

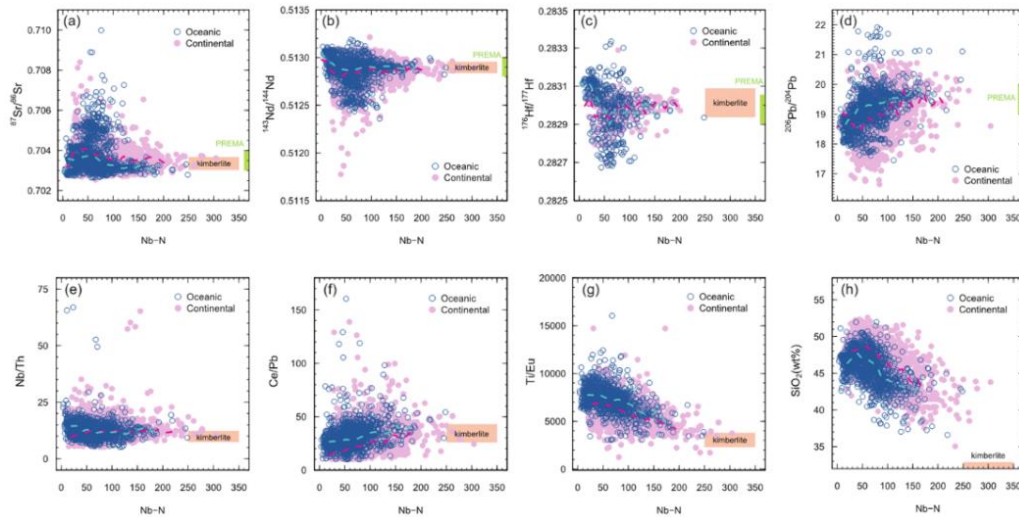
## Kimberlites and basaltic melts as key tracers of Earth’s least processed mantle reservoirs

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### Introduction

Kimberlites along with other low-degree mantle melts are uniquely powerful probes of Earth’s mantle, shedding light on its structure and evolution (Giuliani et al., 2023) and have been shown to share similar isotopic compositions to ocean island basalts (OIBs) (Giuliani et al., 2020). Studies of OIBs have identified a “Prevalent Mantle” component (or PREMA) that appears to represent a common “reservoir” to be mixed into global magma sources (Zindler and Hart, 1986). Recent documentation of this signature in deep-sourced kimberlitic magmatism has increasingly linked PREMA with thermochemical structures (Giuliani et al., 2020) above the core mantle boundary (Large Low Shear-wave Velocity Provinces: LLSVPs). Yet, kimberlites provide geographically limited sampling of Earth’s mantle, which hinders identification of the spatial association between LLSVPs and the PREMA component identified in kimberlites. To further investigate the global distribution of the PREMA mantle component, we utilize a much more widespread class of basaltic magmatism – global Cenozoic alkali basalts, nephelinites and basanites (‘sodic basalts’ hereafter) – that are derived from both continental and oceanic settings.

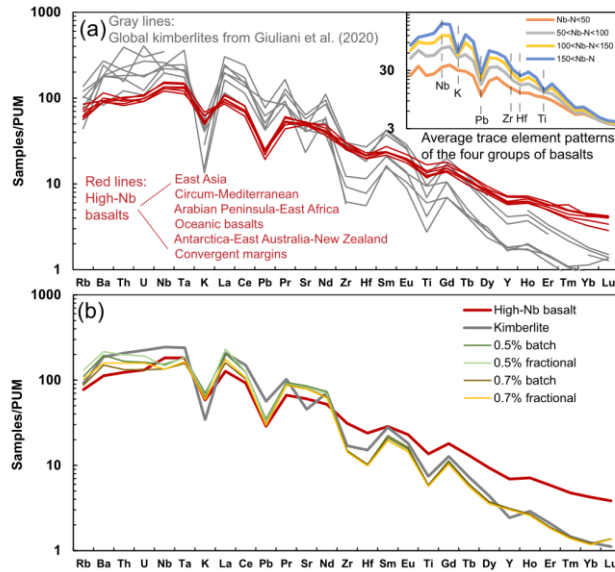


**Figure 1:** Covariation of plots of Nb-N vs (a-d) radiogenic isotope ratios, (e-g) incompatible trace element ratios and (h) silica for Cenozoic sodic basalts from continental and oceanic domains. Nb-N represents Nb concentrations normalised to the primitive mantle value. The dotted curves show median values for continental (red) and oceanic

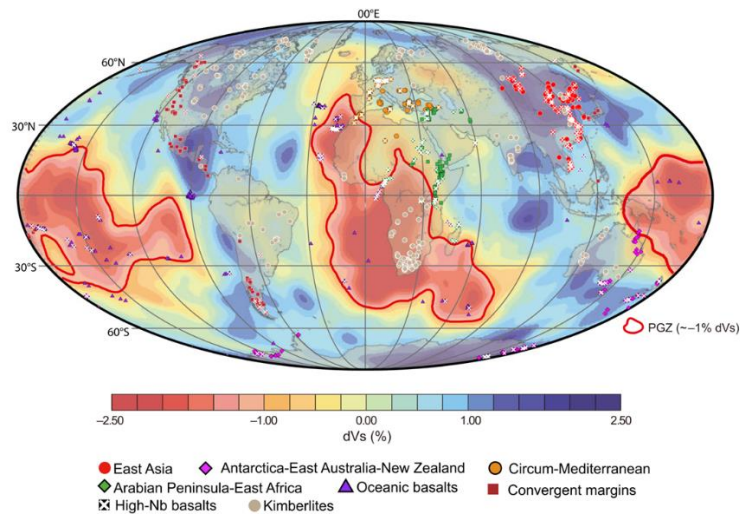
(light blue) sodic basalts based on a binning width of 5 Nb-N units. The kimberlite field is based on primary kimberlite melts for major and trace elements and the depleted kimberlite source for radiogenic isotopes.

## Results

Statistical treatment of the available ~3500 geochemical and isotopic analyses of Cenozoic sodic basalts worldwide, including screening for crustal and lithospheric mantle contamination, shows that at low degrees of melting these magmas exhibit similar trace element and Sr-Nd-Hf isotopic characteristics to the recently identified “depleted kimberlites source” and PREMA (Figure 1) (Cai et al., 2023).



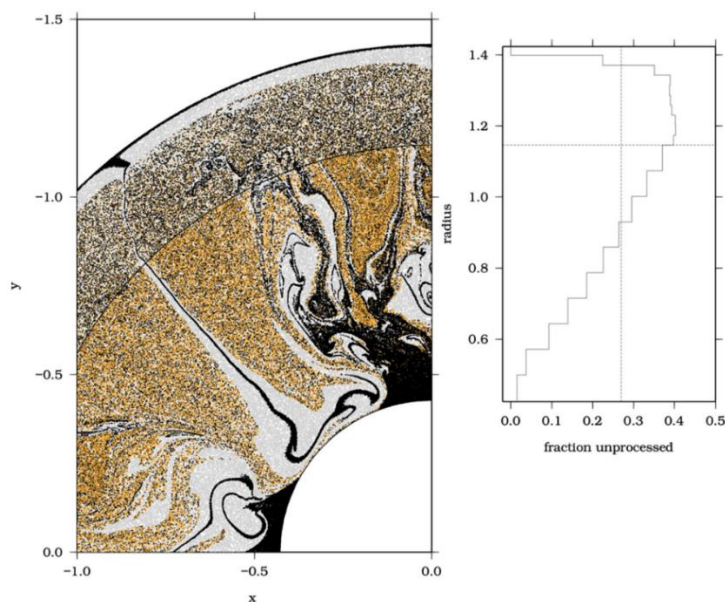
**Figure 2:** Average primitive mantle-normalized trace element patterns of sodic basalts and kimberlites. (a) Average kimberlites and high-Nb basalts (Nb-N>100) from different localities worldwide. The inset shows the average trace element patterns of the four groups of basalts. (b) Results of partial melting model plotted along with the average values of kimberlites and high-Nb basalts.



**Figure 3:** World map showing the global distribution of Cenozoic sodic basalts. The symbols covered by white cross represent high-Nb basalts (Nb-N>100). Shear wave velocity map at the core-mantle boundary (2800km) shows the two Large Low Shear-wave Velocity Provinces (LLSVPs) and plume generation zones (PGZ).

## Discussion and conclusions

Subtle differences between the trace element patterns of kimberlites and low-degree sodic basalts with PREMA-like isotopic compositions can be explained by different degrees of melting of similar mantle sources at different depths (Figure 2), suggesting that low-degree sodic basalts sampled the same source as depleted kimberlites (Figure 1) (Cai et al., 2023). There is no apparent spatial relationship between the distribution of PREMA-like sodic basalts and LLSVPs, implying that the PREMA component is not exclusively associated with LLSVPs (Figure 3). The PREMA-like signature of sodic low-degree basaltic melts occurs in both oceanic and continental magmas, negating an exclusive link to continental lithosphere (Figure 3). Geochemical modelling and mantle convection simulations indicate that PREMA could have been generated soon after Earth accretion, experiencing only minimal melting or enrichment, and then scattered throughout the mantle, including the upper mantle, rather than being the result of mixing between depleted and enriched mantle components (Figure 4). Hence kimberlites and sodic basalts show that PREMA probably represents a widespread fusible component in the mantle that can be mingled with other components at various scales to generate all types of mantle magmatism.



**Figure 4:** Compositional mantle layering predicted by a global-scale mantle-convection model after 4.57 Ga model time. Oceanic crust is shown in black, the depleted mantle is shown in grey and unprocessed mantle (PREMA) is in orange. The diagram on the right shows the present-day depth distribution of the fraction of unprocessed mantle, while the vertical line represents the average fraction of PREMA.

## References

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