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Weathering, Transport and Sedimentation of Rare Earth Elements and Nd-isotopes in a Boreal River Basin – Brackish Bay Area

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The rare earth elements (REE) are widely recognised as excellent tools exploring low temperature geochemical reactions taking place in rivers and estuaries (Sholkovitz, 1995). We report a summary and discussion of both new and previous results from our detailed work on the weathering and transport of REE in a large boreal catchment, the Kalix River drainage basin in northern Sweden.

The REE belong to the most depleted elements during weathering of till in northern coniferous areas and the REE mobilisation also yield a fractionation between light REE (LREE) and heavy REE (HREE). In northern Sweden the till is dominated by 1.9-1.8 Ga granitic material and it was found that during the c. 8700 years of weathering since the glacial ice left the area, between 69 and 84% of the LREE and between 54 and 79% of the HREE have been released from the weathering horizon (Öhlander et al., 1996). The selective weathering yields a LREE enriched pattern for the fraction released from the soil which results in increased Sm/Nd ratios with time in the weathering profile. This imply a decoupling of the weathered/released Nd isotopic signal ($\varepsilon_{Nd(0)}$) from that of the bulk soil (Öhlander et al., 2000).

River water was sampled weekly during 18 months for filtered water (<0.45μm) and suspended particles (>0.45μm) and also Cross Flow Filtration for separation of colloidal particles from the solution fraction (<3 kD, 3000 dalton molecular weight) was carried out. The filtered REE showed large seasonal and temporal variations. The Nd-concentration varied by a factor of ten, between 200 pmol/L to 2100 pmol/L, with a strong relation between high discharge and high concentration. The REE in the Kalix River is mainly transported on particles (>90%), dominated by a colloidal phase primarily composed of organic C and Fe. The colloidal fraction shows a LREE enriched pattern, whereas the solution fraction showed HREE enrichment (Ingri et al., 2000). No significant annual variation in filtered water $\varepsilon_{Nd(0)}$ was observed, with no obvious relationship to Nd-concentration and discharge. The $\varepsilon_{Nd(0)}$ in the river water is significantly lower than in both the unweathered till and average bedrock in the basin and show a closer resemblance with the $\varepsilon_{Nd(0)}$ found in humic substances and plant material. This suggests that the isotopic composition of Nd exported from a large boreal drainage basin is controlled by selective weathering and does not directly reflect that of the bulk bedrock. The absence of significant temporal variation in $\varepsilon_{Nd(0)}$ in river water, and the resemblance with the isotopic characteristics of the humic material from the soil horizons, suggest that the REE transported in the river originates from a common type of source, most likely organic bound REE from the uppermost soil horizons.

The Kalix River empties into the northernmost Baltic Sea, the Gulf of Bothnia, where sediments such as ferromanganese concretions are enriched in REE (2-5 times compared to average shale) (Ingri and Pontér, 1987). The concretions exhibit an preferential enrichment of LREE with smaller concretions being more enriched, with the specific surface area of the concretion as a key factor governing the REE enrichment. It is suggested that the river-born suspended fraction, rich in Fe and organic material, is a conveyer mechanism for the REE transfer to the sediments. However, in the brackish water also release of REE from river-borne particles can be a potential source for REE in the Baltic Sea water and for export to the oceans.

Comparison of REE patterns and $\varepsilon_{Nd(0)}$ from weathering profiles, river water, brackish water and sediments will be presented and interpreted in terms of fractionation and transport from the continental source regions to deposition in the marine environment.

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