Abstract

Cratonic lamproites are rare, small-volume, ultrapotassic volcanic rocks that are found on every continent and have eruption ages spanning at least 2 billion years. These rocks often contain entrained mantle xenocrysts and xenoliths, including diamonds, which allow examination of the sub-continental lithospheric mantle (SCLM). Despite their scientific and economic significance, questions persist regarding the petrogenesis of cratonic lamproites. Contentious issues include the nature and location (lithospheric vs. sub-lithospheric) of their source(s), genetic connections with kimberlites, and the composition and evolution of lamproite melts during ascent. To address these questions, our initial approach involved examining the petrography, mineralogy and geochemistry of selected samples in the eastern Dharwar craton (India) and the Kaapvaal craton (South Africa). Subsequently, building upon these regional studies, we examined a larger sample collection of lamproites from different cratons to explore the global origin of lamproites.

This thesis first presents a detailed study of olivine from the Wajrakarur lamproites, revealing similar melt evolution to adjacent kimberlites, but with interactions involving compositionally different SCLM components for the two magma types. Moreover, six 'transitional kimberlites' from South Africa were investigated and reclassified into either lamproites or kimberlites based on their petrography (e.g., mica abundance) and mineral chemistry. The correlations of the average $^{143}Nd/^{144}Nd_{(i)}$, $^{176}Hf/^{177}Hf_{(i)}$ and emplacement ages with modal groundmass mineralogy, bulk rock K/La, and average chromite compositions, are consistent with derivation from a common evolving source in the sub-lithospheric convective mantle. The transition from older lamproites to younger kimberlites is attributed to the progressive consumption of more geochemically enriched and consequently fusible components, probably originating from subducted crustal material. These two studies provide

evidence of a direct genetic connection between lamproites and kimberlites, providing support for the role of a convective mantle source in the formation of cratonic lamproites.

To ascertain whether this is a global phenomenon, the olivine composition of lamproites from different cratons (e.g., Kaapvaal, Dharwar, Bastar, West Kimberley, Man) were then compared. Similarities in the geochemistry of olivine from lamproites and kimberlites coupled with petrological modelling suggest that cratonic lamproites and kimberlites share similar sub-lithospheric (convective) mantle sources. Lamproites acquired their distinctive enrichment in potassium through interaction with variably metasomatized SCLM during their journey to the surface. Further insights into lamproite sources arise from variations in Sr-Nd-Hf isotope compositions. Sr-Nd-Hf isotopic analyses of 61 fresh samples of cratonic lamproites from diverse cratons, with a specific emphasis on the limited Hf isotopic data, were conducted to reassess the origin of cratonic lamproites on a global scale. Isotopic mixing models suggest a composite source involving: i) a convective mantle endmember, potentially similar to the common Prevalent Mantle (PREMA) component identified in kimberlites and ocean island basalts globally, ii) various and extreme geochemically enriched components derived from metasomatised lithospheric mantle and/or iii) subducted lithologies. This study provides strong support for the hypothesis proposed by two case studies from the Dharwar and Kaapvaal cratons, as well as the olivine chemistry of lamproites worldwide, suggesting similar sub-lithospheric convective mantle sources for cratonic lamproites and kimberlites.

In summary, the olivine chemistry of lamproites, correlations between mineral chemistry and isotopic compositions in adjacent kimberlites and lamproites, and isotopic mixing models reveal that cratonic lamproites require input from both lithospheric and asthenospheric sources. A prevailing asthenospheric contribution, akin to kimberlites, coupled with an enriched phlogopite-bearing lithospheric component and/or input from subduction, is fundamental in the genesis of cratonic lamproites.