Petrogenesis of basanite-nephelinite glasses from early Kilauea

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A sandstone block S508-R3 dredged from 3879 m depth on the Hilina flank, offshore Kilauea, contains abundant volcanic glass spherules of several types. One type, with 22 analysed spherules that span a substantial range of composition (basanite to nephelinite), has attracted attention because of its unusual compositional features. These include low SiO_2, which decreases further with evolution (42.8 to 37.8 wt%), high alkalis, and very high S contents [1, 2]. The samples are thought to be cogenetic because both major- and trace-element concentrations align along linear trends [1, 2]. To the previously published compositional data we have added Fe^{3+}/Fe^{2+} and S^{6+}/S^{2-} by XANES spectroscopy, H_2O and CO_2 by ATR-FTIR, and further trace-element analyses by LA-ICP-MS, including the compatible and chalcophile elements Sc, V, Cr, Mn, Co, Ni, Zn and Cu.

The extended data tell of an intriguing petrogenesis. The new analyses confirm the linear trends, except for the two most evolved samples. The Rare Earth Elements (REEs) are consistent with fractional crystallization of garnet, rather than garnet control by variable degrees of partial melting. K, Rb, Ba and H_2O are a lot less incompatible than the most incompatible trace elements, which include La, Ta and Th, suggesting involvement of phlogopite. Major elements point also to clinopyroxene, so the suite might record phlogopite-eclogite fractionation. Dissolved CO_2 is high and correlates with the highly incompatible elements, but increases more rapidly, perhaps due to a compositional control on degassing. $Fe^{3+}/\sum Fe$ increases from 0.21 to 0.46, but is only weakly correlated with modestly increasing $S^{6+}/\sum S$ (0.16 to 0.27), which may be due to electron exchange on quenching. For samples ostensibly linked by extensive fractional crystallization in the garnet facies to turn up in the same sandstone block invites incredulity, and we note that the linear trends could be produced by inefficient mixing of two related melts; perhaps primitive melt replenished a magma that evolved at depth by phlogopite-eglogite fractionation.

[1] Coombs et al. (2006) J. Volc. Geotherm Res. 151, 19-49.
[2] Sisson et al. (2009) Contrib. Min. Petrol. 158, 803-829.