

Evidence for Hadean mafic rocks preserved in the NE Superior Craton, Canada

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Beside the 4.03 Ga Acasta gneiss in NW Canada, preserved rocks of undisputed Hadean age appear to be absent from the geological archives, despite evidence showing that crust existed on Earth prior to 4 Ga. Therefore, many questions remain regarding when and how Earth's first crust formed. While zircon-bearing felsic rocks constituting most Archean cratons provide robust geochronological constraints, granitoids likely do not represent primordial crust, but rather formed through melting of an older crustal precursor. However, mantle-derived mafic-ultramafic rocks, usually lacking primary zircons, can be challenging to date. The complex thermal history affecting most Archean cratons can also disturb long-lived isotopic systems, leading to imprecise and sometimes equivocal ages. Nevertheless, efforts to better constrain the age of the oldest mafic-ultramafic rocks can provide important insights into the nature and origin of the Earth's primitive crust.

One potential remnant of Hadean mafic crust is the Nuvvuagittuq Greenstone Belt (NGB) in the NE Superior Craton of Canada. The age of the NGB rocks has, however, been the object of a long-lasting scientific debate, with no consensus on their exact age. Here, we focus on large differentiated gabbroic sills intruding the NGB. Samples were collected over a km-size continuous outcrop and specifically targeted to investigate the timing of magmatic differentiation, including evolved plagioclase-rich layers and cumulative hornblende-rich rocks. The gabbroic samples display a variation in $^{142}\text{Nd}/^{144}\text{Nd}$ with $\mu^{142}\text{Nd}$ values ranging from -9.0 to -2.5, and coupled ^{146}Sm - ^{142}Nd data is consistent with igneous fractionation occurring in the Hadean. Including sill samples previously analysed, the long-lived ^{147}Sm - ^{143}Nd and the short-lived ^{146}Sm - ^{142}Nd isotopic systems respectively yield equivalent isochron ages of 4136 ± 133 Ma (initial $\epsilon^{143}\text{Nd}=+0.6$) and 4180^{+53}_{-82} Ma. While the long-lived system can be subjected to post-magmatic isotopic disturbance, the age agreement obtained from the short-lived ^{146}Sm - ^{142}Nd system, unaffected by post-4 Ga Sm-Nd fractionation, strongly supports a Hadean age for the gabbroic sills. Similar isotopic data ($\mu^{142}\text{Nd}$ between -11.3 and -0.9) obtained on gabbroic samples from the nearby Ukaliq belt, sharing petrological, textural and geochemical characteristics with the NGB gabbroic sills, suggest that Hadean mafic rocks may also be preserved beyond the NGB.