

Chromium chemistry in natural waters, Iceland

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Chemistry of Cr and Fe was studied in non-thermal and geothermal waters in Iceland. Chromium (Cr) is typically present at low concentrations (<1 µg/l) in natural waters, but elevated concentrations have been observed in waters with low pH values, e.g. acid mine drainage, and in association with industrial activities. Chromium occurs in two oxidation states, Cr(III) and (VI), these being characterized by different (bio)chemical behaviour and solubility. As Cr(VI) is known to be toxic but Cr(III) an essential micronutrient, it is important to determine the two oxidations states. Iron (Fe) is known to play an important role in the chemistry of Cr through adsorption on and incorporation in Fe containing minerals, and by affecting the distribution of Cr species. In natural waters, iron is present in two oxidation states (Fe(II) and (III)) and understanding its chemistry is complicated by fast oxidation kinetics, importance of colloidal forms and low solubility in the pH range of most natural waters (pH>6).

Samples were collected from non-thermal surface and spring water, surface geothermal water and geothermal well discharges, and analyzed for their major and trace element composition. Chromium and Fe speciation was determined in selected samples. The sampled waters showed wide range of composition with temperature, pH and total dissolved solids in the range of 0-184°C, 2.0-9.6, and 35-4030 mg/l, respectively. The total dissolved Fe and Cr concentrations were between <1 µg/L to 360 mg/L and <0.01 and 660 µg/L, respectively. The highest concentrations were associated with steam-heated acid-sulfate waters with the lowest pH values, whereas the concentrations in neutral to alkaline waters were low, typically <1 µg/L Cr and <100 µg/L Fe.

The main processes controlling Cr chemistry were found to depend on the water pH and rock leaching. At a low pH, Cr(III) becomes released into solution through leaching of Cr-containing minerals contained in basaltic rocks. At neutral to alkaline pH, Cr leaching from rock is limited and Cr(III) concentrations may be further reduced and controlled by solubility of Cr(III)-Fe(III) mineral phases. However, Cr(VI) mobility is enhanced associated with decreasing importance of mineral surface complexation. Indeed, Cr(VI) was frequently found to dominate over Cr(III) at pH>6 in concentrations of a few µg/L.

Deformation mechanisms in Martian Shergottites

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Nakhla and Zagami are both clinopyroxene-rich basaltic shergottite, with some Fe-rich olivine. The microstructure, the preferred orientation of pyroxene using Electron Backscatter Diffraction (EBSD) method and the geochemistry are combined to study subsamples of both Zagami and Nakhla to decipher deformation processes that have occurred on Mars.

Nakhla displays a granular texture, essentially composed of augite, fayalite, plagioclase and magnetite. Our Zagami sample, formed by olivine, plagioclase, and whitlockite is part of the "coarse grained" portion of Normal Zagami texture [1, 2] with long prism of clinopyroxene underlying a weak preferential orientation. Complete maps of both Zagami and Nakhla samples and detailed maps of clinopyroxene single grains were obtained with EBSD. Both samples show a strong preferred orientation of clinopyroxene and CPOs display several point concentrations on <001> axes within a girdle. The relationship between the microstructure and CPOs inferred the possible activation of (100)[001] and (010)[100] slip systems. Moreover, the several point concentrations on clinopyroxene <001> axis might correspond to twinning.

Geochemical maps of clinopyroxene single grains highlight chemical zoning from augite core to pigeonite rims. Phases indexation with the EBSD is concordant with the geochemistry and highlights no variation in the slip system from cores to rims, suggesting either no variation of deformation during the evolution of the geochemical system, or a late deformation event. Inspection of clinopyroxene single grains show that Nakhla clinopyroxenes have almost no internal deformation, rather than Zagami clinopyroxenes showing complicate microtexture with possible activation of several slip systems.

Our results suggest a composite deformation related to magmatic deformation (preferred orientation and prismatic clinopyroxene) and to the shock event (single grain internal deformation and twinning).

[1] Stolper E. M. *et al.* 1979. *Geochimica Cosmochimica Acta*. **43**: 589-602. [2] McCoy T. J. *et al.* 1992. *Geochimica Cosmochimica Acta*. **56**: 3571-3582.