Water-rock interaction at the Theistareykir geothermal field in NE-Iceland

BJARNI GAUTASON[1]* AND KARLIS MUEHLENBACHS[2]

[1]Iceland GeoSurvey & Univ. of Akureyri, P.O. Box 30, 602 Akureyri, Iceland (*correspondence: bg@isor.is)
[2]University of Alberta, Edmonton AB, T6G-2E3, Canada (karlis.muehlenbachs@ualberta.ca)

The Theistareykir volcanic system constitutes the western most part of the Northern Volcanic Zone (NVZ) in Iceland. Unlike its nearest neighbor to the east, the Krafla system, it does not have a well developed caldera structure. However, near the center of the system there are sporadic outcrops of siliceous rocks.

Bæjarfjall is a sub-glacial tuya located centrally in the system. On its northern slopes extensive acid sulfate alteration provides evidence for a vigorous geothermal system. To date six deep (≈ 2 to 3 km) exploration wells have been drilled in the area. Cuttings from the wells record extensive alteration of the bedrock with epidote-chlorite ($T \geq 240°C$) and amphibole-epidote ($T \geq 290°C$) facies metamorphism recorded at relatively shallow depths. Temperature logging and modelling shows that the geothermal gradient in the area follows the boiling point curve in the uppermost 2.5 km.

We have separated cuttings from selected depths in well ThG-1, taking care to obtain only cuttings of the dominant lithology from each of the selected depth intervals. These cuttings have been analyzed for their $^{18}O/^{16}O$ ratios. The $\delta^{18}O$ values of the rocks range from -4.0 to -10,2 (‰ SMOW) recording extensive exchange with meteoric derived hydrothermal fluid and very high time-integrated water-rock ratios. A general trend of decreasing $\delta^{18}O$ with depth is observed. From the data gathered to date it appears that most depleted rock occur close to presently active aquifers. More surprising however, is the depleted character ($\delta^{18}O < -8.0$ ‰SMOW) of apparently unaltered (basaltic) intrusives.

The overall characteristics of the profile ($\delta^{18}O$ vs. depth) is similar to that obtained previously from the Krafla hydrothermal system [2].

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Magnesite growth inhibition by organic ligands: Complexation and adsorption

Q. GAUTIER[1,*], P. BÉNÉZETH[1], G. JORDAN[2], U-N. BERNINGER[2] AND J. SCHOTT [1]

[1] Géosciences et Environnement Toulouse (GET), CNRS, UMR 5563, 14 Avenue Edouard Belin, 31400 Toulouse, France (*correspondence: quentin.gautier@get.obs-mip.fr)
[2] Dept. f. Geo- u. Umweltwissenschaften, Ludwig-Maximilians-Universität, 80333 München, Germany

Magnesite is object of scientific attention due to its potential for long-term CO_2 sequestration. Organic ligands are widespread in natural environments, and because of their promoting effect on Mg-containing silicates dissolution, it has recently been suggested that some carboxylate ligands could be used to enhance *ex situ* mineral carbonation [1]. However, the influence of such organic ligands on magnesite precipitation still needs to be elucidated.

We performed macroscopic and microscopic crystal growth experiments using mixed-flow reactors (MFR) and Hydrothermal Atomic Force Microscopy (HAFM) at temperatures between 80 and 150°C and slightly alkaline conditions. Three model ligands were investigated for their different chemical and structural properties: oxalate, citrate and EDTA.

MFR experiments showed that at concentrations above 0.01 mM, the investigated ligands inhibited magnesite growth. Inhibition is positively correlated with the complexation of Mg^{2+} by the ligands. Furthermore, by precisely calculating saturation states, we show that citrate causes a reduction of the kinetic rate constant of magnesite growth: for instance, citrate concentrations as low as 0.2 mM induce a 4-fold decrease of the rate constant, an effect that is not observed for oxalate. These results point towards different surface effects of the ligands.

HAFM observations showed that all three ligands interacted with steps on the magnesite surface, and modified the shape of growth islands. Measurements of step advancement rates suggest that citrate strongly inhibits growth at acute steps, which has been suggested to control magnesite growth at similar conditions [2].

Therefore at the investigated conditions, inhibition of magnesite growth by organic ligands appears to be a consequence of both Mg^{2+} complexation decreasing solution saturation, and specific interactions of the ligands at the magnesite surface. The results help to assess a potential use of organic ligands for mineral carbonation purposes and may improve our understanding of the long-term fate of CO_2 in ligands-containing storage sites.

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