The origin of Ferropicrite: High pressure melting of mantle pyroxenite beneath continental lithosphere

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Ferropicrite is a rare primitive magma type, found exclusively in association with continental flood-basalt events, which is of importance for understanding melting of fusible lithologies, such as pyroxenite, in the convecting mantle. Ferropicrite is characterised by high MgO and FeO, low Al_2O_3 and strongly fractionated LREE/HREE ratios (e.g. $[La/Yb]_N$ = 12). Such geochemical characteristics cannot be produced by high-pressure melting of mantle peridotite alone, and indicate the involvement of a more enriched and lithologically distinct source.

We focus on a sample set from the Paraná-Etendeka Large Igneous Province (LIP), which formed in response to the impact of the proto-Tristan plume and continental rifting, and is linked to the modern day plume by aseismic ridges. The ferropicrites (133 Ma) were intruded in the Etendeka region of Namibia towards the start of LIP magmatism and before the main flood basalt pulse. The combination of a high mantle potential temperature and thick lithosphere may be key to understanding the origin of these unusual melts: early-onset melting restricted to higher pressures will preferentially sample fusible lithologies within the mantle. Picrite melts - thought to form by high temperature melting of a depleted peridotite source - also outcrop in the area and form a useful comparison scenario for deconvolving the effects of pressure, temperature and source lithology on mantle melt composition.

We demonstrate, using both whole-rock and olivine-hosted melt inclusion trace-element data, that the Etendeka ferropicrites and associated picrites form under high-temperature melting conditions, and that some have suffered little crustal contamination, thus retaining their primary trace-element characteristics. We use these trace-element compositions in forward numerical models of mantle melting to examine the hypothesis that a significant proportion of a distinct mantle lithology, such as pyroxenite or eclogite, is required in the ferropicrite mantle source, relative to the picrite source. Our principal conclusion is that ferropicrites do indeed require a pyroxenite component in their source, so provide strong evidence of melting and recycling of oceanic lithosphere in Earth's convecting mantle during plume upwelling.