Title:

Magmatic evolution of carbonatite:
differentiation of silicate parent magma or direct partial melt of the mantle?

Abstract:

Carbonatites are igneous rocks composed of at least 50% carbonate minerals and are economically important as a source of igneous phosphate and light rare earth elements. They occur as part of intrusive or extrusive igneous suites and are generally subdivided by geochemical composition. Most carbonatites have an unambiguous origin in the mantle; however, both parent melt composition and evolution of carbonatite suites are controversial.

Carbonatites are commonly accompanied by alkaline silicate igneous rocks, which suggests a genetic relationship with a silicate parent. In contrast, occurrences of carbonantite-only suites, with mantle xenoliths, are taken as evidence of direct partial melting from the mantle. Thus, two hypotheses of carbonatite petrogenesis have been proposed: 1) differentiation from a silicate parent magma and 2) direct partial melting of carbonated lherzolite. In the case of the former, a subsequent debate regarding fractional crystallization or liquid immiscibility as the primary mechanism persists.

The Catalão (Brazil) and Mountain Pass (California, USA) carbonatite complexes provide well-studied occurrences to investigate these competing hypotheses. Trace element ratios (e.g., Y/Ho, Zr/Hf, and Nb/Ta) and carbon and oxygen isotopic signatures, combined with known physical properties of carbonatite melts support direct partial melting of the mantle as the primary mechanism for the petrogenesis of the majority of carbonatite complexes.