Probing geodynamics and crust formation processes in the early Archean

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The mechansims and geodynamic processes that gave rise to the formation of Earth's earliest continental crust with tonalite-trondhjemite-granodiorite (TTG) composition are under debate and models either favour either a non-plate tectonic or a modern-like pate tectonic setting [e.g., 1].

A window into the geodynamic processes operating during the Eoarchean is provided by well-preserved >3.7 Ga rocks from the Itsaq Gneiss Complex (SW Greenland). Occurrences of >3.7 Ga mantle peridotites, non-gneissic TTGs and the supracrustal remnants of the Isua Supracrustal Belt provide a coherent image in favour of proto-arc-related TTG formation processes. Field evidence suggest that tholeiitic metabasalts, with modern-like arc trace element signatures, thickened by lateral arc accretion processes. Thermodynamic models predict melting of these metabasalts at pressures of 10-18 kbar to form tonalitic melts, that are represented by the regional TTGs [e.g., 1]. Trace element signatures of ISB metabasalts and adjacent mantle peridotites provide evidence for early crustal recycling processes possibly related to a proto-subduction setting. Hence, the IGC TTG can be seen as truly juvenile contributions to the continental crust.

The earliest granitoids of other cratons, such as from the Ancient Gneiss Complex (Swaziland), however, incorporated older crustal rocks in their genesis as evident from heterogeneous Hf isotope compositions in zircons and rare inherited zircon grains, providing a window into a later stage of crustal evolution. In such cratonic nucleii, the mafic and ultramafic rocks are dominated by tholeiitic metabasalts and metakomatiites, often partly contaminated by older TTG crust.

Hf and ^{142}Nd isotope compositions of meso- and late Archean terranes of cratonic crust reveal that Hadean and Eoarchean mafic crust was early stabilized and incoroporated during crust formation processes by re-melting and mixing with juvenile mantle derived melts [2]. This process may have been active throughout the Archean, mimicing juvenile contributions to the continental crust from a chondritic source.

[1] Hoffmann, J.E., et al. (2019) Earth's oldest rocks. Elsevier. [2] Gardiner, N.J. et al. (2019) CMP 174, 20