Temporal isotopic variations of dissolved silicon in a pristine boreal river

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Interest in quantifying the biogenic impact on the terrestrial biogeochemical Si cycle has increased significantly since biological control has been suggested. Previous observations of isotopic fractionation of Si during biogeochemical and geochemical processes imply that seasonal dissolved Si isotopic patterns in rivers have the potential for use in extracting information about the riverine- and terrestrial biogeochemical Si cycles.

Therefore, variations in the isotopic composition of dissolved riverine Si were investigated for the Kalix River, Northern Sweden, one of the largest pristine rivers in Europe, based on high-frequency sampling during a period of 25 weeks from early April to early October 2006. Temporal variations spanning 0.4‰ for δ^{29}Si and 0.8‰ for δ^{30}Si of dissolved Si in the Kalix River were observed during the period, suggesting that the riverine Si input to the oceans cannot be considered to have a constant Si isotopic composition even on a short time scale.

The results implicate biogeochemical Si-cycling via formation and dissolution of biogenic silica as major processes controlling the Si transport in boreal systems. The Si budget in the river system appeared to be controlled by relative Si accretions during high discharge events and relative Si depletions in the subarctic mountainous and lake dominated areas. There were also temporal variations in Si isotopic composition with accretion (relative Si contribution), accompanied by depletion of the heavier Si isotopes, while the opposite trend was observed during periods of riverine Si depletion. These isotope variations can be explained by release of plant derived silica, depleted in heavier Si isotopes, during the spring snowmelt. Further, increased volumetric contribution from the headwater and losses of Si due to biogenic silica formation by diatoms in the subarctic lakes at a later period are expected to be responsible for the preferential losses of lighter isotopes. These conclusions are further verified by land cover analysis.

Metasomatic crystallisation of sapphirine during Mg-enrichment of gabbros

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Metasomatism in the Bamble Sector, South Norway, caused scapolitisation and albitisation on a regional scale. Scapolitisation is associated with veining, and transformed metagabbros pervasively over areas of up to 1-2 km^2. The contact between pristine gabbro and scapolitised metagabbro is sharp and observed over distances of only a few mm. The boundary is interpreted to represent a fluid front progressing as an initial hydration (amphibolitisation) followed by Cl-saturation and K-saturation, transforming the gabbro to metagabbro dominated by scapolite ($Me_{19\text{-}42}$), edenite and rutile. Presence of sapphirine, enstatite, and a high content of phlogopite and chlorapatite correlate with intense scapolitisation in the vicinity to the fluid channels. Studies on the mineral replacement reactions and the mineral chemical evolution constrain the composition of the scapolitising fluid to be a hydrous volatile rich in Cl, P, and K, enhancing enrichment in Mg and depletion of Fe.

The sapphirine ($(Mg_{3.4}Fe_{0.1}Al_{4.5})(Al_{4.5}Si_{1.5})O_{20}$) occur as tiny needles (< 0.02 mm) in scapolite. Its crystallisation is observed related to the replacement of plagioclase ($(Na_{0.5}Ca_{0.5})(Al_{1.5}Si_{2.5})O_8$) to scapolite ($Na_3Ca_1Al_{3.8}Si_{8.2}O_{24}(Cl_{0.9}(CO_3)_{0.1})$), consuming the excess Al released during the mineral reaction. The reaction can in a simplified form be written:

Plagioclase + Mg + Cl = sapphirine + scapolite

The scapolitisation cause a typical Mg-enrichment of the rock, stabilizing the Mg-rich end member of the mafic phases phlogopite (#Mg=0.95), amphiboles (#Mg=0.81-0.87) and enstatite (#Mg=0.95-0.96). The occurrence of sapphirine during scapolitisation show that the Al-Mg-phase can form in gabbro during strong Mg-metasomatism. Mg-rich rocks as cordierite-anthophyllite-schists occur along the margins of the metagabbros, and are interpreted as result of Mg-enrichment of gabbro during metasomatism.