MICROBIAL MAT INFLUENCE AND EVENT DEPOSITION OF PYRITIC BEDS IN THE PALAEOPROTEROZOIC TALVIVAARA FORMATION

by

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The Palaeoproterozoic Talvivaara formation (2.1–1.95 Ga) in eastern Finland is a ~50-m-thick deposit of dark-grey organic-rich mud beds (Loukola-Ruskeeniemi & Lahtinen 2013). The Talvivaara formation has experienced amphibolite grade metamorphism; however, within less deformed domains, primary sedimentary structures are well preserved. In the core DDKS-010, the interval between 407 and 405 m is characterized by brass-yellow pyritic beds, a few millimetres to a couple of centimetres in thickness, that alternate with dark-grey carbonaceous beds that are some millimetres to centimetres thick. The carbonaceous beds are interpreted as fossil microbial mats; they are characterized by wavy-crinkly organic laminae that resemble lamina structures and intertwined microbial filaments in modern microbial flats. The pyritic beds are event beds; they have uneven bases with the basal depressions often filled with silt and sand-sized grains, demonstrating soft deformation but resistance of the underlying (carbonaceous bed) surface to loading by the event deposition, consistent with a surface-stabilizing microbial mat. Frequent flakes of carbonaceous matter with wavy internal layering and frayed edges ‘floating’ in the pyritic beds are microbial mat fragments that were ripped up from the mat surface by the flow and incorporated into the event deposit (Schieber et al. 2007).

$\delta^{34}$S values of pyrite grains in the pyritic beds, determined in situ by SIMS at Nordsim, range between -12 and -7‰. The $\delta^{34}$S values are shifted by more than 20‰ units from the contemporary seawater sulphate ($\delta^{34}$S = +10.9 ± 2.7‰, Reuschel et al. 2012), consistent with the isotope fractionation by bacterial sulphate reduction. In situ $\delta^{56}$Fe values (between -0.5 and -1.5‰) of the pyrites are slightly shifted from igneous rocks ($\delta^{56}$Fe = +0.09 ± 0.10‰, Beard et al. 2003), which is in the range of the microbial reduction of Fe (oxyhydr)oxides, but may equally well be caused by purely abiotic processes.

The interpreted influence of microbial mats and flow events on the deposition of laminated pyritic lithofacies in the Talvivaara Fm, supported by $\delta^{34}$S and $\delta^{56}$Fe
values of pyrite grains, points towards a marine sedimentary environment with anoxic (ferruginous) background conditions, where pulses of oxic (sulphatic) surface water triggered intense bacterial sulphate reduction and possible microbial iron reduction in microbial mats on the seafloor, leading to pyrite precipitation. This scenario challenges the previous model for the iron sulphide enrichment of the Talvivaara Fm by hydrothermal fluid interactions with the organic-rich muds (e.g. Loukola-Ruskeeniemi & Lahtinen 2013).

REFERENCES


