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Low H_2O/Ce in Icelandic basalts as evidence for crustal recycling

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The generation of new crust at mid-ocean ridges is balanced by the subduction of partially hydrothermally altered basaltic material back into the mantle. This subducted material may then be recycled and returned via mantle plumes to the Earth's surface at hot spots. Long-identified isotopic and trace element signatures of oceanic crust recycling in ocean island basalts (OIBs) have been recently supplemented by evidence of major element, i.e. lithological, heterogeneity in the melting region. For example, combined major and trace element systematics from Iceland suggest that the mantle source contains at least 5% recycled basalt. Observations of high water (H_2O) contents in subglacially quenched basalts from Iceland have previously been attributed to the incorporation of wet recycled material into the mantle source. However, when combined with trace element analyses, recent volatile analyses from the Laki-Grímsvötn and Bárðarbunga-Veiðivötn systems in the Eastern Volcanic Zone (EVZ) of Iceland suggest that the underlying mantle is comparatively depleted in H_2O for its degree of major and trace element enrichment.

Correlations between H_2O and cerium (Ce) within individual mid-ocean ridge basalt (MORB) suites reveal that these elements partition similarly prior to H_2O degassing at low pressures; H_2O/Ce remains constant during melting and fractionation, and hence reflects the average H_2O/Ce of the melting region. MORBs from the Mid-Atlantic Ridge south of Iceland have a mean H_2O/Ce value of 304 ± 48 at a mean La/Yb of 2.1 ± 1.5. In contrast, basalts from the EVZ have a lower mean H_2O/Ce of 180 ± 20 at a higher mean La/Yb of 3.1 ± 0.5. Thus, despite coming from an enriched section of the Mid-Atlantic ridge in terms of trace element content, basalts from the EVZ have the lowest H_2O/Ce values known from the ridge, and are hence comparatively depleted in H_2O. Given that H_2O/Ce from un-degassed basalts is considered to represent mantle source values, we suggest that low H_2O/Ce values in the EVZ reflect the efficient dehydration of recycled crustal components: H_2O and Ce are more readily decoupled during the subduction of altered oceanic crust than during the generation and evolution of primitive basalts. F and Cl are also decoupled during subduction, with Cl being preferentially lost into the mantle wedge during dehydration, providing an explanation for the low Cl/F values of EVZ basalts in contrast with basalts from the Mid-Atlantic ridge. Low H_2O/Ce (and Cl/F) values in basalts from the EVZ thus provide further evidence for a recycled basalt component in the mantle beneath Iceland.