^{138}La-^{138}Ce isotope systematics of Archean igneous rocks

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Although the ^{138}La-^{138}Ce radioactive decay system was established in the 1980s, recent studies mainly focused on young lavas [e.g., 1], and Archean rocks remain poorly studied. Nevertheless, due to a strong coupling of the LREE during mantle melting, coupled Ce and Nd isotope systematics are an excellent tool to better understand crust-mantle differentiation processes through geological time. Here we present ^{138}La-^{138}Ce data for 53 mantle-derived rocks and for 20 felsic rocks from various Archean cratons, including the Pilbara Craton, Barberton Greenstone Belt, Acasta Gneiss Complex and Isua Greenstone Belt. Our data for evolved granitoids show a strong scattering in $\varepsilon Ce_{(i)}$ vs. $\varepsilon Nd_{(i)}$ space. These samples have undisturbed $\varepsilon Nd_{(i)}$ values [e.g., 2] but $\varepsilon Ce_{(i)}$ values that are up to five times lower than modern-day depleted mantle estimates ($\varepsilon Ce_{(i)DM} \approx -1$). As these samples also show strongly negative Ce/Ce* anomalies, the anomalous initial Ce isotope compositions are ascribed to younger metasomatic disturbance of La/Ce ratios, while ^{147}Sm-^{143}Nd compositions remained unaffected.

In contrast, Ce/Ce* anomalies are absent in the majority of Archean mantle-derived rocks. Samples without Ce/Ce* anomalies are characterized by a strong negative correlation of $\varepsilon Ce_{(i)}$ vs. $\varepsilon Nd_{(i)}$ that is also observed in modern-day rocks [e.g., 1]. In addition, whole-rock ^{138}La-^{138}Ce errorchron ages of Archean mantle-derived rocks with similar $\varepsilon Ce_{(i)}$ values overlap with the accepted stratigraphic ages, implying a pristine ^{138}La-^{138}Ce isotope composition. Mantle-derived rocks with undisturbed Ce isotope compositions show a constant decrease of $\varepsilon Ce_{(i)}$ values between 3850 and 2630 Ma, which is best explained by continuous melt extraction from a depleted mantle domain. Nevertheless, there are samples from specific units with significantly higher $\varepsilon Ce_{(i)}$ values and lower $\varepsilon Nd_{(i)}$ values. These values are ascribed to the interaction with an enriched component that either represents a subduction-like origin or shallow level crustal contamination.

[1] Israel et al., (2019) EPSL, 1, 1-12. [2] Schneider et al., (2019) Chem. Geol. 511, 152-177.