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Eoarchean (3.8-3.7 Ga) transition in geodynamic regime of continental crust formation revealed from secular change in TTG composition

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The nature of the geodynamic regime of crust formation in the Headean and early Archean remains poorly understood. There is also considerable debate on whether modern-day-like plate tectonic processes operated on the early Earth, as the thermal and mechanical structure of the lithosphere and mantle may have been different [1]. The bulk of the Archean continental crust is composed of tonalite-trodhjhemite-granodiorites (TTGs) produced by partial melting of hydrated basaltic rocks [2]. Secular changes in TTGs composition through the Archean may therefore reflects changing conditions of melting of metabasalts due to change in the geodynamic regime of crust formation.

In this study, we applied stacked probability density estimates and statistical change-point analysis (Bai-Perron multiple breakpoints test and Bayesian change-point algorithm) on published dataset of TTG rocks [3] with ages spanning from 4.0 to 2.5 Ga to identify the timings of statistically significant changes in TTG chemistry. A systematic shift towards higher value in SiO_2, Al_2O_3, MgO, Na_2O, V, Sr, Rb contents, Sr/Y, La_N/Yb_N, Gd_N/Yb_N ratios, and towards lower value in the TiO_2, FeO_t, MnO, Sc, Cu, Zn, HFSEs, Y, Sm, Eu, and HREEs concentrations of TTG rocks is observed since ca. 3.7-3.8 Ga. The results are suggestive of a significant change in the process/conditions of continental crust formation in the Eoarchean and may be related to transition in tectonic mode, possibly from a stagnant-lid to intermittent mobile-lid-type convective regime. The increase in Sr, Sr/Y, La_N/Yb_N ratios, and decrease in HREE abundances of TTG rocks through the Archean indicates progressive increase in the depth of melting of metabasalts with the trace element chemistries reflecting disappearance of plagioclase and stabilization of garnet in the residues. These signatures possibly reflect the progressive cooling of the upper mantle and evolution from warm and shallow melting of metabasalts in the early archean towards cold and deeper subduction mode in the Neoarchean. Moreover, the increasing Mg#, Cr, Ni with decreasing age indicates more efficient crust-mantle interaction through deeper-level subduction in the late Archean.

[1] Herzberg et al. (2010), EPSL **292**, 79–88. [2] Moyen & Martin (2012) Lithos **148**, 312–336. [3] Johnson et al. (2019) EPSL **505**, 65–75.