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Petrogenesis of migmatites in the Huntly–Portsoy area, north-east Scotland. A reply

YARDLEY (1977) rejects my interpretation in terms of partial melting (Ashworth, 1976) for the lower-grade migmatite types of the Huntly–Portsoy area. His reasons are not compelling, and his alternative interpretation is implausible: it fails to account for obvious and simple features of the rocks, on which the 'anatectic' (partial melting) interpretation is founded. Yardley prefers to emphasize minor, more problematic phenomena, which, however, *are* also consistent with migmatization by partial melting.

The metamorphic differentiation hypothesis, involving diffusion through a small volume of aqueous fluid, which Yardley (1975) has reasonably applied to quartzose veins at lower grade, fails to account for the consistent proportionality of plagioclase to quartz in the simplest (trondhjemitoid) leucosomes of the Huntly–Portsoy area. Depletion of both quartz and plagioclase in restites by extraction of leucosomes of highly variable composition (Yardley, 1975) is clearly a different process from that which determined modal compositions in the Huntly–Portsoy trondhjemitoids (Ashworth, 1976, fig. 4). There are also obvious textural differences between the two leucosome types, though interpretation is hindered by the deformation that has affected the rocks described by Yardley (1975).

Melt origin of the Huntly–Portsoy trondhjemitoid leucosomes is indicated by cotectic composition and unequilibrated textures (Ashworth, 1976). The problems then raised by failure to observe biotite breakdown products or plagioclase differentiation are less severe than Yardley (1977) suggests.

Wholesale dehydration of biotite with quartz requires higher-grade conditions (Ashworth, 1976). There remains the possibility that, during incipient melting, biotite components would be partitioned so as to produce other ferromagnesian minerals in the restite (Yardley, 1977). In the rocks under discussion this effect did not generally produce cordierite, amphibole, etc. in quantities sufficient to survive destructive reaction during subsequent crystallization of the melt (cf. next paragraph). The effect would be restricted, first to the small amounts of biotite components entering the melt, most biotite in leucosomes probably being in the form of microschlieren (Ashworth, 1976, p. 671), and secondly by the limited extent of melting, controlled by availability of H_2O. As Yardley (1977) intimates, only those rocks with initially high f_{H_2O} would be expected to melt appreciably, but while on the subject of additional components in metamorphic fluids, it may be pertinent to mention that experimental production of trondhjemitic melts from sedimentary starting material (greywacke) has been reported, in the presence of an aqueous solution of KCl and NaCl (Kilinc, 1972). The further point that high P may contribute to the stability of trondhjemitoid melting reactions is interesting. $P > 4$ kb during isobaric overprinting of the Andalusite Zone, close to the Andalusite/Kyanite Isograd (Ashworth, 1975), would be consistent with the Al_2SiO_5 phase diagram of Richardson *et al.* (1969). Moreover, there are indications of some increase in pressure between the imposition of the regional zone pattern and the migmatization event, notably the probable replacement of andalusite by kyanite in the 'three-polymorph' rock at Portsoy (Johnson, 1962).

Plagioclase compositions in both leucosomes and restites have been affected by retrograde reaction (Ashworth, 1976). In the muscovite-granitoids, retrograde reaction between melt and adjacent solids produced obvious replacement textures (which, together with the effects of

feldspar solid solution, can account for the scatter of leucosome modal compositions in fig. 9 of Ashworth, 1976). In trondhjemitoids also, plagioclase compositions are expected to be modified by reaction during crystallization of the melt. This is *not* subsolidus equilibration. Considerable zoning persists. Variation in plagioclase composition of $> 10\%$ An was found within small samples (a few grams of rock, or a single probe-slide). Thorough statistical examination for differentiation between leucosome and restite is not considered worthwhile in the continuing absence of closely comparable experimental data. 'P_{H_2O} exerts a strong influence on plagioclase-melt equilibria and . . . the semi-quantitative analysis . . . developed here may not be used to calculate the composition of plagioclase crystallization at high pressures from a magma containing dissolved H_2O' (Drake, 1976). Even if the differentiation effect was detected, it is doubtful whether it would serve as a criterion for melt origin, since Yardley (1975) infers differentiation in the same sense under subsolidus conditions. Rather than differentiation, correlation between leucosome and restite plagioclase compositions was sought (Ashworth, 1976) by taking closely adjacent samples and plotting mid-point values. The observed correlation indicates interaction between leucosome and restite, presumably during retrograde as well as prograde evolution (though retrograde exchange of material was insufficient to disturb detectably the cotectic bulk compositions of trondhjemitoid leucosomes). In these circumstances, failure to detect differentiation of plagioclase composition between leucosome and restite *does not* constitute evidence against an origin by partial melting.

There is no discontinuity between migmatites of lower and higher grade in the Huntly–Portsoy area. There is a transition between muscovite-bearing and cordierite-bearing types, in which granitoid schlieren-migmatites contain both minerals (Ashworth, 1976). Reaction textures in the muscovite-granitoids and the higher-grade migmatites are closely analogous. The sequence of dehydration reactions in the presence of melt correlates with that inferred for many other areas (Grant, 1973).

It was apposite for Yardley (1977) to point out that not all quartz–plagioclase leucosomes are anatectic. Metamorphic segregation is clearly important where vein assemblages correlate with a wide range of low-grade host-rock assemblages (Vidale, 1974). The Huntly–Portsoy area, on the other hand, illustrates localized migmatization, confined to the Sillimanite–potash-feldspar Zone, for which the petrogenetic hypothesis that best accounts for all petrographic and other observations is partial melting in small closed systems. Other areas may not be amenable to identical methods of study, but it is important that appropriate criteria be used in assessing anatectic hypotheses.

Department of Geological Sciences J. R. ASHWORTH
The University of Aston in Birmingham
Gosta Green, Birmingham B4 7ET

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