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Is formation segregation melts in basaltic lava flows a viable analogue to melt generation in basaltic systems?

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Pahoehoe sheet lobes commonly exhibit a three-fold structural division into upper crust, core and lower crust, where the core corresponds to the liquid portion of an active lobe sealed by crust. Segregations are common in pahoehoe lavas and are confined to the core of individual lobes. Field relations and volume considerations indicate that segregation is initiated by generation of volatile-rich melt at or near the lower crust to core boundary via in-situ crystallization. Once buoyant, the segregated melt rises through the core during last stages of flow emplacement and accumulates at the base of the upper crust. The segregated melt is preserved as vesicular and aphyric, material within well-defined vesicle cylinders and horizontal vesicle sheets that make up 1-4% of the total lobe volume.

We have undertaken a detailed sampling and chemical analysis of segregations and their host lava from three pahoehoe flow fields; two in Iceland and one in the Columbia River Basalt Group (CRBG). The Icelandic examples are: the olivine-tholeiite Thjorsa lava (24 cubic km) of the Bardarbunga-Veidivotn volcanic system and mildly alkalic Surtsey lavas (1.2 cubic km) of the Vestmannaeyjar volcanic system. The CRBG example is the tholeiitic 'high-MgO group' Levering lava (>100? cubic km) of the N2 Grande Ronde Basalt. The thicknesses of the sampled lobes ranges from 2.3 to 14 m and each lobe feature well developed network of segregation structures [1,2,3].

Our whole-rock analyses show that the segregated melt is significantly more evolved than the host lava, with enrichment factors of 1.25 (Thjorsa) to 2.25 (Surtsey) for incompatible trace elements (Ba, Zr). Calculations indicate that the segregation melt was formed by 20 to 50% closed-system fractional crystallization of plagioclase (plus minor pyroxene and/or olivine). A more striking feature is the whole-rock composition of the segregations. In the olivine-tholeiite Thjorsa lava the segregations exhibit quartz tholeiite composition that is identical to the magma compositions produced by the nearby Grimsvotn and Kverkfjoll volcanic systems during the Holocene. The Surtsey segregations have whole-rock composition remarkably similar to the FeTi basalts from adjacent Katla volcanic system, whereas the segregations of the Levering flow are identical to the 'low-MgO group' basalts of the CRBG. Is this a coincidence or does volatile induced liquid transfer, as inferred for the formation of the segregations, play an important role in magma differentiation in basaltic systems?

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