Coupling of mantle and flood basalt provinciality in continental rifts: example from Karoo-Ferrar LIP

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The incipient rifting stage of continental breakup often involves emplacement of compositionally diverse flood basalts. The cause of the general geochemical lithosphere-affinity of flood basalts is highly relevant to understanding of rift zones and the composition and convection of Earth's mantle. Specifically, it is still unclear whether the geochemical lithosphere-affinity arises primarily from large-scale melting of heterogeneous continental lithospheric mantle or complex magmatic differentiation.

In the Jurassic Karoo-Ferrar flood basalt province, the occurrence of compositionally different magma types that range from mildly enriched (low-Ti) to strongly enriched (high-Ti) varieties has been commonly ascribed to strongly heterogeneous lithospheric mantle sources. Here I re-examine the roles of mantle source heterogeneity and differentiation in the Karoo-Ferrar province and show that the flood basalts can be readily divided into geochemically distinctive i) eastern and western sub-provinces and ii) high-pressure and low-pressure mantle melting environments using Nb-Zr-Y and REE systematics, respectively.

The magma types of the eastern (∼Antarctic) sub-province are characterised by Nb-Zr-Y systematics typical of depleted mantle-sourced magmas, whereas those of the western (∼African) sub-province show affinity to primitive or enriched mantle sources. Comparison of the least-contaminated rock types and geochemical modelling suggest that the Nb-Zr-Y dichotomy stems from a large-scale mantle heterogeneity beneath Gondwana, whereas the numerous magma types generally result from differentiation (cf. Luttinen et al., 2015). Given that 1) the geochemical province boundary coincides with the incipient Africa-Antarctica rift-zone, 2) the rift-zone flood basalts can be distinguished by depleted heavy REE suggestive of very high pressure melting, and 3) the rift-zone basalts record the oldest emplacement ages, it is conceivable that the geochemical provinciality and onset of rifting and magmatism in the Karoo-Ferrar province, as well as the eventual breakup were controlled by a sub-Gondwanan mantle province boundary revealed by the Nb-Zr-Y characteristics.

References:

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