Biogenicity of Fe-oxyhydroxide filaments in silicified low-temperature hydrothermal deposits

KAREN C. JOHANNESSEN[1]*, NICOLA MCLOUGHLIN[2], PER ERIK VULLUM[3] AND INGUNN H. THORSETH[1]

[1] Centre for Geobiology and Department of Earth Science, University of Bergen, Norway (*correspondence: Karen.C.Johannessen@uib.no)
[2] Albany Museum and Department of Geology, Rhodes University, Grahamstown, South Africa
[3] SINTEF, Materials and Chemistry and Department of Physics, NTNU, Trondheim, Norway

Biomineralized twisted and branching stalks of microaerophilic Fe(II)-oxidizing bacteria are considered promising biosignatures of microbial Fe-oxidation in jaspers and iron formations. The identification of Fe-oxidizing bacteria in the rock record is dependent on knowledge of the deposition and preservation of extracellular stalks in modern settings. In this study we examined siliceous iron deposits at an extinct part of the Jan Mayen Vent Fields, the Arctic Mid-Ocean Ridge, with the aim of resolving whether signatures of biogenic Fe-oxyhydroxide mineralization are preserved after early diagenesis. Optical and scanning electron microscopy in combination with focused ion beam-transmission electron microscopy (FIB-TEM) allowed us to study both the textural association of filaments and the cross-sections of individual stalks. Our results revelead both clearly biogenic and apparently abiogenic filamentous textures, which differed in filament directionality, width and ultrastructure. Twisted stalks and hollow tubes produced by Fe-oxidizing bacteria were composed of concentric Fe-oxyhydroxide laminae encrusted by thick silica casings. Inter-laminar variations in the contents of Si, P and S suggest that early diagenetic alteration is mediated by succesive, chemically distinct hydrothermal fluid pulses, which initiate Fe-oxyhydroxide mineralization on the stalk surfaces. The content of carbon did not differ from background levels, indicating that organic compounds may be lost from the cores of the stalks prior to silicification. Abiogernic features included 10-30 μm wide filaments and dendrites composed of nm-sized iron spherules dispersed in silica. The spherules contained microcrystalline domains, suggesting temperatures exceeding those associated with microbial Fe-oxidation. Our study demonstrates that abiogenic processes can generate stalk-like filaments in Fe- and Si-rich hydrothermal environments and that organic carbon is less likely than textural features and stalk ultrastructures to survive early diagenesis and silicification.