



Mechanisms of quartz dissolution and cement precipitation at high pH and low temperature surface conditions

Lisa de Ruiter (1), Håkon Austrheim (1), Anette E. Gunnæs (2), and Dag K. Dysthe (1)

(1) Physics of Geological Processes, University of Oslo, Norway (l.d.ruiter@fys.uio.no), (2) Department of Physics, University of Oslo, Norway

Weathering of ultramafic rock under subarctic conditions leads to the formation of high pH and Mg-rich fluids at Earth's surface. Felsic minerals are prone to dissolution under such conditions. Evidence from eastern Norway where felsic till covers an ultramafic complex shows that quartz at the surface dissolves 3-4 orders of magnitude faster than at average surface conditions. Subsequently, this rare combination of quartz and ultramafic rocks results in the replacement of quartz by a nanocrystalline Mg-silicate cementing phase. This phase is similar to man-made M-S-H (magnesium silicate hydrate) cement, which is currently of interest as an alternative CO₂-neutral cement but not yet developed for commercial use.

The high pH fluid originating from the ultramafic complex results in conditions in which quartz is far out of equilibrium and can dissolve. The dissolution of the quartz starts at subgrain boundaries, leading to the fracturing of the quartz in a remarkable honeycomb texture and surrounds the subgrains by the Mg-silicate precipitate. Where the subgrains have dissolved completely, a honeycomb shaped pore space is left behind. With transmission electron microscopy, an amorphous silica layer with a thickness of 100 nm on the quartz surface was observed. We suggest that the amorphous silica is a product of dissolution and reacts with the Mg-rich fluid to precipitate the Mg-silicate cement, allowing for further quartz dissolution and the complete replacement of quartz by cement.

Our findings shed new light on fluid-rock interactions at high pH and low temperature surface conditions. We follow the dissolution-precipitation process from the origin of the fluids to the precipitation of the Mg-silicate gaining a better understanding of the processes controlling reaction rate and mass transport. Our study also provides new insights contributing in the development of CO₂-neutral industrial cement.