Alkalic magmas and the diversity of mantle compositional variation

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As very small degree melts, mafic-alkalic magmas are sensitive tracers of small-scale compositional heterogeneity in the mantle. Some alkalic magmas contain trace element and isotopic signatures indicative of sources dominated by components derived from subducted sediments. Excellent examples of this end member are the alkalic magmas of Italy. In the north, mantle sources for these magmas contain tens of percent subducted sediment whereas in the south, the sources are just overprinted by small volume fluids released from the subducting plate. Many mafic-alkalic and carbonatitic magmas, however, have isotopic compositions that overlap values seen in intraplate oceanic basalts. Along with key OIB-like trace element ratios (e.g. Ce/Pb, Th/Ta) this suggests that these magmas simply represent very low degree (<1%) melts of "normal" mantle. Within this group, there are examples of regional isotopic differences that suggest lithospheric sources. For example, group I kimberlites from South Africa have εNd > +4 whereas similar composition kimberlites from Brazil have εNd < -4. The isotopic compositions of these kimberlite groups, however, also overlap the range seen in slightly older regionally-associated flood basalts, the Karoo and Parana, respectively. This may suggest sources in lithospheric mantle that was metasomatized by melts from compositionally distinct sublithospheric mantle. Mafic-alkalic magmas from Montana have OIB-like trace element characteristics, but extreme isotopic compositions (e.g. εNd often < -15) indicating source metasomatism some 1.8 Ga prior to the Cenozoic magmatism. Low $^{187}Os/^{188}Os$ in potassic ultramafic magmas (kimberlites, katungites, meimechites) point to peridotitic sources whereas more radiogenic Os in Na-rich varieties (e.g. kamafugites, nephelinites) suggest pyroxene-rich sources. Mafic-alkalic magmas appear most commonly in "thermally-limited" settings where melting cannot proceed to high enough degrees to make basalt. Such settings include areas where adiabatic ascent is inhibited by thick lithospheres (cratons, early stages of continental rifting), marginal to plumes in the early and late stage of ocean island formation, the final stages of a dying subduction zone, or in areas of rigid lithosphere where heating can only be accomplished by conduction from below. This marginal melting regime enhances the contribution from easily fusible metasomatic components in the source if they are present.

Implications of a non-chondritic primitive mantle for chemical geodynamics

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Among the compositional components identified in the mantle, most attention has been devoted to those components produced by continental and oceanic crust production and recycling. "Primitive mantle" appears in most models of mantle compositional variation, but usually in the abstract sense in that few, if any, samples of oceanic basalt have all the characteristics expected for a melt of the model primitive mantle that is assumed to have chondritic relative abundances of the refractory lithophile elements. For example, the high $^{3}He/^{4}He$ component may sample a reservoir preserving primitive mantle noble gas characteristics, but at the same time generally has positive εNd and often has Pb isotopic composition plotting well to the right of the Geochron. PREMA, for "prevalent mantle" was coined by Zindler and Hart (1986) early in the investigation of mantle isotopic variation as the most common isotopic component seen not only in ocean island basalts but in both continental and oceanic large igneous provinces and as a component in many intraoceanic island arc lavas. This component largely vanished from the discussion of mantle compositional variation in part because its origin was unclear – it could not be primitive mantle because it did not have chondritic Nd or Hf isotopic composition and it might just be some "most likely" mixture between depleted mantle and enriched recycled components. The elevated $^{142}Nd/^{144}Nd$ of all post-Hadean igneous rocks on Earth, however, suggests that primitive mantle has Nd, and by inference Sr and Hf, isotopic compositions in the realm of what traditionally has been called depleted mantle. We use the trace element characteristics of Baffin Island and Ontong-Java lavas that have isotopic compositions closest to those expected for the non-chrondritic primitive mantle to examine how this reservoir was produced early in Earth history. We also explore the consequences of a non-chondritic primitive mantle for such issues as the relative fraction of DMM and PREMA in the current mantle and the role of the primitive mantle in the origin of the massive volcanism associated with large igneous provinces.