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Dynamic melting in an Archean mantle plume: Chemical signature of Prince Albert Group komatiite and basalt, Nunavut, Canada

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The Prince Albert Group (PAG) is a ca. 2.7 Ga greenstone belt characterized by a distinctive komatiite-quartzite association that, including similar belts to the southwest, continues for >1000 km along strike. Continental sedimentary deposits, bimodal volcanism, and the recognition of crustally contaminated komatiite and basalt suggests a marginal continental rift setting, while the extensive amount of komatiite indicates a mantle plume was involved. The bulk of the volcanism is concentrated in the lower PAG and is comprised of a basal basaltic/gabbroic horizon, and upper komatiite dominated sequence, together comprising ~2-3 km of thickness. U-Pb TIMS zircon ages of crystal and lapilli tuffs within the basalt and komatiite horizon yield crystallization ages of 2729.8±1.2 and 2729.7±0.9 Ma, respectively. The minimum age of this lower volcanic sequence is constrained by a 2718±2 Ma crosscutting granodiorite, and a 2722±11 Ma detrital zircon in quartzite.

Unlike other well-known komatiite occurrences PAG komatiites display a wide range in major element content and incompatible element ratios (Fe_2O_{3T}=9.3-15.6; Ce/Sm_N = 0.39-1.06; Gd/Yb_N = 0.52-1.32). The MgO content of fine-grained spinifex lavas (24.6-30.3 wt.%) correlates inversely with Fe_2O_{3T} and Gd/Yb_N. Uncontaminated basalt displays an even wider spectrum of incompatible element ratios (Ce/Sm_N = 0.60-2.13; Gd/Yb_N = 1.0-3.24). The Nd isotopic composition (εNd) of komatiite ranges between +2.0 to +4.3 (n=25), however, over 70% of the komatiites range between +2.0 and +3.0. The Nd isotopic composition of basalt ranges between +1.7 to +2.9 (n=9) similar to the range displayed by most komatiite. When plotted on a Sm-Nd isochron the basalt and komatiite (εNd < +3) samples yield an age of 2732±27 Ma, in agreement with U-Pb ages of felsic tuffs. The chemical fractionation observed in PAG magmas at similar Nd isotopic composition suggests a common source for basalt and most komatiite that was melted over a wide range in pressure and temperature. The mixing of polybaric melts was incomplete, potentially due to variable melt density and/or the time scales of melt production and extraction. Dynamic melting models similar to those proposed for Phanerozoic plume-derived magmas (e.g. Iceland, Columbia) can explain the geochemical heterogeneity of PAG komatiite and basalt.