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A new flood basalt province from Northern Australia: Geochronology and petrogenesis of the Cambrian Kalkarindji low-Ti basalts

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A voluminous outpouring of tholeiitic lava, the newly defined Kalkarindji low-Ti continental flood basalt province (CFB), covered an extensive area (>10^6 km^2) of northern Australia in Cambrian times. This relatively unknown and until recently little studied CFB is Australia's largest Phanerozoic-age province; it comprises the Antrim Plateau Volcanics and northern Australian stratigraphic equivalents, and likely the coeval Table Hill province, to the south.

New high-precision $^{40}Ar/^{39}Ar$ dating of feldspar separates from basalts across the province yield an average radiogenic 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, Nd isotopic signatures that resemble felsic continental crust. They are characterized by low relative HFSE abundances (Ti, P, Nb) together with extreme enrichment in Th, U and elevated Rb/Ba and La/Sm.

The chemical evolution of the basalts 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 prior to near-surface crystal fractionation in compositions more primitive than 9 wt% MgO.

Distinctive geochemical and isotopic features of the Proterozoic North Australian felsic crust, e.g. elevated Th/U, high LREE are reflected in the geochemistry of the basalts pointing to local crust as a likely contaminant. Trace element, 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 a primitive picrite parental liquid, without the requirement for melting depleted peridotite.

Segregation of the parental picrite magma occurred at ~1.5-2.0 GPa, equivalent to ~50-70 km depth in the mantle. However, in Proterozoic times, 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 Cambrian times, 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.

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Zircon U-Pb and O isotope evidence for a large-scale ^{18}O depletion event in the Neoproterozoic large igneous province of South China

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SHRIMP U-Pb dating and laser O isotope analysis were carried out on zircons from granite, granitic gneiss and eclogite along the Dabie-Sulu orogenic belt in the northern margin of the South China Block. The results show that most of zircons have protolith ages of 700 to 800 Ma and metamorphic ages of 215 to 245 Ma, respectively, and that there is a wide variation in zircon $\delta^{18}O$ values from −10.9 to 8.5‰. Most of the $\delta^{18}O$ values are lower than normal mantle zircon $\delta^{18}O$ values of 5.3±0.3‰ and almost half have prominently negative values. The igneous zircons have preserved their magmatic zoning and middle Neoproterozoic U-Pb age during the Triassic metamorphism, indicating low fluid availability. Widespread low $\delta^{18}O$ values are identified in the igneous zircons of middle Neoproterozoic age, within an outcrop area of over 20,000 km^2 in this region. The low $\delta^{18}O$ zircons record the presence of large volumes of low $\delta^{18}O$ igneous rocks that were derived from remelting of meteoric-hydrothermally altered rocks at some time between 700 and 800 Ma.

The U-Pb ages for metaigneous protoliths and granites are correlated not only with the timing of rifting accompanying the breakup of Rodinia supercontinent, but also with contemporary glacial deposits in the South China Block at paleolatitudes of 30 to 40°N. Melting of glacial ice and snow is suggested, instead of the direct involvement of meteoric water, to produce the low $\delta^{18}O$ fluid with oxygen isotopic signatures like the cold-climate meteoric water. The rifting created conditions favorable to anatexis of meteoric-hydrothermally altered rocks. Glaciated regions supplied copius water for the water–rock interaction during magma emplacement along rifting zones. Both rifting and glaciation favored the generation of the low $\delta^{18}O$ magmas in the region. The low $\delta^{18}O$ zircons are thus interpreted to have crystallized from the low $\delta^{18}O$ magmas of middle Neoproterozoic age. The large-scale remelting of hydrothermally altered crust not only results from repetitive emplacement of mafic magmas along the rifting zones with protracted episodes of water–rock interaction, but also involves rift systems that rapidly introduce large volumes of fluid through confined pathways and traps in a short space of time in response to tectonic triggers. Occurrence of the large-scale ^{18}O depletion during the middle Neoproterozoic may be a manifestation of the cold paleoclimate related to the snowball Earth event.