be Cambrian in age, a possibility within the range drawn for the base of the Cambrian in Downie *et al.* (1971, table 3), see also Dunning (1972, p. 181). The placing of the Dolomitic Beds on Islay into the late Precambrian seems more likely in the light of the radiometric date of 660 m.y. obtained by Pringle (*in* Dunning 1972) from shales of the Varanger Till (≡ Portaskaig Boulder Bed) and according to Dr Downie (personal communication) the microfossils are comparable with those in the Middle Brioverian.

We are grateful for Dr Downie's comments on the manuscript of this letter.

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Microcline porphyroblasts in the Moinian rocks of the Western Highlands

Sirs——I would suggest that there is a different interpretation of the observations by Drs Smith and Harris (1972) regarding microcline porphyroblasts. Their plate 1 seems to be a very good example of graded bedding. 'Porphyroblasts' of microcline, orthoclase-perthite and oligoclase are common in semipelitic and psammitic rocks of the Moine series in the Ross of Mull (Haynes 1969) and frequently occur at the base of well-graded beds, which contain current-bedding in their upper parts. They also occur in pebbly psammitic horizons within an essentially pelitic sequence. These clastic grains of feldspar have not grown during metamorphism but have often recrystallized.

The validity of this argument is supported where metamorphic grade is considered. Smith and Harris' statement that "it is probable therefore that garnet growth and microcline growth were coeval during the post-F_2, pre-F_3 period and likely that both minerals co-existed in pre-F_2 rocks" is directly contradicted by the AKF diagram presented as Figure 2 in their paper. Turner (1968) shows that in stable pelitic and quartzo-feldspathic assemblages the tie-line muscovite-biotite is stable throughout the upper greenschist and lower almandine amphibolite facies. It is only replaced by the almandine-microcline tieline after the reaction.

$$\text{Muscovite} + \text{quartz} \rightarrow \text{K-feldspar} + \text{sillimanite}$$

has taken place. Thus at the grades under which microcline porphyroblasts were supposed to grow the reaction

$$\text{K-feldspar} + \text{almandine} \rightarrow \text{muscovite} + \text{biotite} + \text{quartz}$$

would be operative and K-feldspar + almandine is an unstable assemblage. The co-existence of these minerals can be regarded as further proof of the stability of clastic K-feldspar during relatively high grade metamorphism. In examples from the Ross of Mull F_1 garnets may be physically flattened during F_2 against the clastic grains of orthoclase, but have subsequently resisted alteration throughout several metamorphic peaks.

The Druimindarroch locality appears to be a graded semipelitic horizon, not only because of its similarity to others elsewhere, but also if metamorphic stability is considered. Insufficient evidence is presented to comment on other localities mentioned by Smith and Harris. The dying out of microcline 'porphyroblasts' southwards may however be explained by chemical and sedimentological factors. Graded beds would best be developed in semipelitic horizons where there was a good supply of clastic K-feldspar. Moine rocks however become more sodic towards the south (Butler 1965) and away from the Torridonian foreland sediments (Williams 1966). Thus in Ardnamurchan and the Ross of Mull most of the coarser clastic rocks are greywackes, not arkoses. Couple this with the observation that under most weathering and transporting conditions microcline is more stable than plagioclase, and the absence of 'porphyroblasts' further south may be explained. In Mull microcline clasts are common in red pebbly psammites and semipelites, but the thicker pelitic and semipelitic sequences only contain occasional pebbly horizons with clasts of oligoclase or orthoclase perthite.

Perhaps a chemical study of the Druimindarroch locality from right to left (plate 1 of Smith and Harris) would reveal a change in composition equivalent to a right to left swing across fields 1 and 2 of their AKF diagram. Moine rocks are clastic sediments and should be treated as such. In the transition sequence between arkosic sediments and semipelitic greywacke type sediments in the Ross of Mull, the mixed provenance of the sediments is well marked. A typical graded bed one metre thick may consist of current-bedded semipelite near the top and arkose at the bottom. A sample near the top contains 5% Na_2O + 2% K_2O (oligoclase 50%, quartz 30%, biotite 15%) and near the bottom 5% K_2O + 3% Na_2O (quartz 40%, clastic microcline 30%, oligoclase 25%). Very little can be said about metamorphic grade in relation to folding episodes when large changes in chemistry may occur within a single bed.

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SIRS——We are grateful for the interest shown in our results by Dr. Haynes and hope that his views and results on the interesting regional trends in the chemistry of the Moinian rocks will be more fully published. We cannot agree, however, that conclusions based on chemistry can change conclusions based on the accurate observation of geological relationships. By contrast to the last sentence of Dr. Haynes' letter; a great deal *should* be said about the textural evidence for metamorphic grade in relation to fold episodes before confirmatory chemical analysis is applied.

Our detailed mapping of many areas of Moinian rocks in the Western Highlands (Johnstone *et al.* 1969, and *in* the Morar (61) sheet (1971)) has made us familiar with the graded pebbly beds which characterise many parts of the Moinian outcrop. We are thus able to distinguish confidently feldspar porphyroblasts from polymict pebbly beds as also were such astute field geologists as W. Q. Kennedy, A. G. McGregor and C. T. Clough. The possibility that the microcline crystals from our localities are clasts was discussed during the preparation of our work and largely discounted, although the evidence in certain cases is equivocal. It does not seem to us to follow that, because some Moines are pebbly, a Moinian rock containing conspicuous white feldspar crystals, must also of necessity be pebbly.

The conclusions reached about the Druimindarroch locality are based on the detailed textural relationships between porphyroblasts and schistosity. Grains orientated by *D*2 and constituting the *S*2 foliation pass without deflection, as trails of relict inclusions, through many microcline porphyroblasts. Orientated trails, chiefly of quartz and epidote grains, occur not only as relict inclusions in microcline but form much of the groundmass fabric; the grain size in the groundmass has increased somewhat since the episode of porphyroblast growth. However, it is not only traces of schistosity which are preserved as inclusions in the porphyroblasts. In some cases, the remnants of bedding lamination, picked out by finely spaced heterogeneity in the concentration of epidote can be traced within microcline crystals, and in the semipelitic groundmass in which the microcline crystals are set.

Chemical commentary on mineral assemblages which *exist* in these Moinian semi-pelitic rocks do not affect the validity of our observations. The comment that the muscovite-biotite tie has not broken down in our rocks must be accepted and we certainly made no claim to the contrary. The reaction quoted by Dr. Haynes:

$$\text{Muscovite} + \text{quartz} \rightarrow \text{K-feldspar} + \text{sillimanite}$$

is presumably that which would contribute some at least of the K-feldspar to partial melts of the Moinian rocks. In most of the Moinian pelitic, so-called, migmatites of the Western Highlands the granitic fraction may not represent a partial melt since it consists mainly of plagioclase and quartz. Hence, even these rocks (of much higher grade than those described from Druimindarroch) probably have not experienced the reaction producing K-feldspar at the expense of muscovite.

Observation that microcline, garnet, muscovite, biotite assemblages exist must stand. Assemblages, which on textural evidence, clearly formed in the post-*D*2, pre-*D*3 period and which survived the long period of M_2P regional metamorphism are likely to be equilibrium assemblages though admittedly this is an inference and not an observation. Where garnet has been recorded in the same thin section as microcline, it forms small individual crystals and constitutes less than 1% by volume of the rock. It occurs in a very small proportion of the thin sections examined, being included in our report for completeness. The composition of the garnet which coexists with microcline is unknown but if it is particularly lime-rich, it, like the epidote, would have to be regarded as an additional phase, not appearing on the AKF diagram. In most of the rocks examined garnet and microcline do not coexist, although textural evidence shows that their crystallisation is broadly coeval. All the microcline-bearing rocks must lie in sector 2 of our AKF diagram (Smith and Harris 1972, fig. 2), while the vast majority of Moinian garnetiferous pelites which lack microcline lie in sector 1. One of the main purposes of our paper was to show that, unlike many Dalradian schists, Moinian garnetiferous pelites contain progressive biotite and lack progressive chlorite. This, we have concluded, following Mather (1970), is due to an abundance of available potash, a point underlined by the existence and stability of the microcline porphyroblasts at many localities.

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THE UPPER GLENKILN-HARTFELL CHERTS AND MUDSTONES OF BROADLAW, AND THEIR STRATIGRAPHICAL SIGNIFICANCE

SIRS——Occurrences of chert and basaltic lavas in the Southern Uplands have generally been considered to be of Arenig age, through comparison with known Arenig cherts at Ballantrae. One such outcrop occurs about 1 km south of Broadlaw, Midlothian, and is well exposed in a cutting of the road B7007 between Middleton and Innerleithen (grid reference [NT 347533]). Peach and Horne (1899, p. 269) interpreted the succession as consisting of cherts (Arenig), grey mudstone (Glenkiln), and black shale (250 mm thick) topped by greywacke (Hartfell). Walton (1960, p. 122) suggested that the cherts were interbedded with the ashy mudstones and shales, and also (though without palaeontological evidence) that the sequence was wholly of Glenkiln age.

The southernmost exposures in the eastern wall of the road cutting (locality A, Walton 1960, p. 120) display a prominent horizon 1·2 metres thick, consisting of lenticular and tabular beds of black chert up to 100 mm thick with partings of soft, greenish-grey mudstone. Beneath this, probably in inverted succession, are blocky grey mudstones, locally ashy. Comparable rocks at locality D, the southernmost exposure in the western wall, have 20 mm chert ribs. Between the mudstone and the chert at locality A occurs a centimetre of fissile black mudstone, sheared into lenticles. This yielded 23 rhabdosomes and two juvenile individuals referable to *Amplexograptus perexcavatus* (Lapworth) (cf. Bulman 1962). One fragmentary *Dicranograptus* was also recovered, and was determined as *D.* cf. *nicholsoni* Hopkinson (cf. Elles and Wood 1901–14, p. 171; pl. 25, fig. 1d. Also Strachan 1971, pp. 23, 80). *A. perexcavatus* appears in the Glenkiln and Lower Hartfell Shales, characterizing especially the Lower Hartfell (Bulman 1962, p. 464). *D. nicholsoni* ranges through the entire Glenkiln-Hartfell succession, with an acme in the Upper Glenkiln and lowest Hartfell (*wilsoni* zone). The fossil evidence therefore places the Broadlaw inlier close to the Glenkiln-Hartfell boundary (Harnagian on the revised correlation of Williams *et al.* 1972).

We agree therefore with Lamont and Lindström (1957) that the occurrence of considerable thicknesses of chert, and even of basaltic volcanics—both of which occur at numerous localities in the Northern Belt, separately or in association—cannot in