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Anomalous Nd-Hf isotope systematics of southeast Australian alkali basalts reveal multistage depletion-enrichment history of continental lithospheric mantle

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Widespread intraplate volcanism has occurred in eastern Australia since late Cretaceous times. Age-progressive volcanic fields are often linked to the northwards passage of the Australian plate over a putative mantle plume. In contrast, there are also a number of age-independent volcanic fields along the eastern seaboard of Australia that are more commonly linked to melting induced by edge-driven convection. These age-independent volcanic fields coincide with regions of thin lithosphere, elevated topography and slow shear-wave velocity anomalies within the upper mantle. Regardless of the geodynamic trigger for melting, petrological evidence indicates a significant contribution of metasomatised lithospheric domains within the mantle source.

Here, we present new Sr-Nd-Hf-Pb isotope ratios of five age-independent volcanic fields across the state of New South Wales in southeastern Australia: Dubbo, Barrington, Maybole, Jugiong, Bokhara. All samples are primitive alkali basalts (MgO>8 wt%), with minimal modification via crystal fractionation or crustal assimilation. The observed trace element, Sr-Nd and Pb isotope systematics are consistent with moderately incompatible element enriched mantle sources that overlap the global MORB-OIB arrays. Hafnium isotope ratios, however, are elevated above the global MORB-OIB trend and show significant enrichment of eHf relative to eNd. Hf-isotopic compositions are similar over a wide range of eNd, with deviations in eHf as high as 15 above the mantle array for the least radiogenic Nd sample. Intraplate basalt compositions that deviate significantly from the mantle array towards more radiogenic Hf are rare and only one other occurrence, on the Colorado Plateau, is known to us. These peculiar Hf isotope ratios may reflect melting of metasomatically enriched domains within ancient subcontinental lithosphere. Possible metasomatic agents may be small-fraction silicate melts. Alternatively, the melt source could include sediment incorporated into the local continental lithosphere during Palaeozoic orogenic accretion.