Scanning electron micrographs of microbial sulfide deposition from (INSPIRE_Pyrite project)

Website: https://www.bco-dmo.org/dataset/637892
Data Type: experimental
Version: working
Version Date: 2016-02-04

Project
» INSPIRE Track 1: Microbial Sulfur Metabolism and its Potential for Transforming the Growth of Epitaxial Solar Cell Absorbers (INSPIRE_Pyrite)

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Table of Contents

Dataset Description

These six pictures give clear visual support to the proposal that marine microbes can deposit pyrite (FeS_2). In several of the micrographs, the marine microbe *Desulfovibrio hydrothermalis strain AM13*, a deep-sea vent microbe, can be seen growing on the provided substrate.

[table of contents | back to top]

Data Files

File
SEMmicrographs.csv (Comma Separated Values (.csv), 1.90 KB) MD5:dc7664f94fe12683825a52595eef7f1b Primary data file for dataset ID 637892

[table of contents | back to top]

Parameters

Parameter	Description	Units
image	scanning electron micrograph as jpg	image
brief_desc	brief description of the what is on the image	text

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	SEM/EDX
Generic Instrument Name	Scanning Electron Microscope
Dataset-specific Description	Scanning Electron Microscopy coupled with Energy Dispersive X-ray (SEM/EDX) Spectroscopy. "Scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDX) is the best known and most widely-used of the surface analytical techniques. High resolution images of surface topography, with excellent depth of field, are produced using a highly-focused, scanning (primary) electron beam. The primary electrons enter a surface with an energy of 0.5 – 30 kV and generate many low energy secondary electrons. The intensity of these secondary electrons is largely governed by the surface topography of the sample. An image of the sample surface can thus be constructed by measuring secondary electron intensity as a function of the position of the scanning primary electron beam. High spatial resolution is possible because the primary electron beam can be focused to a very small spot (
Generic Instrument Description	A scanning electron microscope (SEM) scans a focused electron beam over a surface to create an image. The electrons in the beam interact with the sample, producing various signals that can be used to obtain information about the surface topography and composition.

[table of contents | back to top]

Project Information

INSPIRE Track 1: Microbial Sulfur Metabolism and its Potential for Transforming the Growth of Epitaxial Solar Cell Absorbers (INSPIRE_Pyrite)

This INSPIRE award is partially funded by Biological Oceanography Program in Division of Ocean Sciences, in the Directorate of Geosciences; the Electronic and Photonic Materials Program in the Division of Materials Research, Directorate of Mathematical and Physical Sciences.

A simple idea motivates this project: By characterizing the mechanisms underlying pyrite film deposition by subsurface microbes living at hydrothermal vents, can approaches be developed to controllably grow high-purity pyrite films that could be used to produce low-cost photovoltaic solar cells? Recent in situ studies at hydrothermal vents have found "subsurface" microbes associated with the deposition of large crystalline metal sulfides (up to 1.1 millimeters), including iron pyrite. In laboratory incubations, vent microbes specifically deposited pyrite (FeS_2), devoid of Zn, Cu and other metals that were abundant in the liquid media. Abiotic incubations did not exhibit this specificity. The investigators hypothesize that, in situ, microbes deposit pyrite via a number of potential processes, including a physiological process called extracellular electron transfer (EET), wherein microbes shuttle electrons to/from minerals. In situ, EET-enabled microbes may use conductive minerals to electrically access oxidants, and deposit pyrite on these surfaces. Vents are thus natural bioelectrochemical cells, which grow metal sulfides via microbial and abiotic electrochemical processes, though the details and mechanisms remain to be determined. This project is aimed at elucidating the mechanisms underlying microbial FeS_2 pyrite bio-deposition, and assessing how microbes might be used to deposit epitaxial films for solar cells absorbers. FeS_2 pyrite has been identified as prospective low cost solar absorbers because of their abundance, suitable band-gap (~0.95 eV) and high optical absorbance. Microbial pyrite film deposition at lower temperatures (<100 C) might offer a radically new, low cost approach to creating large area PV solar cells. Nothing is currently known about the mechanisms underlying microbial pyrite growth, though the large crystal sizes suggest epitaxial deposition is favored over re-nucleation implying that, once nucleated, epitaxial growth can occur. A series of experiments using natural vent microbial communities and isolates will be conducted to determine: A) environmental factors that influence bio-deposition; B) potential molecular mechanisms; C) the microstructural and electrical properties of these films; and D) whether bio-deposition by single species or consortia yields films of highest purity, size and homogeneity.

The project is both highly-integrated and transformative. It is relevant to our understanding of microbial sulfur cycling, as little is known about how microbes mediate crystalline pyrite formation and the degree to which this influences sulfur isotope geochemistry. Molecular studies will be used to interrogate relevant microbial metabolic processes and constrain the possible mechanisms of pyrite film growth, which is critical to advancing our ability to grow FeS_2 films for device applications. Understanding the effects of substrate crystallography and electrical conductivity on the growth morphology will further inform our knowledge of microbial pyrite deposition. Notably, this research differ from existing biomimetic approaches. The studies are not focused on crystal growth via tethered peptides or synthetic extracellular matrices. Rather, they aim to advance our understanding of natural biodeposition, use the insights gained to grow pyrite materials and devices.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1344241

[table of contents | back to top]