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Geochemical investigations of altered basalts from Reykjanes geothermal system (SW Iceland)

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In the frame of the international Iceland Deep Drilling Project (IDDP), Reykjanes high-T geothermal system (Reykjanes Peninsula, SW-Iceland) offers a unique possibility to study on land the effects of hydrothermal alteration on basaltic rocks from oceanic crust. In order to better constrain such a process, EMPA and SIMS micro-analytical techniques have been used to investigate the geochemical (major, minor and trace element constituents, Li and B included) features of magmatic phases, i.e., plagioclase (plg) and clinopyroxene (cpx), of 11 drill-cuttings selected on the basis of different depths (400–3000 m) from the well RN-17, along with one dolerite dyke core-sample (2246 m depth) from well RN-19. *In-situ* EMPA and SIMS experimental data have been compared with the Sr isotope values on mineral separates and Sr-Nd ratios from whole rock obtained by TIMS method, and with those of bulk rock trace elements determined by ICP-MS and ID techniques.

The geochemical results of bulk rock and mineral phases have showed a quite complex geological history beneath the studied area. Such a complexity steams from the occurrence of:

1. almost flat REE-patterns, low B contents and low Sr isotope values in the deeper cuttings;

2. slightly LREE enrichments, high B contents and high Sr isotope ratios in the shallower ones;

3. relatively narrow whole rock $^{143}Nd/^{144}Nd$ isotope range;

4. Sr isotope ratios modified in the mineral phases (plg and cpx);

5. high U concentrations in the whole rock and in mineral phases.

The variation of LREE contents in the cuttings could be ascribed to different degrees of hydrothermal alteration caused by the interaction with an external fluid phase. It would derive from an early leaching reaction with unaltered or weakly altered diabase dykes (Bach & Irber, 1998), these latter being very common beneath Reykjanes system. The interaction with this fluid phase is confirmed by the fact that the mineral phases (plg and cpx) show modifications only in their Sr isotope ratios. Sr and Nd isotope decoupling along with variable B contents in all the cuttings would suggest for such a phase a significant seawater contribution, as invoked by Sveinbjörnsdóttir (1992).

The differences occurring between the shallower and deeper cuttings might be ascribed to decrease of seawater effectiveness due to a reduction of rock permeability with depth. In this frame, the "black smoker" ophiolitic model (Honnorez, 2003) could be suitable to account for these geochemical characteristics.

The high U contents showed by the whole rock and mineral phases seem to be related to a primary feature of the parental melt rather than the result of hydrothermal alteration. This hypothesis is confirmed by Chauvel & Hémond (2000), who suggested the occurrence of an heterogeneous lithospheric mantle beneath Iceland due to the existence of an old recycled oceanic crust that stored in the mantle for a long time (potentially since the end of the Archean).

References

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