Microbial 'Life Signatures': Novel biogenic mineral production and enzyme detection in microorganisms

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Many biogenic minerals are produced as a bi-product of microbial metabolism. Generally, biogenic minerals have no known abiotic analog or an analog which is chemically or physically distinct from the biotic form. Laboratory and *in situ* studies have revealed the importance of microorganisms in the formation of biogenic minerals, not only in elemental biogeochemical cycling but also in the detection of 'viable life signatures' in a wide variety of samples and environments.

Microorganisms from the Alvord Basin hydrothermal system in southeast Oregon were cultured on a freshwater medium using selective growth conditions to promote the growth of microorganisms that produce or transform arsenic, iron, and selenium bearing minerals. Isolates capable of mineral transformation were characterized and the minerals were analyzed using surface spectroscopy methods. One isolate (YeAs) when grown on soluble oxided arsenic compounds has the the ability to produce beta-realgar, an arsenic sulfide mineral that has never been observed as a product of microbial mineral metabolism. This novel compound, produced by microbial arsenic transformation is an excellent example of novel biogenic mineral production. Additional isolates capable of selenium and iron production and transformation have also been cultured.

Biochemical methods were utilized to detect, extract, and purify biological (enzymatic) activities responsible for mineral formation. Assay methods have been developed to detect enzymes and their related activities. Protein extracts were subjected to non-denaturing (ND) polyacrylamide gel (PAGE) analysis, and native enzyme complexes in an active state were effectively resolved. Using an activity stain, enzymes involved in mineral transformation were detected, including the arsenic reductase involved in beta-realgar formation by YeAs.

This research will greatly aid geomicrobiologists and exobiologists interested in novel biogenic minerals by providing isolated and characterized microorganisms that produce the mineral of interest, while also offering methods for detecting and resolving the microbial enzyme(s) related to the mineral. In addition, the tools developed can be applied to microbial life detection in uncharacterized extreme earth environments that represent possible analogs to those found on Mars and other worlds.