Chemical weathering of fast weathering silicate rocks on Stjernøya in Northern Norway

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Slow weathering minerals contribute via kinetically controlled reactions to the composition of surface waters (quartz, feldspar, mica). In contrast, solubility limits the input by fast weathering minerals such as calcite. The silicates nepheline ($NaAlSiO_4$), olivine (forsterite Mg_2SiO_4) and An-rich plagioclase ($NaCaAl_3Si_5O_{16}$) are transitional between kinetic and solubility control.

In the Seiland Igneous Complex (SIC) of N Norway ultramafic rocks, nepheline syenite and gabbro cover large outcrop areas together with local carbonatite. In an extensive sampling campain we collected water and rock samples within the nepheline syenite underground mine of Northcape Minerals AS in addition to lake and stream water and rock samples. The comparison of the data of 62 water samples from the most reactive silicate rocks (RSR) with carbonatite (very fast) and granite (very slow) permits the derivation of relative field derived weathering rates.

Surface water develops very distinct composition patterns after very short flow path in the catchments of all RSR (< 100m). The total of dissolved solids (TDS) is highest in carbonatite catchments followed by nepheline syenite, then various distinct varietes of gabbro and finally lowest in ultramafic rocks containing olivine. TDS in water from granitic catchments is lower by an order of magnitude compared to RSR.

Calcite saturation is reached in carbonatite catchments after extremely short flow distances leading to karst and biotite-enriched weathering surfaces. In dunite and other olivine-bearing ultramafic rocks olivine dissolves congruently and no secondary weathering products such as serpentine develops. The waters always remain undersaturated with respect to olivine. Nepheline dissolves rapidly and Na- and K-zeolites such as natrolite and phillipsite are ubiquitous on water-conducting fractures of the nepheline syenite mine from 200m below surface downward. The chemical evolution of the water migrating downward shows that it is completely contolled by nepheline alteration.

Water in gabbro catchments is primarily contolled by plagioclase weathering but additional mineral in some of the gabbros such as olivine contribute to the water composition pattern. Molal Ca/(Ca+Na) increases with TDS in waters from all gabbro units to about 0.4-0.5 indicating that rainwater (0.1) is modified by plagioclase dissolution. Water samples from road tunnels through gabbro units have high-pH (9.4) as a result of silicate dissolution. Fractures are coated with Ca-zeolites in contrast to the nepheline syenite.