High-precision HFSE partitioning between garnet, amphibole, and alkaline melt, Kakanui, New Zealand

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The high field strength elements (HFSE: Zr, Hf, Nb, Ta) are an important group of chemical tracers that are increasingly used to investigate magmatic differentiation processes. Successful modeling of these processes requires accurate mineral-melt partition coefficients (*D*). To date, these have largely been determined by ion microprobe or laser ablation-ICP-MS analyses of the run products of high-pressure, high-temperature experiments. Since HFSE are (highly) incompatible, relatively immobile, and high-charge, these experiments and their analysis are challenging. Here we explore whether high-precision analyses of natural phenocryst-host melt systems can provide improved constraints on HFSE partitioning.

We have determined HFSE concentrations in natural garnet and amphibole phenocrysts and their nephelinite host melt from Kakanui, New Zealand with high precision isotope dilution (^{180}Ta-^{178}Hf-^{176}Lu-^{94}Zr mixed spike) on a Neptune multi-collector-ICP-MS at VU University Amsterdam. Major and trace element compositions, as well as Lu-Hf isotopic compositions were also determined to assess phenocryst-host melt equilibrium and to provide context for the HFSE *D* value measurements. The garnet and amphibole phenocrysts and host melt have identical initial ^{176}Hf/^{177}Hf isotopic compositions, and rare earth element *D* values plotted as a function of ionic radii show classic near-parabolic trends that are in excellent agreement with crystal-lattice strain model expectations. Both observations strongly suggest full equilibrium between phenocrysts and melt.

High-precision isotope dilution results for Zr and Hf in garnet (D_{Zr} = 0.211±0.006 and D_{Hf} = 0.208±0.007 [2σ]), and for all HFSE in amphibole are consistent with previous experimental findings. However, our measurements for Nb and Ta show that conventional methods may overestimate Nb and Ta concentrations in garnet (Ta concentrations in Kakanui garnet range from 5-9 ppb), thereby overestimating both Nb and Ta absolute *D* values for garnet by up to 3 orders of magnitude. As a consequence, the role of residual garnet in imposing Nb/Ta fractionation may be less important than previously thought.

Determining amounts and timing of soil erosion using *in situ* cosmogenic ^{14}C and ^{10}Be

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The sustainable use of soils represents one of the key challenges that society faces. We test whether cosmogenic ^{14}C and ^{10}Be depth-profiles can be used to determine amounts and timing of soil erosion on a soil formed on a Younger Dryas moraine in Scotland. The cosmogenic exposure age of a boulder on a moraine is an estimate of the moraine's age and an uneroded soil/till on the moraine must have the same cosmogenic nuclide inventory as the boulder. Any shortfall in the soil/till material cosmogenic nuclide inventory is therefore a measure of erosional loss. ^{10}Be, given its long half-life relative to Holocene timescales, can only show the erosional loss, whereas *in situ* ^{14}C, with a substantially shorter half-life, can also discriminate between the various timings of surface erosion (Fig. 1).

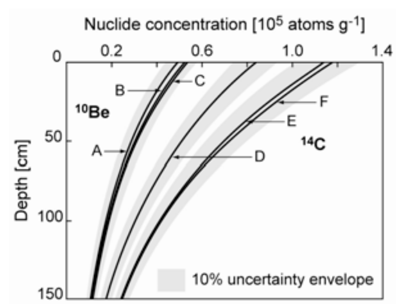

Figure 1: Conceptual depth-profiles of ^{10}Be (A,B,C) and ^{14}C (D,E,F) on 10.5 ka till for erosion of 10cm of topsoil at: (A,D) 0ka (last few centuries), (B,E) 4ka, and (C,F) 6ka.

^{10}Be exposure dating of two boulders confirms the Younger Dryas age of the moraine (10.5±0.9 ka). Eighteen ^{10}Be determinations in till material of varying size fractions from a 240 cm pit from the moraine crest confirm that the cosmogenic nuclide depth-profile from a sediment body of Holocene age can be reconstructed and, thus, the technique can be applied for estimating amounts and timing of at-a-site Holocene soil erosion. The ^{10}Be results in the till samples suggest no grain-size effects and also that muogenic production is negligible. The *in situ* ^{14}C measurements in the pit material are in progress.