南アフリカ・バーバトン緑色岩帯ムーディーズ層群シェバ鉱山における32億年前縞状鉄鉱層中の微化石様構造

Microfossil-like carbonaceous materials in 3.2 Ga banded iron formations of Sheba Gold mine, Moodies Group, Barberton Greenstone Belt, South Africa

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Archaean microfossils have been an important subject for understanding early earth ecosystem (Javaux et al., 2010; Sugitani et al., 2007). However, biogenicity of microfossil-like structure in Archaean rocks is sometimes highly debated since the structures can be formed by abiogenic process (e.g., Garcia-Ruiz et al., 2003). Banded Iron Formations (BIFs) are one of representative chemical sedimentary rocks in early Archaean to Paleoproterozoic and iron oxide in them is considered deposits associated with microbial activities in terms of the oxidation process. However, organic materials including microfossils in BIFs have been poorly investigated. In this study, we performed morphological investigation of organic materials together with constraints from geological, petrological and geochemical data on ~3.2 Ga shallow BIF of Sheba gold mine, Moodies Group, Barberton Greenstone Belt, South Africa.
Rock samples were classified into Sandy-siltstone (6.1–16.3 wt% Fe_2O_3), Carbonate rich (Carb-) siltstone (21.6–32.8 wt% Fe_2O_3) and Magnetite rich (Mgt-) siltstone (18.9–50.2 wt% Fe_2O_3) based on petrographic observations. Sandy-siltstone consists of relatively large detrital quartz (< ~60 μm), whereas Carb-siltstone and Mgt-siltstone show similar size distribution of detrital quartz (< ~30 μm). Modal analysis indicates that sedimentary settings of Carb-silitstone and Mgt-siltstone are almost identical. Contents and stable isotope ratios of organic carbon in these samples indicate 0.03–0.29 wt% and ~−27 ‰. Most organic materials were observed as ~35 μm diameter, transparent thin flakes and scattered in detrital quartz-rich layers, whereas sheet-like and filamentous organic materials were also observed as minor components. Organic materials sticking on surrounding minerals were picked up by microsampling (Axis pro SS, Microsupport, Japan) directly from thin sections and observed by field emission scanning electron microscope (FE-SEM, JEOL JSM-6500F) and transmission electron microscope (TEM, JEOL JEM2100F). Close-packed and deformed ~1 μm hollow projections were observed on surface of the flaky organic materials. The organic materials sometimes show polygonal depressed area, suggesting that they were compressed by adjacent minerals during metamorphism. Nano-sized Fe, Ti and Cr-bearing particles were sometimes aggregated on organic materials. Organic materials were also extracted by acid-treatment and heavy media separation from powdered samples to estimate fraction of each morphology in samples. Morphologies of organic materials are classified into three types: 30–50 μm flake, > 100 μm filament and ~50 μm indeterminate grain. Note that sheet-like organic materials could not be observed in acid-treated and heavy media separation samples, probably due to deformation during centrifugation in the extracted procedure. Raman spectrum of acid-treated samples indicate that organic materials have experienced 340–576 °C metamorphic temperature, which is slightly higher compared to that of metamorphic facies of Moodies group (greenschist facies, 300–500 °C).
Carbon isotope analysis, Raman spectrum and positional relationship of the organic materials indicate that they are indigenous and biogenic origin. Carb-siltstone is rich in filaments compared to Mgt-siltstone,

although carb-siltstone and Mgt-siltstone deposited in identical sedimentary settings. These results suggest multiple microbial species and fluctuation of the microbial activities in 3.2 Ga shallow oceans. Distinct iron contents of Carb-siltstone and Mgt-siltstone (Carb-siltstone: 22–33 wt%, Mgt-siltstone: 19–50 wt%) also suggest that fluctuation of multiple microbial activities affected the iron fixation. If filamentous organic materials were originated in oxygenic photosynthetic bacteria, our results suggest that oxygenic photosynthetic bacteria influenced iron-bearing mineral flux depending on depositional setting and nutrient supply in 3.2 Ga shallow ocean. Detail observations of flake organic materials suggest that they could be benthic microbial mats flourished on sands trapping nano-size minerals from detritus, torn apart by waves.

キーワード：バーバトン緑色岩帯、ムーディーズ層群、微化石、太古代
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