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Generation of Permeability in Metamorphic Rocks by Reaction with Basinal Brines: Dolomitisation in the SW Highlands of Scotland

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Growth of dolomite and ankerite under retrograde conditions is widespread in the Dalradian of the SW Highlands of Scotland (Fein et al., 1994). Dolomites have higher oxygen isotope ratios (+25 to +28 per mil) than Dalradian marbles (+ 15 to + 18 per mil). At South Bay on Loch Fyne, dolomitisation fronts have penetrated a few metres into marble bands away from a minor fault. Dolomitisation was previously assumed to have occurred at about 400ºC on the basis of fluid inclusion micro-thermometry. However, new stable isotope analyses show that the quartz that hosts the fluid inclusions is not in equilibrium with dolomite in the same vein, and a much lower temperature is possible for dolomitisation.

We have made an integrated BSEM, CL and ion microprobe study of samples collected close to the dolomitisation front, and have identified a series of textural domains. Irregular bright (in CL) grain boundary domains are heavier in oxygen isotope ratio (+ 19 to +24 per mil) than unaltered marble, as are mottled recrystallised grains. Dolomite appears to have grown in grain boundary porosity produced by dissolution of calcite, and is generally zoned to ankeritic rim compositions. The same porosity is lined by dark (in CL), zoned calcite which ranges from +20 to +7 per mil in oxygen isotope ratio. A final bright calcite CL zone lining porosity shows the highest oxygen isotope ratios (+29 to +33 per mil), and probably precipitated from local seawater under ambient conditions. Age relationships between dolomite and dark calcite are equivocal, but on balance the dark calcite appears to be later.

Our data shows that fluids of radically different origin exploited the same porosity in Dalradian marbles. Preliminary crush-leach analyses of dolomite indicate the presence of brines with high Br/Cl ratios, consistent with an origin as residual fluids from seawater evaporation. We suggest that permeability was enhanced in the marbles by reaction with an evolved basinal brine, possibly of Permo-Triassic age, at temperatures of around 100ºC. The porosity was then exploited by a fluid of meteoric origin at similar temperatures. Similar reactions appear to have occurred on a regional scale in pelitic and semi-pelitic schists where ankerite growth is widespread. There is a remarkable similarity between the sequence of events in the marbles and secondary porosity generation in some oilfields, and we believe that dissolution reactions at relatively low temperatures may be an important mechanism for enhancing the permeability of metamorphic basement rocks.

Fein JB, Graham, CM, Holness, MB, Fallick, AE & Skelton, ADL, *J. Met. Geol.*, **12**, 249-260, (1994).