Stable isotope systematics in metasediments of the Scottish Highlands

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Introduction

The metasediments of the Scottish Highlands represent an ideal model to study wether the metamorphic overprint during Caledonian orogeny was accompanied by fluid infiltration, since the unmetamorphic sedimentary rocks of the Torridonian are most likely the equivalents of the metamorphic Moinian metasediments.

Analytical methods

Three profiles starting from the Torridonian through the Moinian and ending up at Great Glen Fault were sampled in detail and whole-rock and mineral samples were analyzed for their chemical- as well as oxygen and hydrogen isotopic compositions (Figure 1).

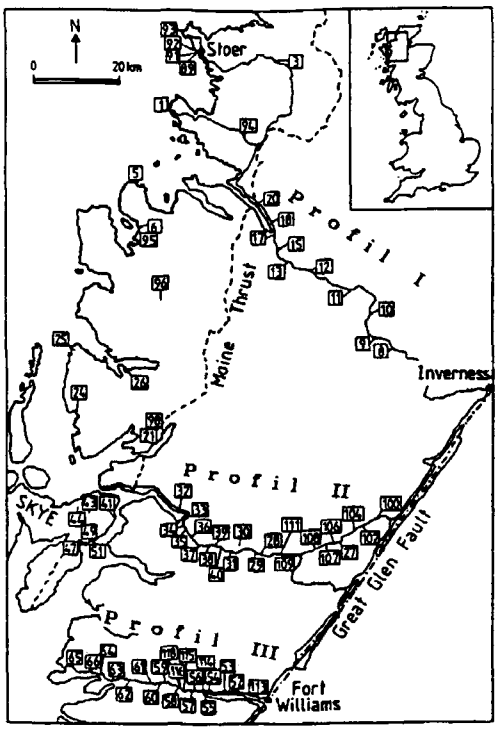

FIG. 1.

Results

Geochemically the sedimentary rocks of the Torridonian and Moinian metasediments are very similar, indicating that no major changes occured during metamorphism and that the two series indeed originate from the same source region, thus justifying an isotopic detail-study which could show the effects of fluid infiltration from an external source during metamorphism.

From the Torridonian single components such as quartz and feldspar pebbles show a large spread in $\delta^{18}O$ from 2 to 17 ‰ for quartz whereas the feldspar single crystal pebbles vary only from 9 to 11 ‰. The whole-rock $\delta^{18}O$ values vary systematically with the chemical composition as indicated by the positive correlation with the Garlick-index (Figure 2). The clay fraction $<2\mu$ (mainly illite with low amounts of mixed-layer illite-smectite) is isotopically lighter than the corresponding whole-rock values indicating the purely detrital origin of the clay minerals as typical for a sedimentary environment with a large accumulation rate (Bouquillon *et al.*, 1990; Clayton *et al.*, 1978). This is supported from δD values of the clay minerals where we observe a difference between the those in clay dominated layers with δD values between -50 and -60 ‰ and the clay fraction separated from sandstones with slightly lighter values down to -80‰. We assume that the more permeable sandstones were affected by some postdepositional exchange with a lighter fluid

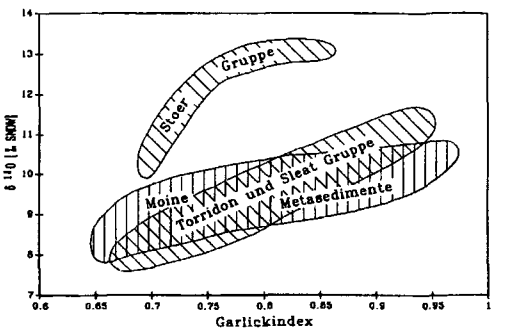

FIG. 2.

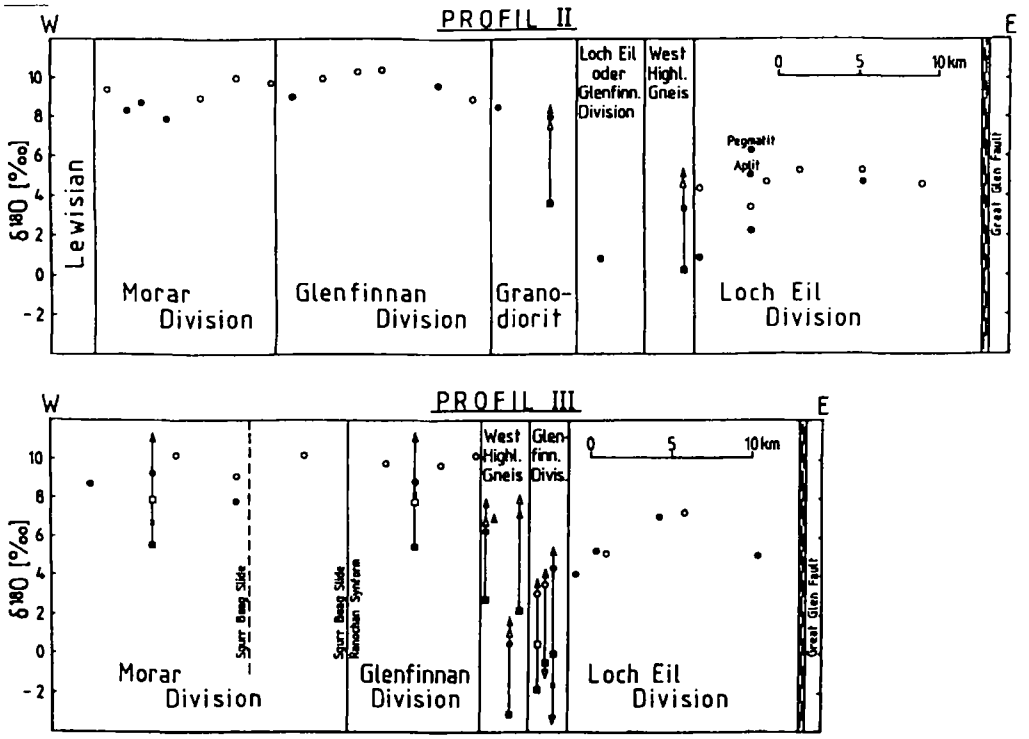

FIG. 3.

whereas the impermeable clay horizons within the Torridon group as well as the clay minerals of the Aultbea formation kept their original predepositional composition.

Similar ranges and systematics of isotopic compositions are found in the metasediments of the Moinian (Figure 2). It is interesting that the metapelites are lighter in 18O than associated quartzites, mirroring the relations between clay minerals and detrital quartz from the Torridonian. In the vicinity of the West Highland Gneiss we observe a pronounced decrease of $\delta^{18}O$ whole-rock and mineral values (Figure 3) indicating a precaledonian hydrothermal fluid–rock exchange with meteoric ground water. The metamorphic overprint during Caledonian orogeny was not able to whipe out these O-isotopic compositions. It is interesting, however, that the δD values of the metamorphic mineral phases are homogenious throughout the Moinian within a given lithounit and display no indication for a hydrothermal interaction with meteoric water. We suggest therfore that during the regional metamorphic overprint a redistribution of δD values was accieved at low fluid–rock ratios with fluids set free by dehydration reactions in the pelitic country rocks.

Conclusions

The stable isotopic data of the Torridonian and Moinian sedimentary rocks and metasediments respectively can be derived from one source. The Caledonian metamorphic fluids were essentially internally buffered and not altered by later events. Prior to Caledonian metamorphism a hydrothermal convection system was established in the vicinity of the West Highland Gneiss.

References

Bouquillon, A., France-Lanord, C., Michard, A. and Tiercelin, J.-J. (1990) *Proc. Ocean Drill. Prog. Sci. Results*, **116**, 43–58.

Clayton, R.N., Jackson, M.L. and Sridhar, K. (1978) *Geochim. Cosmochim. Acta.*,.**42**, 1517–22.