# Study at the nanoscale of iron biomineralization on organic fibres by a phototrophic iron-oxidizing bacterium

KARIM BENZERARA[1], JENNYFER MIOT[1], MARTIN OBST[2], ANDREAS KAPPLER[2], FLORIAN HEGLER[2], FRANCOIS GUYOT[1] AND GUILLAUME MORIN[1]

[1]Institut de Minéralogie et de Physique des Milieux Condensés, CNRS, UPMC, IPGP & University Paris Diderot, 140 Rue de Lourmel, 75015 Paris, France
[2]Geomicrobiology Center for Applied Geoscience (ZAG), University of Tuebingen, Sigwartstrasse 10, 72076 Tuebingen, Germany

Iron-oxidizing bacteria can impact the formation of iron minerals by their metabolic activity and by forming nucleation surfaces. Some of them can also seemingly control the localization of mineral precipitation but biochemical actors of such a potential strategy are still not known. Here, we have studied the formation of nano-goethite (α-FeOOH) by the phototrophic anaerobic iron-oxidizing bacteria *Rhodobacter* sp. strain SW2 at neutral pH. On the contrary to what is observed for some other neutrophilic anaerobic iron-oxidizing bacteria (Miot *et al*. [1]), biomineralization by SW2 occurs exclusively outside the cells, sometimes on polymer fibres emerging from the cells (Miot *et al*. [2]). Scanning Transmission X-ray Microscopy (STXM) analyses performed at the C K-edge suggest that these fibres are composed of a mixture of lipids and polysaccharides or of lipo-polysaccharides. We observed that the iron and organic carbon contents on these fibres are linearly correlated at the 25-nm scale, which in addition to their texture suggests that these fibres act as a template for mineral precipitation, followed by a limited crystal growth. Moreover, we evidence a gradient of the iron oxidation state along the mineralized fibres at the submicrometer-scale. Fe-minerals on these fibres contain a higher proportion of Fe (III) at the cell contact and the proportion of Fe (II) increases at distance from the cells. Altogether, these results demonstrate the primordial role of organic polymers in iron biomineralization and provide first evidence for the existence of a redox gradient around these non-encrusting Fe-oxidizing bacteria.

[1] Miot *et al*. (2009a) Iron biomineralization by neutrophilic iron-oxidizing bacteria. *Geochimica Cosmochimica Acta*, **73**, 696–711. [2] Miot *et al*. (2009b) Extracellular iron biomineralization by photoautotrophic iron-oxidizing bacteria. *Applied & Environmental Microbiology* **75**, 5586–5591.

# Stardust and CI-chondrite sulfides

E.L. BERGER[1]*, D.S. LAURETTA[1], T.J. ZEGA[2] AND L.P. KELLER[3]

[1]Lunar and Planetary Laboratory, Dept. of Planetary Sciences, University of Arizona, Tucson, AZ 85721 (*correspondence: elberger@lpl.arizona.edu)
[2]Naval Research Laboratory, Washington D.C., 20375
[3]Robert M. Walker Laboratory for Space Sciences, ARES, Johnson Space Center, Houston, TX 77573

NASA's Stardust Mission successfully returned a diverse collection of material from Comet 81P/Wild 2; from high-temperature CAI-like components to low-temperature sulfide minerals. While the CAI-like assemblages returned by the spacecraft bear witness to mixing of high-temperature components in the early Solar System, sulfides provide complementary information about low-temperature material. Sulfides may represent the strongest evidence for preservation of grains that experienced aqueous alteration at some point in their history. Some of the Stardust sulfides bear a striking resemblance to the sulfides in CI chondrites, suggesting a possible relationship between the two types of material. In particular, pyrrhotite, pentlandite, and cubanite occur in both collections.

Compositions and crystal structures of Stardust sulfides are characterized using transmission electron microscopy (TEM) at Johnson Space Center, on the JEOL 2000FX STEM and the JEOL 2500SE field emission STEM. CI-chondrite sulfides are characterized using a combination of electron microprobe analysis and TEM, using the Cameca SX-50 Electron Microprobe at the University of Arizona and the JEOL 2200 FS TEM at the Naval Research Laboratory.

The crystal structures and compositions of these sulfides, both individually and in combination, yield constraints for formation conditions. For example, the presence of orthorhombic cubanite, in the Stardust and CI-chondrite collections, provides a maximum temperature constraint of 210°C [e.g. 1]. The stability of 4C monoclinic pyrrhotite, which has been identified in both collections, is restricted to temperatures below ~250°C [2]. Combinations of cubanite and pyrrhotite, as well as pyrrhotite and pentlandite furnish further constraints. The mineralogical heritage of these grains aids in elucidating early solar system processes.

[1] Pruseth *et al*. (1999) *Eur. J. Mineral* **11**, 471–476. [2] Wang *et al*. (2008) *J. Sulfur Chem*. **27**, 271–282.