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The formation of alteration rims in basaltic lava flows upon hydrothermal circulation

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We investigated fossil hydrothermal systems in the North of the Reykjavik peninsula (Iceland), in order to better understand water-rock interactions occurring during hydrothermal fluid circulation. The observation of a lava flow formation showed that the basalt is practically not altered, except in zones of a few cm thickness around the largest fractures (i.e. alteration rims). XRD analysis and observations of polished thin sections by optical microscope evidenced a severe alteration of the protolith in the alteration rim. Secondary minerals mostly consist in pyrite, calcite and chlorite, indicating a temperature of 250°C during the hydrothermal event. The presence of pyrite and calcite in the alteration rim and their absence in the rest of the rock suggest that the fluid contained significant amount of volcanic gasses H2S and CO_2 and probably followed an ascending path. Most of the calcite is located in fractures that have been formed after the precipitation of the other secondary minerals. This observation, coupled with fluid inclusions analysis, indicates a second hydrothermal event that happened at lower temperature and pressure.
We reproduced those observations by using a geochemical reactive transport model (OpenGeoSys-GEM code). The purpose was to decipher how diffusion and mineral reaction kinetics (protolith dissolution and secondary minerals precipitation) influence the alteration, and to establish the time duration of the hydrothermal circulation.