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Radiogenic and Stable Isotope Constraints on the Source Regions of Phanerozoic Carbonatites and Associated Igneous Rocks from Western South Africa and Southern Namibia.

Ogungbuyi, P.I, Janney, P.E, and Harris, C.
Department of Geological Sciences, University of Cape Town, Rondebosch 7701, South Africa.

Carbonatites and associated alkaline silicate rocks from the 55 Ma Zandkopsdrift carbonatite complex of Namaqualand, South Africa display a narrow range of Sr and Nd isotope compositions ($^{87}Sr/^{86}Sr$: 0.70327 to 0.70341, $^{143}Nd/^{144}Nd$: 0.51273 to 0.51274). The $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$ ratios of the carbonatites and related, dominantly silicate igneous rocks (aillikite, olivine melilitite) are higher and lower, respectively, than Bulk Earth indicating derivation from a long-term depleted mantle source. The initial $^{206}Pb/^{204}Pb$ values for Zandkopsdrift carbonatites and alkaline silicate rocks range from 19.4 to 21.0 which, in combination with their Sr and Nd isotope compositions indicate an affinity with HIMU-type ocean island basalts. One Zandkopsdrift olivine melilitite sample analysed previously (Janney et al., 2003) extends to anomalously unradiogenic initial $^{206}Pb/^{204}Pb$ values (17.5), which may reflect crustal assimilation. The variations in $^{238}U/^{204}Pb$ (5 to 350) and $^{232}Th/^{204}Pb$ (23 to 539) in the rock samples are exceptionally large, but the fact that most samples fall within a relatively narrow range of Pb isotope values, as well as their Sr, Nd and Pb isotopic similarity to other alkaline magmas along the SW margin of Africa (e.g., Alphard Banks alkali basalts and Robertson melilitite; Janney et al. [1] and the Dicker Willem carbonatite [3]), which also show strong HIMU affinities, argues against major post-emplacement disturbance of their U/Pb and Th/Pb ratios. In $\varepsilon_{Hf}(t)$-$\varepsilon_{Nd}(t)$ space, the carbonatites and associated silicate rocks fall up to 8 ε_{Hf} units below the ε_{Nd}-ε_{Hf} MORB-OIB array, indicating mixing with a source with moderate ε_{Nd} and exceptionally unradiogenic Hf isotope composition, similar to that seen in the Namaqualand-Bushmanland and some Western Cape melilitites (Janney et al. [2]). The unradiogenic Hf and radiogenic Pb isotope compositions of the Zandkopsdrift Complex rocks are consistent with an ancient silicate melt component (possibly oceanic crust) in their sources that was at least partly derived by melting in the presence of garnet. The similarities in the radiogenic isotope compositions of carbonatites and silicate igneous rocks between the carbonatites and the associated alkaline silicate rocks requires a common origin from a single mantle source. $\delta^{18}O$ and $\delta^{13}C$ isotopes were measured for carbonatites and aillikites. The ^{13}C values are close to those expected for mantle-derived carbonatites (-3.9 to -8.8 ‰), while the $\delta^{18}O$ values are significantly higher (+13. 3 to 21.8 ‰). The high $\delta^{18}O$ value observed in carbonatites and aillikites is most likely attributable to secondary alteration by hydrous fluids. This supports the inference that the Zandkopsdrift carbonatite is magmatic in origin but was later affected by secondary alteration which resulted in the elevated O stable isotopes. The 'mantle-like' C isotope composition is inconsistent with significant assimilation of C-bearing crustal rocks. Comparative Sr-Nd-Pb-Hf and C and O stable isotopic results will also be presented for the ≈550 Ma Marinkas Quellen and ≈49 Ma Dicker Willem carbonatites of southern Namibia, to provide constraints on the geochemical evolution of carbonatite sources in southwestern Africa.

References

[1] Janney et al., (2002) J. Petrol. 3:2340-2368
[2] Janney et al. (2002; 2003) 8th Int. Kimb. Conf. Abs.: abstract 127
[3] Cooper and Reid, (2000) Contrib. Mineral. Petrol. 139:570-583