Olivine-hosted melt inclusions in Mg- and Fe-rich magmas: Tracing mantle source and crustal processing in the Paraná-Etendeka LIP

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Magmas erupted in continental flood basalt (CFB) provinces have the potential to provide a unique insight into the nature and composition of the Earth's convecting mantle. In CFB provinces, early-phase mantle melting is restricted to relatively high pressures and lower fractions, so any 'streaks' of readily fusible material are likely to make a greater contribution to the final aggregate melts. However, the perceived geochemical complication of crustal and lithospheric mantle contamination during CFB genesis, and rare occurrence of primitive magmas, means that studies of mantle heterogeneity have usually been based on oceanic basalts.

This study examines low 87Sr/86Sr, high 143Nd/144Nd MORB-like picrites and rare ferropicrites from the Early-Cretaceous Parana-Etendeka LIP in order to assess composition and heterogeneity of their contributing mantle source regions, as well as subsequent crustal storage and contamination. These primitive melts were erupted as part of the main 132Ma CFB pulse. While the compositions of the picritic melts are consistent with their derivation from high-temperature melting of peridotite, petrological and experimental studies suggest that the ferropicrites with their distinctive major-element (FeO >13 wt%, low Al2O3) and trace-element (fractionated HREE, [Gd/Yb]n = 2-3.5) chemistry formed by melting of a garnet pyroxenite source. Isotopic ratios suggest low levels (<15%) of upper crustal and lower crustal contamination for the picrites and ferropicrites, respectively.

Our study focuses on olivine-hosted melt inclusions from the picrites and ferropicrites. These provide a 'snapshot' of the compositions of trapped mantle melts before significant crystallisation, contamination and mixing. We have combined major- and trace-element analyses of fully-homogenised melt inclusions together with mineral chemistry to make a preliminary assessment of the nature of contributing melt source regions and also the level and style of contamination. Elevated concentrations of incompatible trace elements, such as Rb, Sr and K, in a subset of the picrite melt inclusions are evidence of upper crustal contamination. Ferropicrite melt inclusions show enrichments in Ba along with a striking depletion in Nb, which may be indicative of lower-crustal contamination. Ferropicrite melt storage at the base of the crust is also indicated by the presence of clinopyroxene phenocrysts, and may be due to the high melt density. Concentric zonation of these phenocrysts indicates a pulsed magma supply to these deep, but most likely small volume, crustal magma chambers.

Variations in trace-element ratios of olivine-hosted melt inclusions in ferropicrites and picrites indicate a fundamental difference between their contributing melt source regions. The small length-scales of lithological heterogeneity in the upwelling proto-Tristan plume head are most readily identified in the compositions of early high-pressure ferropicrite melts.