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Epidotisation and fluid flow in sheeted dyke complex : new field and experimental constraints

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Hydrothermal system in oceanic crust is usually studied via dredge samples and drilled holes but their equivalent are also found in ophiolitic complexes (Oman, Cyprus). In the deepest zone, the fluids react with the sheeted diabase dikes at 400°C and 400 bars to form epidosites by enrichment in epidote and quartz [1]. Mineralogy and chemistry of epidosites have been widely studied on fields [1] and hydrology is generally studied using numerical models [2]. However, the relations and the timing of the emplacement of diabase dikes, their alteration in epidosite and the regional deformation remain unclear. We performed experiments on diabase sampled in the Troodos complex (Cyprus), 1) to stress the P-T-fO_2-fluid composition conditions of the reaction of epidotisation and, 2) to quantify interrelations between the permeability and the epidotisation during deformation.

In Troodos, we observed two major types of epidosite: 1) a pervasive epidosite in the core of dikes and a banding which is parallel to chilled margins and, 2) assemblages of epidote and quartz as alteration fronts in cooling joints or in the form of veins cross-cutting non-epidotised dikes. This last type of epidotisation clearly appears to be a hydrothermal veining process.

We synthesized epidote in a static autoclave with external heating at 500°C and 2500 bars. Epidote was formed by the following reaction: 6 albite + 2 hematite + anorthite + 7 Ca2+ + 6 H_2O $\rightarrow$ 4 epidote + 8 quartz + 6 Na+ + 8 H+. The calculated variation of the molar volume is about -3% (creation of porosity). Two parameters are essential to synthesize epidote from diabase: the oxygen fugacity and the composition of the fluid (enriched in Ca and Fe). However, there is an obvious problem of nucleation at 400°C and 400 bars.

In order to understand how fluid flows throughout sheeted dikes, in situ measurements of permeability during coaxial deformation have been performed in a Paterson apparatus by infiltration of Argon and water. The permeability of the diabase prior deformation is about 10-20 m2. After fracturation of the sample, the permeability increased rapidly up to 10-19 m2. After stress relaxation, the permeability decreased slowly to its initial permeability. Moreover, the permeability of epidosite is about 10-19 m2. So this suggests that epidotisation generates porosity.

The main problem is the initiation of fluid flow because of the impermeability of diabase. From our results and field evidence, we suggest two hypotheses: 1) fluid flows via fractures and cracks and, 2) fluid flows into a rock in a subsolidus state (importance of degassing). To explore this last hypothesis, experiments will be performed at high temperature (T > 850°C) with an infiltration of water through a synthetic diabase placed under late magmatic conditions. So, in these conditions, nucleation of epidote could be facilitated from a glass.

[1] Richardson C. J., Cann J. R., Richards H. G., Cowan J. G., 1987. Earth and Planetary Science Letters, 84, 243-253.

[2] Coumou D., Driesner T., Geiger S., Heinrich C. A., Mattahai S., 2006. Earth and Planetary Science Letters, 245, 218-231.