Alpha recoil loss from baddeleyite evaluated by depth profiling and numerical modelling: Implications for U-Pb ages

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Advances in analytical methods allow precise U-Pb analyses of very small baddeleyite crystals with thicknesses of less than 10 microns. Baddeleyite crystals typically have a tabular habit with high surface area to volume ratios for which the effects of alpha recoil loss may result in a systematic age bias. The magnitude of alpha recoil in baddeleyite was evaluated by depth profiling using a SHRIMP ion probe on polished and unpolished surfaces of Phalaborwa baddeleyite crystals. Analyses consisted of 50 measurement cycles of five masses, ^{197}Au (proxy for surface Pb), ^{204}Pb, ^{206}Pb, ^{238}U and ^{254}UO over a depth of 400 nm. Secondary beam normalized U and UO counts increase with depth for both polished, but more significantly for non-polished grains, and do not provide a reliable measure of U concentration with depth. The difference may be due to surface effects in non-polished material. Depth-related changes in UO/U and Pb/U were corrected based on a correlation of Pb/U and UO/U, similar to that employed for U-Pb calibration in zircon. Depth profiles of the polished grain interiors show no variation in corrected Pb/U ratio with depth. In contrast, analyses on non-polished crystal faces indicate significantly lower Pb/U in the first 50 nm (20-30% lower at 20 nm) with no significant variation below 50-60 nm. The profiles indicate measureable alpha recoil loss to depths of about 50 nm in baddeleyite. Modelling of the profiles yields an estimate for the average recoil displacement of about 30 nm, similar to that of zircon. Therefore, alpha recoil loss should be significant at the 0.1-1.0% level for ^{206}Pb/^{238}U ratios in the smallest analyzed crystals reported in the literature and is a likely explanation for associated discordance. Since differential alpha recoil effects on ^{207}Pb and ^{206}Pb are at least an order of magnitude smaller than total losses, ^{207}Pb/^{206}Pb ages should not be significantly biased.

^{186}Os-^{187}Os systematics of EM and HIMU flavours

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Controversy surrounds the interpretation of ^{186}Os-^{187}Os enrichments in ocean island basalts (OIB). Originally suggested as evidence for core-mantle interactions [1], alternate models have been proposed that include melting of pyroxenite-peridotite mixtures, or base metal sulphides (BMS), with long-term (Re+Pt)/Os enrichment [2]. Ultimately, alternative models are reliant on crustal recycling and upper mantle metasomatic processes. To test between the hypotheses, we have targeted OIB spanning a range of compositional 'flavours' recognised in Sr-Nd-Pb isotope space, and that are considered to be the products of variable recyling and metasomatism [3].

New coupled ^{186}Os-^{187}Os and highly siderophile element (HSE; Os, Ir, Ru, Pt, Pd, Re) data are presented for a suite of EM2-type Samoan and HIMU-type Canary Island lavas. Samoan lavas are considered to derive from a source dominated by peridotite with some sediment, and little or no eclogitic component. They span a limited range of ^{187}Os/^{188}Os (0.127-0.132), with relatively high Os abundances (0.08-5.6 ppb) [4]. Canary Island lavas are some of the most radiogenic OIB ever measured for ^{187}Os/^{188}Os (0.132-0.175), and have Os contents <1.1 ppb [5]. Neither island group shows evidence for derivation from an HSE-depleted source. Despite radiogenic ^{187}Os/^{188}Os, Canary Island lavas have ^{186}Os/^{188}Os ratios within the upper mantle range; collection of the first ^{186}Os-^{187}Os data for Samoan lavas is in progress.

The Os isotope systematics of Canary Island lavas suggests a mantle source with long-term high Re/Os, but with no corresponding Pt/Os enrichment. Combined, these characteristics are consistent with a mantle source containing variable proportions of recycled material within a peridotitic, depleted-MORB mantle. Addition of BMS can neither explain the coupled ^{186}Os-^{187}Os systematics, or the coherent O-Os isotope variations of Canarian lavas [5]. Additional analysis of the 'flavours' will shed further light on the generation of coupled ^{186}Os-^{187}Os enrichments in OIB.

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