Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.15408

Do the different geographic distributions of HIMU and EM mantle domains record later onset of continental crust subduction relative to oceanic crust subduction?

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Subduction contributes heterogeneous material to the mantle. Subducted continental materials give rise to EM (enriched mantle) domains with radiogenic Sr isotopes, while subducted oceanic crust gives rise to HIMU (high $^{238}U/^{204}Pb$) domains with radiogenic Pb isotopes. Oceanic hotspots sampling EM mantle domains ($^{143}Nd/^{144}Nd < 0.5126$) have plume conduits that emerge from the southern hemisphere, suggesting a geographically limited extent for this domain. By contrast, HIMU compositions ($^{206}Pb/^{204}Pb > 20$) are found in hotspots at all latitudes. The relative timing of formation of these compositionally distinct mantle domains may help explain their geographic distribution.

We propose that the geographic confinement of the EM mantle domain in the southern hemisphere is explained by onset of deep continental crust subduction in the late Neoproterozoic, when Gondwana was constructed in the southern hemisphere as a result of continent-continent and arc-continent collisions. Continental crust did not begin entering the mantle until slabs became rheologically stronger in the cooler mantle of the Neoproterozoic, when slab breakoff occurred at depths necessary to transport continental crust past the point of no return, below which continental crust is negatively buoyant in the mantle. Prior to the late Neoproterozoic, continent collisions also occurred in austral and boreal hemispheres, but did not result in significant subduction of continental crust past the point of no return because slabs were rheologically weaker in a hotter mantle and broke-off at more shallow depths before reaching the point of no return. While continental collisions have occurred over the past 300 million years—a period marked by drift of the continents into the northern hemisphere—subducted material requires several hundred years to complete the whole-mantle cycle from subduction zones to mantle plumes, so northern hemisphere hotspots have not yet sampled continental crust recently subducted into the northern hemisphere.

In contrast to deep continental crust subduction, which became more common relatively recently, oceanic crust subduction initiated by the Archean. Oceanic crust subduction has occurred at all latitudes since the Archean, explaining the distribution of HIMU domains at all latitudes. Thus, the different geographic distributions of EM and HIMU domains may related to later onset of continental crust subduction.