigraphical/structural mapping methods, and appear not only to be compositionally distinct, but also to be associated with
different metasediment types. Such a correlation must therefore be regarded as little more than an attractive idea, on present data.

_Sillimanite-rich pelites._ The possibility that the Ardgour and Glen Dessarry sillimanite gneisses represent metamorphosed weathering products is at first sight supported by their high contents of Al, Ti, Y, Zr, Nb and Ce, compared with over 150 analysed Lewisian, Moinian and Dalradian Al₂SiO₅-bearing pelites (Rock _et al._ 1985). These elements would be concentrated in regoliths (as bauxite, zircon, apatite, etc.). Among difficulties with the idea, however, are the following:

(i) The sillimanite-gneisses have simultaneously high contents of K and Ba, while their contents of Fe, Mg, Ca etc. are not atypical of Scottish metasedimentary pelites; yet both these groups of elements ought to be depleted in regoliths.

(ii) There is then an unexplained 'coincidence' that these sillimanite-gneisses 'happen' only to occur as xenoliths within, or in the aureoles of, the high-T Glen Scaddle and Glen Dessarry major intrusions—a 'coincidence' compounded by the presence of further sillimanite-gneisses in the aureole of the Glen Loy 'gabbro'—a third major intrusion just W of the Great Glen (Rock _et al._ 1984, fig. 1; Rock _et al._ 1986).

Rock _et al._ (1986) argue instead that these sillimanite-gneisses are restites: meltout of quartzo-feldspathic material during contact metamorphism has concentrated refractory minerals (rich in Al, Zr, etc.), but because the pelitic precursors were composed dominantly of quartz and feldspars, has not substantially altered the already low initial contents of some other major elements. Moreover, the presence of minerals such as hypersthene in the Ardgour sillimanite-gneisses is much easier to explain on this restite model (through the reaction *sillimanite + diopside = hypersthene + anorthite*), than on the regolith model of Russell _et al._ (1986).

_K-feldspar._ Whilst we have no objections to the model of Russell _et al._ (1984) for the Aberfeldy deposit, these citations of other scattered K-feldspar and K-Ba-feldspar occurrences seem to us rather arbitrary. Russell _et al._ (1984) themselves admit that "the exact nature of the precursor to celsian is unknown" even at Aberfeldy, after exhaustive multidisciplinary studies. Given that most Dalradian feldspars now exhibit metamorphic textures, how have these other supposedly authigenic feldspars been distinguished from, for example, abundant metasomatic K-feldspars reported from Dalradian marbles and calc-silicate rocks (e.g. Evans and Leake 1970), or, for that matter, from metasomatic Ba-microcline in Moine psammites in the same position relative to the Great Glen as the Ardgour succession (Rock 1984)? Where diageneric textures are preserved in Dalradian carbonates, Fairchild (1985) found for example that over 80% of K-feldspar in the Middle Dalradian Bonhaven Dolomite is non-authigenic, presumed detrital. Much more detailed studies are surely needed to prove that all these occurrences can be genetically linked into an overall stratigraphical model.
Scapolite. We feel that inferences of evaporitic conditions from predictions of high SO₄ in the Argdour scapolite would be more plausible after actual analysis. Moreover, the origin of scapolite is surely too complex for such a straightforward inference—the marialite end-member often reflects metasomatism, whereas the meionite end-member may form merely by isochemical metamorphism (Deer et al. 1962). The occurrence of actual sulphate minerals (e.g. anhydrite, baryte) in the Great Glen Limestones might be more credible evidence for evaporitic conditions—such minerals can be preserved even in Archaean evaporitic limestones (e.g. Sighinolfi et al. 1980), and do in fact occur in the Lewisian marbles of Loch Maree (Muir et al. 1956). Yet the low Ba and S contents of the Great Glen marbles would seem at least to rule out baryte as a significant constituent, so that positive evidence for evaporitic conditions is once again lacking.

To summarise, we can only find arguments now against a model which regards the Great Glen limestones as a transitional Dalradian-Durness Limestone “missing link”. Garson and Plant’s (1972) speculation, that the Great Glen limestones “represent a transitional Moinian-Dalradian series bordering the Lewisian continental shelf”, seems to us equally plausible on available data. Attribution of the Great Glen limestones to a separate lithostratigraphical unit is, we believe, the only logical interim answer: our ‘Albynian’ will remain a valid stratigraphical term if either the Garson and Plant or Russell et al. speculation eventually proves correct. By contrast, ‘Middle Dalradian’ may prove to be yet another incorrect guess as to the age of the Great Glen limestones—and there have surely been enough such guesses already (Rock et al. 1984).

References


SPENCER, A. M. and SPENCER, M. O. 1972. The Late Precambrian/Lower Cambrian Bonahaven Dolomite of Islay, and its stromatolites. Scott. J. Geol. 8, 269–82.

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