

Evidence for Hadean mantle depletion from 3.7-3.8 Ga metabasalts from Isua, SW-Greenland

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The occurrence of Hadean zircons has provided strong evidence for the presence of stable continental crust at this early time in Earth's history (e.g. Harrison et al., 2005). The existence of such crust requires some kind of concomitant mantle differentiation and depletion. However, due to the lack of Hadean mafic rocks, very little is known about the evolution of the Earth's upper mantle during its first few hundred Myrs..

Here we report Hf isotope and high-precision high-field-strength-element (Zr, Hf, Nb, Ta) data for mafic rocks from the ca. 3.71->3.81 Ga old Garbenschiefer unit of the Isua supracrustal belt (ISB). These rocks constitute the oldest known preserved record of mafic crustal material on Earth, thus potentially preserving evidence for a possible record of mantle depletion in the Hadean to early Archean. The Garbenschiefer metabasalts also constitute the oldest subduction related rocks on Earth (Polat et al., 2002). They have been metamorphosed under amphibolite facies conditions.

Initial ϵ_{Hf} values (at 3.75 Ga) for the boninite-like metabasalts from the Garbenschiefer unit range from +3.8 to +7.9. The samples display $^{176}\text{Lu}/^{177}\text{Hf}$ values as high as 0.085, indicating extremely depleted mantle sources that underwent previous melt extraction in the garnet-stability field. The elevated ϵ_{Hf} values are clearly of primary origin, as the initial ϵ_{Hf} and γ_{Os} (Frei et al., 2004) correlate with major and trace elements. Hence, these data provide the first firm evidence for the development of a Hadean depleted mantle reservoir that persisted into the Archean. The volume of this depleted reservoir was probably small, as other mafic units of the ISB do not originate from such a depleted reservoir (Polat et al., 2003).

All mafic samples from the Garbenschiefer unit follow AFC curves, suggesting assimilation of up to 30 % enriched crustal material, possibly marine sediments or igneous rocks with TTG-like composition.

References

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