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Mantle magma meets low-$\delta^{18}O$ crust in melilitite pipes of Namaqualand, South Africa

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Olivine melilitite pipes are among the youngest magmatic rocks in South Africa. The Namaqualand cluster comprises at least 10 closely spaced subvolcanic diatremes that span an age range of 35-56 Ma. These pipes, themselves, are part of the 400-km-long Namaqualand-Bushmanland-Warmbad (NBW) melilitite province, which extends from near the west coast of Namaqualand, to the Warmbad region of south-eastern Namibia (Day et al., 2014). The basement rocks through which all Namaqualand pipes were emplaced belongs to the Garies Terrane of the Namaqua-Natal Mobile Belt except for the most southerly pipes, which intrude rocks of the Cretaceous Koegel Fontein igneous complex. The magmas have moderate to strong HIMU isotope signatures, consistent with a deep convecting mantle origin. Olivine from the Western Cape and Bushmanland clusters have $\delta^{18}O$ values of between 4.99-5.26‰ Day et al. (2014), with an average of 5.14‰ (n=12). This is within the range of peridotitic mantle olivines (Mattey et al. 1994). Olivine from the Namaqualand cluster have similar $\delta^{18}O$ values (mean 5.04‰), but the range is larger (4.23 to 5.30‰, n=24). The olivines with lowest $\delta^{18}O$ values are from pipes that were emplaced into the ~134 Ma Koegel Fontein igneous complex (average $\delta^{18}O$ = 4.94‰).

The country rock at Koegel Fontein complex is cut by a shear zone with $\delta^{18}O$ values as low as -3.3‰. The low $\delta^{18}O$ values of olivine in the melilitites is best explained by assimilation of Koegel Fontein country rock crust having the lowest measured $\delta^{18}O$ values. Large amounts of crustal assimilation are not plausible as they would result in detectable increases in SiO_2 and Pb/Ce ratios. There is no correlation between $\delta^{18}O$ value and initial Sr and Nd isotope ratio or any other index of crustal contamination. Up to 10% crustal assimilation may be ubiquitous in olivine melilitite, but is only recognised at Koegel Fontein where the country rock, which is compositionally similar throughout the NBW province, has very low $\delta^{18}O$ values.