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Hydrothermal alteration of oceanic crust observed in the Oman ophiolite

Naoya Yoshitake[1]; Shoji Arai[2]

[1] Earthsicence, Kanazawa Univ.; [2] Dept. Earth Sci., Kanazawa Univ.

We examined genesis of dark brownish 'chlorite rocks' formed by hydrothermal alteration in the oceanic crust of the Oman ophiolite. The outcrop belongs to the isotropic gabbro member located slightly below the lower boundary of the sheeted dyke complex along Wadi Bani Umar. The chlorite rocks form network-like veins replacing minerals both in the gabbro and dolerite dykes. Thickness of the vein is variable from several centimeters to several meters. Formation of the chlorite rock combined with wall-rock alteration may record an important process of chemical exchange caused by hydrothermal circulation within the oceanic crust. In this study, we treated the 4 sets of sample taken on across the boundary between the chlorite rock vein and wall gabbro and dolerite (2 sets of samples).

In the gabbros, clinopyroxenes are partially replaced by Mg-hornblende, and the degree of replacing increases with a decrease of the distance from the chlorite rock vein. Orthopyroxenes are replaced by dark brown aggregates of amphibole and chlorite along rims and cleavages.

The samples were analyzed by XRF for major elements and by solution ICP-MS for trace elements. Special care was taken for making solution samples for the trace element analysis.

Bulk-rock major elements do not change in wall mafic rocks by distance from the chlorite rock vein. However, SiO_2, CaO, Na_2O and K_2O are distinctly lower and FeO is higher in the chlorite rock than in the wall rocks. Amounts of Sr, Ba, and Pb are lower in the chlorite rocks than in the gabbro for the 2 sample sets. The chlorite rock and the wall gabbro show very unique REE patterns. The gabbro shows LREE-depleted patterns, which are almost constant irrespective of the distance from the chlorite rock. In contrast, the vein chlorite rock exhibits distinct negative Eu anomalies.

The Eu anomaly in the chlorite rocks is caused by chloritization of plagioclase. Other REE were not removed by the relevant fluids, and REE (excluded Eu) in chlorite rocks are stored by crystallization of rutile.

The amphiboles first replaced pyroxenes by high-temperature (ca. 800 C) hydrothermal fluids near a spreading axis, and low-temperature (ca. 500 C) hydrothermal fluids achieved choritization to form chlorite rock slightly off the spreading axis.