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The birth of a cratonic nucleus: lithogeochemical evolution of the 4.02–2.94 Ga Acasta Gneiss Complex

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Abstract:

Crust forming processes on the early Earth have long been debated and relatively few rock and mineral samples exist with which to evaluate many hotly contested themes. The Acasta Gneiss Complex contains rock units with crystallization ages exceeding 4.0 Ga, making them the oldest known evolved rock units in the world. However, the AGC has experienced a long and complex history with multiple periods of igneous intrusion, deformation and metamorphism. Indeed, previous workers have demonstrated that orthogneisses within the AGC have igneous ages ranging from ~4.03 to ~3.4 Ga. This large range in crystallization ages gives us the opportunity to investigate the evolution of Earth's earliest known continental crust through a period of greater than 1 billion years.

Here we present an updated geologic map of key areas within the Acasta Gneiss Complex in which we delineate units based upon age as well as composition. Whole-rock geochemistry, zircon LA-ICPMS U-Pb geochronology and SIMS O-isotope analyses from a large suite of samples indicate a significant change in mode of crust formation over 400 million years. These data document a gradual change from a shallow crustal processes generating basaltic to andesitic compositions at 4.02 Ga to deep-seated partial melting of hydrated basalt, represented by voluminous Archean TTG-like intrusions at 3.6 Ga.

We find no evidence that classic Archean TTG-like rock units are present within the ACG prior to 3.6 Ga, suggesting a significantly different tectonic process at work prior to this time. We invoke an oceanic plateau-like model to describe the evolving nature of crust formation within the AGC, which forms a buoyant, evolved nucleus. This nucleus then initiates deep-seated partial melting of mafic crust forming voluminous TTG-like units at ~3.6 Ga. This ultimately serves to stabilize the crust and forms a nucleus for later formation of the Slave craton.