Combined experimental and geochemical evidence for the origins of Tasmanian intraplate basalts

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A suite of primitive xenolith-bearing basalts from Oatlands in Tasmania, Australia, spans the compositional range olivine nephelinite to olivine tholeiite. The basalts are sodic (with Na/K > 2) and have high concentrations of total alkalis, P_2O_5, Nb and LREE relative to most OIB-type basalts with similar SiO_2 and MgO concentrations. When mantle-normalized, the more alkaline compositions show strong relative depletions in Pb and have high U/Pb similar to basalts of high-μ type. Measured $^{143/144}$Nd for the basalts have a limited range (0.51293-0.51308) whereas $^{87/86}$Sr is more variable (0.703090-0.704681) due to relatively radiogenic Sr in the olivine tholeiite.

Overall, the geochemical data are consistent with the derivation of the original basalt magmas from a relatively uniform peridotitic mantle source that was slightly less depleted in LREE and LILE than the MORB source. However, model calculations made using experimentally obtained mineral/melt partition coefficients for one of the basalts (UT-70489) show that incompatible element concentrations in the nephelinites and basanites are too high for them to have been produced by melting of unenriched peridotites, even if magma production involved infinitesimally small degrees of melting. This contradiction can be explained if melting to produce the magmas was initiated at depths below where the magmas finally equilibrated with their local host rocks. The ascent of near-solidus melts along a sub-adiabatic geotherm would have caused them to partially crystallize and accumulate at shallower depths. Tapping of the residual melts by surface volcanism could then have produced nephelinites and basanites with strong incompatible element enrichments. We have used our partition coefficients to quantitatively model this process and to reproduce the relative and absolute concentrations of incompatible elements in the basanite UT-70489 from a source similar to the MORB source.