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Secondary Ion Mass Spectrometry Analysis of Iron Isotopes Reveals Micro-Scale Heterogeneity in Earth's Oldest Banded Iron Formation

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We report a novel secondary ion mass spectrometer (SIMS) method for the in situ analysis of Fe isotopes with ca. 20 micrometers spatial resolution. The method, set up on a Cameca IMS1270 instrument, utilises an ${O_2}^-$ primary beam, secondary ion extraction at 10kV, and multicollector Faraday Cup detectors for simultaneous measurement of ^{54}Fe, ^{56}Fe and ^{57}Fe, as well as an electron multiplier to monitor potential isobaric Cr interference on ^{54}Fe. Typical external reproducibility on δ^{56}Fe is $<$0.3 permil (2 RSD). This method has been applied to magnetite crystals comprising the banded iron formation (BIF) from the 3.7 Ga Isua Greenstone Belt, southwest Greenland. In three lithologic variants of BIF (quartz + magnetite; quartz + magnetite + minor amphibole; amphibole + magnetite + quartz), across a distance of several mm, individual magnetite crystals of BIF show δ^{56}Fe values up to 2 permil, and within single magnetite-rich layers, there is a $>$2 permil range in δ^{56}Fe. The high positive values appear to require deviation from simple equilibrium and kinetic fractionation effects involved in precipitating Fe^{3+} from dissolved Fe^{2+}, while heterogeneity probably represents small scale changes occurring during diagnesis.