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Experimental insights into the origins of aillikites and alnöites

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Ultramafic lamprophyres consist of three types based on the dominant groundmass minerals: carbonate in aillikites, melilite in alnöites, and nepheline/alkali feldspars in damtjernites. Aillikites fill the gap in SiO_2 contents between carbonatites and silicate magmas – compositions that unmix at crustal pressures into carbonatite and nephelinite/melilitite. Aillikites commonly have 20–30 wt% SiO_2 with some below 20 wt% forming a continuum towards carbonatites. They are the closest natural analogue to near-solidus melts found in melting experiments on peridotite with CO_2 and H_2O at 4-6 GPa. Melts between carbonatite and silicate have also been invoked for early-stage kimberlite melts, which gain SiO_2 due to incorporation of lithospheric material during ascent. This raises several questions: (i) Is the compositional similarity of aillikites to experimental melts fortuitous? (ii) If kimberlite melts at 200km depth are also transitional between carbonate and silicate, why do aillikites not also incorporate large amounts of lithospheric material? (iii) Are distinct magma types needed to explain aillikites and alnöites?

We present results of near-liquidus melting experiments on an aillikite from Aillik Bay (21 wt% SiO_2) and an alnöite from Beaver Lake, Antarctica (34.5 wt% SiO_2). Olivine is the liquidus phase in aillikite experiments between 1.1 and 5 GPa. Phlogopite, the other main phenocryst in natural rocks, is present only at ≤ 3.5 GPa and is joined by apatite and Ti-oxides at lower temperatures. The aillikite exsolves H_2O+CO_2 fluid at ≤ 2 GPa, which probably explains yellow/orange coatings on cracks in the field. Carbonates occur only close to the solidus where melts are carbonatitic (≤ 5wt % SiO_2). In the Antarctic alnöite, olivine is also the liquidus phase (1.2- 2.5 GPa), joined by clinopyroxene and phlogopite, with garnet only at 2.5 GPa. These results demonstrate that aillikites are not primary melts and that fractionation drives them to lower SiO_2. Reconstructing fractionation suggests primary melts have >30 wt% SiO_2 but have separate origins from alnöites. The distinction must lie in higher volatile contents for aillikite parental magmas. Although partial melts of peridotites with CO_2 and H_2O are aillikitic in composition, aillikites must have distinct origins.