Nitrogen-Helium-Argon isotope relationships in subglacial glasses from Iceland's Neovolcanic zones

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Nitrogen isotopes in Ocean Island Basalt (OIB) glasses show positive values, up to +6 ‰, which has led to ideas on ancient nitrogen recycling from the surface to the deep mantle [1]. If indeed the source of the N is the deep mantle then there should be correspondence between the highest primordial noble gas signatures (i.e. highest $^{3}He/^{4}He$ ratios) and the positive $\delta^{15}N$ signatures. However, the current database of $\delta^{15}N$ from high $^{3}He/^{4}He$ OIB is limited. Given the excellent exposure of fresh and glassy material, Iceland remains one of the few hotspot localities where this hypothesis can be tested in detail.

We report new high-precision nitrogen isotope data for 34 geochemically well-characterized subglacial basaltic glasses using newly developed methods at Scripps [2]. The glasses, which cover all the currently- active volcanic zones of Iceland, span a wide range in helium isotope (8-26 R_A) but show rather limited $^{40}Ar/^{36}Ar$ ratios (298-1330) [3]. N-isotopes in samples with sufficient, i.e., detectable, N_2 (> 2 $\mu cm^3STP/g$) range from -2.9 ‰ to +6.2 ‰. To avoid samples potentially affected by degassing-induced isotopic fractionation and/or air interaction, we have filtered the $\delta^{15}N$ dataset using $^{4}He/^{40}Ar^*$ ratios to identify (and remove) highly degassed samples (n= 8). In contrast to He-isotopes, there appears to be no spatial control on the filtered $\delta^{15}N$ dataset; however, we note the dominance of positive values in the Eastern Rift Zone.

We investigate simple binary He-N_2 isotope mixing and show that these data can be explained with K mixing values ($K= (N/He)_{MORB}/(N/He)_{PLUME}$) between 1 and 50 indicating that the high $^{3}He/^{4}He$ signature may in fact be coupled with a high $\delta^{15}N$ endmember [4] that has either i) lost He before mixing with the MORB endmember, similar to the two-step model of He depletion followed by open-system degassing developed by [3], and/or ii) excess N_2. We speculate that the high $\delta^{15}N$ endmember needed to explain these mixing relationships strongly suggest recycled N-components in the Icelandic mantle.

[1] Marty & Dauphas, (2003) *EPSL*, [2] Barry et al., (2012) *G-cubed*, [3] Füri et al., (2010) *GCA*, [4] Prade et al., (2009) AGU.

The accessory mineral record of metamorphism and protracted melt crystallization in a metamorphic core complex

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Partial melting during high grade metamorphism is an important mechanism of crustal differentiation. In the northern East Humboldt Range metamorphic core complex of Nevada, USA, Late Cretaceous high grade metamorphsim and leucogranite intrusion was followed by decompression, resulting a steep P–T path segment across fluid absent dehydration melting melting reactions in aluminous pelites.

U/Th-Pb and trace element SHRIMP analyses of zircon and monazite from metapelites indicate a complex metamorphic and partial melting history that includes protracted zircon crystallization and 3–4 chemically distinct phases of monazite growth in each sample. Monazites from within the Winchell Lake nappe (WLN) show moderate Y cores, low Y/higher Th mantles, and high Y rims, giving Th-Pb ages of ~84 Ma, 72–63 Ma, and 30–40 Ma respectively. Monazites from lower structural levels (beneath the WLN) commonly show irregularly-shaped low U cores that give Jurassic–Early Cretaceous Th-Pb ages. These cores may constitute the only evidence for an earlier Mesozoic metamorphic event in the East Humboldt Range. Chemical zoning patterns are generally similar to WLN monazite, but Cretaceous monazite core growth began >10 m.y. earlier. Higher U cores/mantles from these monazites fall in two age groups, near 96 Ma with low Y, and near 84 Ma with more moderate Y. High Y monazite from a sillimanite-bearing leucosome gives a weighted mean age of 83 ± 2 Ma, interpreted to represent leucosome crystallization beneath the WLN. Thin, higher Y monazite rims beneath the WLN give ages near 71 Ma and 35 Ma.

Zircons from migmaties within the WLN give concordant U-Pb ages spanning from 78–61 Ma, interpreted to represent protracted crystallization of in situ anatectic melt. Zircon grown during melt crystallization, in both leucosome and melanosome domains, shows a moderate depletion in heavy rare earth elements (HREE). This is consistent with growth during melt crystallization and resorption of observed HREE-depleted garnet on the decompression and cooling path. Garnet zoning patterns suggest fairly rapid cooling from peak temperature conditions (~750°C, 7 kbar), evidenced by relatively narrow diffusion profiles for resorbed garnet that back-reacted with melt. A lack of significant residual alkali feldspar and muscovite indicates that a large portion of the anatectic melt was lost from the system.

Zircon U-Pb and Ti data from the WLN are consistent with an extended presence of small amounts of melt at near-solidus conditions (~680°C, 5 kbar) for nearly 15 million years, suggesting that cooling nearly ceased at these conditions and melt-enhanced ductile flow did not occur at this time in the East Humboldt Range. As a result, retrograde net transfer reactions involving melt or a residual fluid phase are limited (1) kinetically, by grain boundary and volume diffusion, and (2) by the evolution of the reactive bulk compositon due to segregation and crystallization of anatectic melt.