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Research Article

Formation of iron-rich shelled structures by microbial communities

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Abstract

In this paper, we describe the discovery and characterization of shelled structures that occur inside galleries of Pyrenees mines. The structures are formed by the mineralization of iron and zinc oxides, dominantly franklinite ($ZnFe_2O_4$) and poorly ordered goethite (α-FeO(OH)). Subsurface oxidation and hydration of polymetallic sulfide orebodies produce solutions rich in dissolved metal cations including $Fe^{2+/3+}$ and Zn^{2+}. The microbially precipitated shell-like structure grows by lateral or vertical stacking of thin laminae of iron oxide particles which are accreted mostly by fungal filaments. The resulting structures are composed of randomly oriented aggregates of needle-like, uniform-sized crystals, suggesting some biological control in the structure formation. Such structures are formed by the integration of two separated shells, following a complex process driven likely by different strategies of fungal microorganisms that produced the complex macrostructure.

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Figures S1–S14

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Highlights

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Microbial Communities Form Iron Shells in Abandoned Mines

David Shultz, Freelance Writer03 September 2015

High in the Pyrenees Mountains, deep in abandoned mines, scientists discovered peculiar black shells that seem to crop up of their own accord on metal surfaces. These bulbous protrusions coat steel pipes, cables, and rods left behind by the miners, and now researchers think they know why they form.

Through careful analysis of the shells' composition and structure, *Fernández-Remolar et al.* concluded that microbes —fungi primarily—form the shells, depositing iron oxide and other minerals as part of their natural metabolism.

The clam-like structures—composed of an upper and lower shell—have a rough symmetry to them and always grow outward from a single point of attachment. Electron microscopy revealed small-scale, fiber-like crystals arranged into lines growing outward from the steel surface. The shells appear to be formed layer by layer, with crystal size and composition varying across layers.

To determine what sorts of microbes might be laying down the mineral layers, scientists used spectrometric techniques in combination with an antibody-covered chip originally designed to search for life on other planets. Specifically, the team analyzed cave environments by testing for 300 different components of microbial cells, such as DNA, proteins, and other biomolecules, to generate a fingerprint of what sort of organisms might be present.

The researchers report that fungal filaments, which sequester iron ions from the mine waters, appear to be the dominant players in the shells' formation, especially in the latter stages of development after the base layers have been laid down by bacteria. The result of this complex interplay between microbes and iron-rich water is a rapid biomineralization process that sprouts iron-rich shells from the surface of steel structures.

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