Basaltic Cannibalism in Iceland

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It is widely understood that assimilation of felsic crust contributes significantly to the generation and evolution of magmas at continental arcs. It is less understood how and to what extent assimilation of mafic crust may contribute to magma formation and evolution at island arcs and mid-ocean ridges. Felsic rocks have lower melting temperatures relative to typical basalt magmatic temperatures, allowing for relatively economical assimilation of these materials. Assimilation of basalt, by contrast, is energetically expensive. Furthermore, the composition of the basaltic crust will be generally similar to the composition of the basaltic magma, giving the crust less leverage over the bulk magma composition upon assimilation. However, the energetic cost of assimilating poorly crystallized hyaloclastite, palagonite, or scoria may be much less than that of assimilating holocrystalline basalt, and if these materials have experienced hydrothermal alteration prior to assimilation there may be distinct, observable isotopic tracers of this process. We present two examples of volcanic systems in Iceland where independent lines of evidence suggest significant assimilation of older basaltic crustal material by younger basaltic magmas. At Lakagigar, in the Eastern Volcanic Zone, anomalously light boron isotope ratios measured in plagioclase-hosted melt inclusions provide evidence for assimilation of hydrothermally altered crust prior to the fissure eruption of 1783-84. At Thrihnukagigur, in the Western Volcanic Zone, multiple populations of plagioclase in surface lavas provide evidence for assimilation of an older scoria cone buried beneath subsequent lava flows. One population of plagiclase in the ~4 Ka surface lavas can be correlated with plagioclase from the buried scoria cone, remnants of which are still present within the now-empty magma chamber, on the basis of crystal morphology and trace element ratios. We propose that such episodes of basaltic cannibalism may be common where intruding magmas form sills due to density contrasts between massive lava flows and scoria, hyaloclastite, or tillite layers buried within the Icelandic crust. Supporting evidence for the occurrence of similar processes in Iceland is provided by seismic and geodetic observations at Eyjafjallajokull, which indicate multiple magma intrusions into mid-crustal sills prior to the 2010 eruption.