

The 3.5 Ga Middle Marker Horizon: an environmental transition?

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The Palaeoarchean era (3.6–3.2 Ga) is a critical period in the evolution of early life on Earth. The Middle Marker (MM) horizon is the oldest sedimentary unit of the Onverwacht Group of the Barberton Greenstone Belt (BGB, South Africa). This approximately 7-meter horizon is dated to 3.47 Ga and consists of black, black and white, and gray cherts with preserved sedimentary features. The MM was formed by the accumulation of volcano-sedimentary deposits in a shallow water environment. Microbial mat-like structures have been observed and interpreted as reflecting a fossilized microbial ecosystem. Here we report detailed sedimentology, petrology and geochemistry of the MM horizon from 3 different outcrops. The black chert unit is characterized by horizontal/cross-laminations, 0.2 wt.% total organic carbon (TOC) contents, low sulfide contents, large sulfur mass-independent fractionation (S-MIF) up to 2.77 ‰, and flat chondrite-normalized REE patterns. In contrast, the gray cherts are characterized by their massive texture, low TOC contents (0.01 wt. %), high sulfide contents, close to zero S-MIF, and LREE-enriched patterns. Notably, our results document the oldest positive $\Delta^{33}\text{S}$ record in the BGB. Thus, we suggest that the black cherts were deposited on shallow shelves at low accumulation rates, whereas the gray cherts accumulated rapidly during episodic volcanism. Furthermore, the oxygen and silicon isotopic compositions of the chert suggest an important contribution of post-depositional fluid circulation that affected the entire horizon. The $\delta^{18}\text{O}$ values of cherts vary in a narrow range between +11 to +13 ‰, while their $\Delta^{17}\text{O}$ values are -0.06 ‰ on average, likely originating from an interaction with hydrothermal fluids. Our findings refine both the environmental and post-depositional history of the MM Formation and suggest that this horizon has recorded an important environmental transition in both the C and S cycles. This study contributes to our understanding of the interplay between geological and biological processes of the early Earth.