

BIOMINERALIZATION AND STABILITY OF FRAMBOIDAL GREIGITES

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The biomineralization of framboidal greigites is a biologically controlled mineralization, where ferrimagnetic iron sulfide, greigite (Fe_3S_4), is crystallised intracellularly in bacterial magnetosomes of sulfate reducing bacteria (SRB) [1].

Transmission electron microscopy (TEM) observations of framboidal greigites from a sediment core of the Black Sea [2] are shown in Fig. 1.

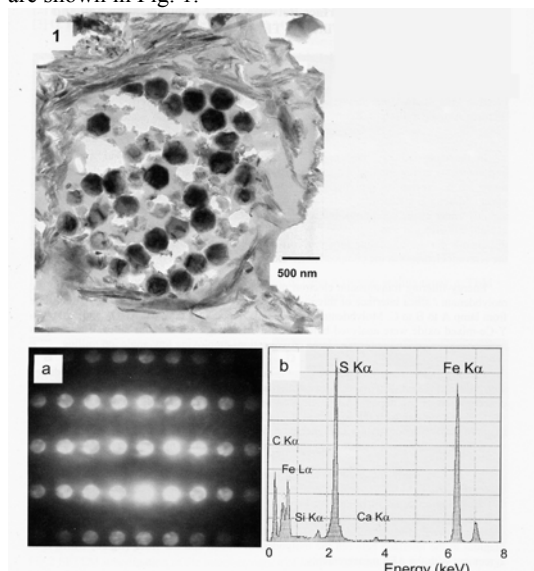


Fig. 1 TEM bright field image of an ultramicrotome section of a framboidal greigite. a. Convergent beam electron diffraction (CBED), b. EDX analysis [3].

The single crystals show the cubic symmetric structure of a ferrimagnetic inverse thiospinel, $\text{Fe}^{2+}\text{Fe}^{3+}_2\text{S}_4$, having a cell-edge length $a = 9.868 \text{ \AA}$ [4]. The isometric crystals of $\sim 0.5 \mu\text{m}$ exhibit $\{111\}$ as the dominant form accompanied by $\{100\}$. Each of the single crystals was surrounded by a membrane. These individual cubo-octahedral microcrystals are packed into a regular 3-D array within the framboid. Each greigite octahedron is tetrahedrally coordinated by 4 octahedra over $\{111\}$ to form a 3-D array and with 4 vacancies in form of icosahedra, where the triangles of the octahedra and icosahedra are of the same size. One icosahedron is surrounded by 20 octahedra. The formation of framboidal greigites in the Black Sea may have begun with a symbiosis of SRB and methanogenic archaea (MA) in the chemocline zone and their sedimentation to the anoxic bottom of the Sea. The diameters of the MA are a factor 1.5 greater than those of the SRB [5]. In our model the exchange reaction $\text{SO}_4^{2-} + \text{CH}_4 \rightarrow \text{SH}^- + \text{HCO}_3^- + \text{H}_2\text{O}$ takes place over the membranes of both bacteria. The MA correspond to the icosahedra and the SRB to the octahedra. The icosahedra form a close package of 74 % together with 26 % of the 3D-octahedra array. The framboidal greigites are stable under anoxic conditions. Under influence of oxygen the greigite is changed partially to pyrite.

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[5] Boetius A., Ravensschlag K., Schubert C.J., Rickert D., Widdel F., Gieseke A., Amann R., Jørgensen B.B., Witte U. & Pfannkuche O. (2000), *Nature* **407**, 623-626.