Biomineralization of jarosite by *Purpureocillium lilacinum*, an acidophilic fungi isolated from Río Tinto

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Río Tinto (Huelva, Southwestern Spain) is an extreme environment with a remarkably constant acidic pH and a high concentration of heavy metals, conditions generated by the metabolic activity of chemolithotrophic microorganisms thriving in the rich complex of the Iberian Pyrite Belt (IPB).

In this study, we report the specific biomineralization of (hydronium)-jarosite, an iron sulfate mineral that appears in abundance on Río Tinto banks by an acidic fungal isolate, *Purpureocillium lilacinum*. Different fungal species were isolated from Rio Tinto; characterized, cultured and tested for their ability to promote the formation of jarosite. Of the 10 strains tested, only *P. lilacinum* was able to produce jarosite. The biomineral was characterized by X-Ray Diffraction (XRD) and its formation was observed with high-resolution transmission electron microscopy (TEM) and scanning electron microscopy (SEM) coupled to Energy-dispersive X-ray spectroscopy (EDX) microanalysis.

Jarosite began to nucleate on the fungal cell wall, even on dead cells (although with much less efficiency). Also extracellular polymeric substances (EPS) released by the fungus could serve as nucleation sites for this biomineralization process. Our model proposes the creation of Fe^{3+}/Fe^{2+}-rich microdomains in the cell walls of *P. lilacinum* that induce the supersaturation and precipitation of jarosite. This change in the proportions of reduced and oxidized iron species, can be produced by the electrostatic interaction between soluble ferric iron and the negatively charged groups of the fungal cell wall, acting as nucleation sites for mineral precipitation according to previous studies [1].

The occurrence of *P. lilacinum* in an ecosystem with high concentrations of jarosite strongly suggests that might participate actively in the formation of this mineral in the river banks.

[1] Konhauser (1998) *Earth Sci Rev* **43**, 91-121

The biological control on the atmospheric pCO_2 level through geologic time

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Here we constrain the atmospheric pCO_2 levels during the evolution of the Earth's biosphere through pre-biotic, anaerobic, pre-plant aerobic, and plant stages based on the BLAG-type geochemical modeling of CO_2 cycling. We have developed a new set of equations considering: (i) the flux and fate of CO_2 and reduced volcanic gases; (ii) the biological influence of soil formation; (iii) the cycling of phosphorus-bearing compounds; (iv) the C/P ratios of kerogen; (v) the burial efficiency of organic matter in sediments; (vi) the weathering efficiency of kerogen; (vii) the production efficiency of biogenic CH_4; and (viii) the formation of organic haze in the atmosphere and the deposition of haze-C in sediments. Our modeling suggests that the atmospheric pCO_2 remained at > 100 PAL during most of the pre-biotic-, anaerobic-, and pre-plant aerobic stages. No additional greenhouse gases (e.g., CH_4, H_2) were necessary to maintain a warm Earth under a faint young Sun. A transition of the biosphere caused a drastic change in the atmospheric pCO_2 level: a drop from >1,000 to ~100 PAL due to the development of an anaerobic world; a rise from ~100 to ~1,000 PAL during the anaerobic to aerobic transition; and a drop from ~20 to ~2 PAL due to the development of the plant world. Fluctuations in the soil-forming land area profoundly affect the climate of the Earth. Continental breakup would result in a global cooling event, while the formation of supercontinents would result in global warming.

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