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Petrogenesis of shoshonites and ultrapotassic rocks associated with the high-Ti basaltic lavas of the Tuli basin, Karoo Large Igneous Province, southern Africa

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The Tuli basin in Zimbabwe and Botswana is one of the largest and best-preserved remnants of rift-related sequences associated with the Karoo Large Igneous Province of southern Africa. Early Jurassic tholeiitic high-Ti picrites and basalts are ubiquitous at the Tuli basin, but rare alkaline rocks are also found in the volcanic sequence. Remnants of flood basalt eruptions, and related alkaline igneous rocks, are postulated to provide a comprehensive record of plume activity, continental breakup and rifting throughout the world, however, the alkaline magmatism associated with the more voluminous picrites and basalts remain under-explored in the northern Karoo LIP.

The studied samples (n = 32) are porphyritic, comprising nepheline-rich rocks with plagioclase, clinopyroxene and olivine as phenocrysts. These rocks have shoshonitic affinities and most vary from alkaline basaltic-trachyandesite to trachyandesite. New whole-rock elemental and Sr-Nd-Pb isotope data reveal compositional heterogeneity that ranges from e.g., 46.5–57.0 wt% SiO_2, 0.2–6.0 wt% Na_2O, 1.0–9.4 wt% K_2O, Zr/Nb = 1.6–18.5, $^{87}Sr/^{86}Sr_i$ = 0.70439–0.70705, εNd_i = -8.3–-1.1, and $^{206}Pb/^{204}Pb_i$ = 17.3–17.8. Here we have identified three distinctly different groups of alkaline samples and termed them nephelinites (K_2O/Na_2O <0.5), shoshonites (K_2O/Na_2O = 0.5 to 2) and ultrapotassic shoshonites (K_2O/Na_2O >2).

Similar to the Tuli picrites and basalts, the alkaline rocks exhibit a bimodal distribution in Zr/Nb with ultrapotassic shoshonites having Zr/Nb >15, whereas nephelinites and shoshonites have Zr/Nb <3.7 and are at the lower end of the Tuli range. Shoshonites, however, show distinct compositional differences from nephelinites implying that each alkaline group formed from separate petrogenetic processes. Variable incompatible element concentrations and ratios (e.g., Zr/Y, Ce/Y, La/Yb) suggest that the degree of partial melting is different for each group. Shoshonite data reflect variable melting degrees with residual garnet in the source, whereas ultrapotassic shoshonites have the lower Zr/Y and Ce/Y ratios with relatively flat slopes in LREE/HREE indicating more extensive melting. Crustal assimilation, on the other hand, appears to play a less important role in the petrogenesis of the Tuli alkaline rocks as Th/Yb vs. Nb/Yb, together with radiogenic isotope ratios, overlap or approach the mantle array.