Fractionation of Sm-Nd isotopes during weathering of till

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Weathering of till in northern Sweden results in the formation of well-developed spodosols. The till is in most cases dominated by granitic material, and most of the Zr can be expected to occur in the mineral zircon, $ZrSiO_4$, which is resistent to weathering. Relative to the immobile element Zr, only organic matter has been enriched in the E-horizon. All other elements including Ti have been depleted to varying degree in the E-horizon. The *REE* are among the elemenst most strongly depleted, and the loss of *REE* from the E-horizon decreases as the atomic number increases. During 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 E-horizon (Öhlander *et al.*, 1996).

There is a broad correlation between the age of the terranes that supply Nd to the oceans, and the Nd isotopic characteristics of seawater (e.g. Goldstein and Jacobsen, 1987). The pattern with decreasing loss of *REE* during weathering leads to a change of the Sm/Nd ratios, which potentially could lead to a change of the Nd isotopic composition. Such an isotopic fractionation would indicate that the Nd isotopic composition of the riverborn transport of Nd to the oceans not necessarily in detail directly reflects that of the bedrock. To study if weathering leads to a fractionation of Nd isotopes, we have analysed the Nd isotopic composition of the various horizons including living plants and humus of two profiles of weathered till (typic haplocryods) in northern Sweden. The E-horizon samples represent the uppermost 3–4 cm of the soil profiles, the B-horizon samples were taken at a depth of 30–40 cm, and the C-horizon samples were taken at a depth of *c.* 1 m.

The C-horizon samples of the till from the sampling stations 88904 and 88917 have $\varepsilon_{Nd(0)}$-values of −22.1 and −23.2, respectively, very similar to the values of Palaeoproterozoic granitoids dominating the bedrock in the area. The uncertainty of the analyses of the till samples is *c.* 0.4 ε-units. For station 88904, assuming that Zr is immobile, 65.6% of the total amount of Sm have been lost from the E-horizon, and 68.7% of the Nd. The Nd thus has been lost to a slightly higher degree than Sm, resulting in a change of the Sm/Nd ratio from 0.198 to 0.218. This has also resulted in a change of the Nd isotopic composition illustrated by a change of $\varepsilon_{Nd(0)}$ from −22.1 to −18.1 (Fig. 1). The sample of the B-horizon has lost 32.5% of the Sm and 32.7% of the Nd but the Sm/Nd ratio is almost unchanged; 0.198 in the C-horizon and 0.199 in the B-horizon. The $\varepsilon_{Nd(0)}$ values are therefore almost identical with values of −22.3 and −22.1 for the B- and C-horizons, respectively.

Both plants and humus have lower Sm/Nd ratios and more negative $\varepsilon_{Nd(0)}$ values than the soil samples. This is illustrated in Fig. 1 where a linear trend with the E-horizon and organic samples displaced on the different sides of the original soil value is evident. This pattern fits with an interpretation where the Sm

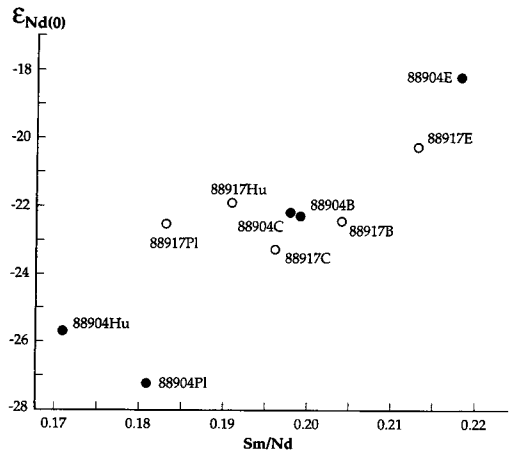

FIG. 1. $\varepsilon_{Nd(0)}$ *vs* Sm/Nd for samples from the stations 88904 and 88919. E = sample from the E-horizon, B = sample from the B-horizon, C = sample from the C-horizon, Hu = sample of the humus, Pl = sample of plants.

and Nd taken up by the plants have the isotopic characteristics of the amounts of these elements released by weathering in the E-horizon.

The situation is similar for station 88917. In the E-horizon 73.3% of the Sm and 75.3% of the Nd have been lost, resulting in an change of the Sm/Nd ratio from 0.196 to 0.213. This in turn has resulted in a change of $\varepsilon_{Nd(0)}$ from −23.2 to −20.2. In the B-horizon sample, 53.0% of the Sm and 54.7% of the Nd were lost during weathering, which changed the Sm/Nd ratio from 0.196 to 0.204 and $\varepsilon_{Nd(0)}$ from −23.2 to −22.4. The E-, B- and C-horizon samples define an almost linear trend in Fig. 1, whereas the samples of plant and humus at this station are displaced towards lower Sm/Nd ratios at a certain $\varepsilon_{Nd(0)}$ value.

One sample of the 'dissolved phase' (<0.45 μm) of the Kalix River, which drains the area where the till stations are located, has an $\varepsilon_{Nd(0)}$ of -25.1 ± 0.5. Although the data base is small, the results allow the conclusion that there is a fractionation of Nd isotopes during the weathering of till, and indicate that it is possible that the isotopic characteristics of the riverborn Nd correspond to the Nd released by weathering rather than to bedrock or unweathered till.

The explanation to the isotopic fractionation in the till is that a larger proportion of the Nd released by weathering, is released from minerals with a lower Sm/Nd ratio than the bulk soil, compared with the amount released from minerals with a higher Sm/Nd ratio. Although the various *REE*-carrying minerals had the same initial Nd isotopic composition, 1.8−1.9 Ga of decay of ^{147}Sm to ^{143}Nd has resulted in a higher present $^{143}Nd/^{144}Nd$ ratio in the minerals with a higher Sm/Nd ratio.

References

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