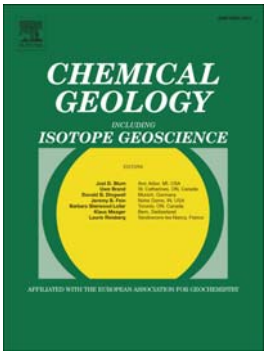

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Multiple mantle sources of continental magmatism: Insights from "high-Ti" picrites of Karoo and other large igneous provinces

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ABSTRACT

Magmas forming Large Igneous Provinces (LIP) on continents are generated by extensive melting in the deep crust and underlying mantle and associated with break-up of ancient supercontinents, followed by formation of a new basaltic crust in the mid-oceanic rifts. A lack of the unifying model in understanding the sources of LIP magmatism is justified by lithological and geochemical complexity of erupted magmas on local (e.g. a cross-section) and regional (a single and different LIP) scales. Moreover, the majority of LIP rocks do not fit general criteria for recognizing primary/primitive melts (i.e. < 8 wt% MgO and absence of high-Fo olivine phenocrysts).

This study presents the mineralogical (olivine, Cr-spinel, orthopyroxene), geochemical (trace elements and Sr-Nd-Hf-Pb isotopes) and olivine-hosted melt inclusion compositional characteristics of a single primitive (16 wt% MgO), high-Ti (2.5 wt% TiO_2) picrite with high-Mg olivine (up to 91 mol% Fo) from the Letaba Formation in the ~180 Ma Karoo LIP (south Africa). The olivine compositions (unusually high $\delta^{18}O$ (6.17‰), high NiO (0.36-0.56 wt%) and low MnO and CaO (0.12-0.20 and 0.12-0.22 wt%, respectively)) are used to argue for a non-peridotitic mantle source. This is supported by the enrichment of the rock and melts in most incompatible trace elements and depletion in heavy rare earth elements (e.g. high Gd/Yb) that reflects residual garnet in the source of melting. The radiogenic isotopes resemble those of the model enriched mantle (EM-1) and further argue for a long-term enrichment of the source in incompatible trace elements.

The enriched high-Ti compositions, strongly fractionated incompatible trace elements, presence of primitive olivine and high-Cr spinel in the Letaba picrites are closely matched by olivine-phyric rocks from the ~260 Ma Emeishan (Yongsheng area, SW China) and ~250 Ma Siberian (Maimecha-Kotuy region, N Siberia) LIPs. However, many other compositional parameters (e.g. trace element and $\delta^{18}O$ compositions of olivine phenocrysts, Fe^{2+}/Fe^{3+} in Cr-spinel, Sr-Nd-Hf isotope ratios) only partially overlap or even diverge. We thus imply that parental melts of enriched picritic rocks with forsteritic