Statistical re-evaluation of REE pattern in TTGs to decipher formation processes of the first continental crust

SA LADWIG[1*], AJ MCCOY-WEST[1], P CHOWDHURY[1], JF MOYEN[2], T IVANIC[3], O NEBEL[1] AND P CAWOOD[1]

[1] School of EAE, Monash University, Melbourne, 3800 VIC
[2] Université Jean-Monnet, Saint-Etienne, 42023 France
[3] Geological Service Western Australia, Perth, Australia

The Archean cratons represent the earliest fragments of the felsic continental crust, which is predominantly composed of sodic granitoids known as Tonalite-Trondhjemite-Granodiorites (TTGs). Here, we analyse a large compilation of CI normalized rare-earth-element (REE_N) compositions of TTGs worldwide to elucidate how crust-forming processes may have varied in the early Earth.

REE_Ns are best suited for this purpose. But, comparing the REE_N patterns of TTGs does not give meaningful results as they have similar shapes. Hence, we use the polynomial approach [1] that quantifies the linear slope and curvature of a REE_N pattern using two parameters-λ_1 and λ_2, respectively. We calculate these parameters for TTG compositions from different cratons and plot them in a λ-diagram (λ_1 vs λ_2). Results show that overall, TTGs are distinctly different than Phanerozoic granitoids. TTGs of different cratons exhibit two distinct trends in the λ-diagram: (1) a horizontal-trend describing variations in λ_1-values as compared to λ_2-values (e.g. Pilbara craton), and (2) an inclined-trend describing a concomitant decrease in λ_2-values with increasing λ_1-values (e.g., Superior craton). Given the λ_1 (slope) and λ_2 values (curvature) represent relative enrichment of LREEs and MREEs respectively [1], the horizontal-trend signifies large variation in the LREE enrichment pattern while the inclined-trend implies a coeval change in LREE and MREE concentrations.

Trace element modelling suggests that the inclined-trend could be reproduced by decreasing the amphibole:garnet ratio in the residue along a geotherm, i.e. if the residual assemblage changes from (garnet-)amphibolite to (garnet-)granulite with progressive melting. The horizontal-trend could be due to variations in source rock compositions and represents partial melting in presence of amphibolite residues. These different residual assemblages suggest that the *P-T* conditions of TTG formation varied significantly among the cratons and thus, have implications for interpreting the global Hadean-Archean geodynamics.

[1] O'Neill (2016), *Journal of Petrology*, **57**, 1463-1508.