Evidence of microbial sulfate reduction in nanopyrites enclosed in 2.7 billions year old stromatolitic organic remains

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Microbial sulfate reduction (MSR) is a common metabolism in modern stromatolites involved in carbonate precipitation and lithification. MSR is thought to have operated very early on Earth but was not precisely identified in fossil stromatolite due to the difficulty of recognizing original microbial signature from abiotic diagenetic processes.

We studied by NanoSIMS the sulfur isotope composition of pyrites associated with stromatolitic limestones of the 2.7 Gyr old Tumbiana Formation (Western Australia). Two types of pyrites were analyzed: 1) sub micron-pyrites occurring in organic material lining the domical shape of stromatolite knobs and 2) larger pyrites present as randomly-distributed grains in micritic carbonate and mudstone layers. The analyzed sub micron-pyrites show a large range of $\delta^{34}S$ values of about 82‰ (from -35.4 ‰ to + 47.1‰), with one main population at about -12‰ and two others centered at -35 ‰ and +14 ‰. In contrast, pyrite in the rock matrix shows a narrower range of $\delta^{34}S$ values between -5.3 ‰ and +3.4‰. This indicates that the nanopyrites preserved in the carbonaceous layers are pristine features and were not re-homogenized with the surrounding matrix after trapping. The 80‰ range found in individual kerogenous-rich layers indicates that the sub-microns pyrites were formed in the microbial mat through MSR during early diagenesis in the sediments. These results confirm that MSR metabolisms actively participate to the biogeochemical cycling of sulfur during the Mesoarchean.