Petrogenesis and geochronology of the Cambrian Kalkarindji low-Ti CFB Province – northern Australia

L.M. GLASS[1], V.C. BENNETT[2] AND D. PHILLIPS[3]

[1] Research School of Earth Sciences, Australian National University, Canberra; linda.glass@nt.gov.au
[2] RSES, ANU, Australia; Vickie.Bennett@anu.edu.au
[3] Earth Sciences UniMelb; Aust; dphillip@unimelb.edu.au

The Early-Middle Cambrian Kalkarindji low-Ti continental flood basalt province represents a voluminous outpouring (>10^6 km^2) of tholeiitic lava and is Australia's largest Phanerozoic-age CFB province. It comprises the Antrim Plateau Volcanics, northern Australian stratigraphic equivalents, and to the south, the coeval Table Hill province and Boondawari dolerite. High-precision $^{40}Ar/^{39}Ar$ dating of feldspar separates from basalts across the province yield an average age of 507 ±4 Ma (2σ) which places the eruption event close to the Early-Cambrian – Middle-Cambrian boundary.

At fixed Mg# the basalts are chemically homogeneous and have trace element and Sr and Nd isotopic signatures requiring a component of felsic continental crust. They are characterized by low relative HFSE abundances, together with extreme enrichment in Th, U and elevated Rb/Ba and La/Sm. Basalt chemical evolution was dominated by crystal fractionation from ~9 to 3 wt% MgO. Isotopic and key crust-sensitive trace element ratios do not correlate with indices of fractionation, indicating that the crust-like signature was already present in primitive (>9% MgO) basalts prior to near-surface crystal fractionation.

Distinctive geochemical and isotopic features of the Proterozoic North Australian felsic crust, e.g. elevated Th/U and high LREE, are reflected in the geochemistry of the basalts pointing to local crust, rather than an exotic component as a likely contaminant. Trace element and Sr and Nd isotopic geochemical signatures for the majority of the basalts can be reproduced by AFC processes involving ~10% contamination of a picritic parental liquid by average Proterozoic 1.8 Ga north Australian felsic crust. The distinctive low-Ti signature of the basalts can be reproduced by contamination of an NMORB picrite parental liquid.

Segregation of the parental picrite magma occurred at ~1.5-2.0 GPa, equivalent to ~50-70 km depth in the mantle. However, in the Proterozoic, 200 km thick subcontinental lithosphere underlaid the future eruptive centre. In order for parental picritic magmas to segregate from their source at 50-70 km in the Cambrian, the lithosphere in this region must have been substantially thinned. Catastrophic delamination of the lithosphere in response to rapid Cambrian rotation of the Australian continent is a possible thinning mechanism. A plume model to generate the parental partial melts is feasible providing the pre-existing lithosphere can be removed.