New insights into the 3.4 Ga sulfur and iron cycle from the ICDP Buck Reef Chert drill core

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Understanding geobio-interactions are of special interest for reconstructing early Earth's environments and the ~3.4 Ga old Buck Reef Chert in the Barberton Greenstone belt marks a rather unexplored key stratigraphic unit. Here we present petrographic, major and trace element analyses, Pb-Pb ages, as well as multiple sulfur and iron isotope data of pyrite from the BARB3 drill core, obtained by the ICDP-funded Barberton drilling project. We focus on pyrite nodules present in organic carbon-rich cherts (up to 6.8% TOC).

Nodule textures indicate early diagenetic growth. This finding is corroborated by Pb-Pb model ages of 3355 ± 20 Ma, in broad agreement with the depositional age. Multiple sulfur isotope data reveal that the majority of microdrilled pyrite samples possess a mass-dependent sulfur isotope composition and that cluster around the values assumed for volcanic sulfur ($\delta^{34}S$ = -1.8 to 0.8‰, $\Delta^{33}S$ = -0.148 to 0.196‰). Apart from this cluster, we identified subpopulations of pyrite grains with positive $\delta^{34}S$ and $\Delta^{33}S$ values showing a prominent mass-independent signature and pyrite grains with $\delta^{34}S$ values as low as -19.1‰ and $\Delta^{33}S$ near 0‰. This distribution highlights that the depositional environment of the Buck Reef Chert saw a complex interplay between volcanic sulfur input, atmospheric elemental sulfur deposition and potentially microbial sulfur cycling. The $\delta^{56}Fe$ values of the same pyrite nodules range from 0.4 to -2.46‰, encompassing almost the entire range for the Archean and potentially indicate microbial iron cycling during deposition of the Buck Reef Chert.

Our work demostrates a close link between different sulfur and iron sources and mixing processes between them, but also highlights the need for detailed petrographic and isotope studies on drill core material. We will show how such a combination can be used to unravel and identify the paleoenvironmental conditions of the Buck Reef Chert.