4.3.24

Environmental limits of the circumneutral iron-oxidizing bacterial isolate ES-1: Field, culture, and kinetic results from voltammetric analyses

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Voltammetric analyses using Au-amalgam microelectrodes were accomplished at sub-mm spatial increments at iron-rich marsh environments(pH 6.2) near Contrary Creek, Virginia, USA, and in gradient culture tubes. The freshwater circumneutral iron oxidizing isolate ES-1 was cultured under microaerobic conditions in gradient tubes and used in laboratory kinetic experiments to investigate physiology and fundamental controls on the environmental limits of growth.

Profiles from field environments and gradient culture tubes (Figure 1) clearly show growth and activity of ES-1 limited to microaerophilic regions and several instances where metal sulfide molecular clusters represent a significant proportion of total iron. Kinetic experiments show statistically significant differences in iron oxidation rates between abiotic and culture experiments only when the oxygen concentration is less than 20 µM.

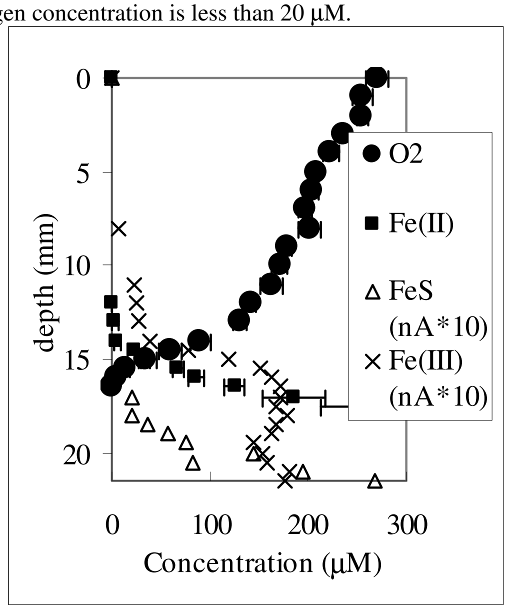

Figure 1 – Profile of ES-1 gradient culture tube from voltammetric sensor data. Note that Fe(III) and FeS reported in nA*10, not µM.

4.3.25

Assessment of iron oxides associated with mixed neutrophilic iron-oxidizing bacteria

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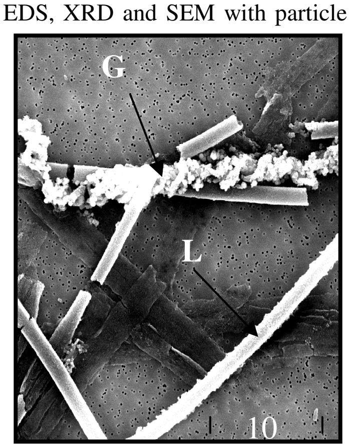
Iron oxides in natural environments are commonly small and poorly ordered. The direct association of hydrous ferric oxides with iron oxidizing bacteria (FeOB) is evident, and demonstrates a bacterial catalytic affect on mineral growth. Trace metal sequestration by bacteriogenic iron oxides (BIOS) has been repeatedly demonstrated [1,2]. Accordingly, highly reactive BIOS plays a strong role in the cycling of trace metals in natural systems.

To evaluate the influence of FeOB on the particle size, chemical composition and mineralogy of iron oxides, natural BIOS was analyzed. The BIOS studied consisted of a bacterial consortium of varying proportions of Gallionella ferruginea and Leptothrix ochracea, two ubiquitous FeOB. Experimentation included EDS, XRD and SEM with particle size analysis.



A significant trend was observed for iron oxide particle size associated with sheaths of L. ochracea in comparison to stalks of G. ferruginea within the same sample. Although L. ochracea sheaths were visibly encrusted with iron oxide, individual grain size was smaller (0.15-0.2 µm) versus that on G. ferruginea stalks (0.4-0.8 µm). Mineral variation was also observed for eutrophic versus oligotrophic environments, which can be attributed to the influence of organics in mineral growth. Other abiotic factors such as temperature, water velocity and dissolved oxygen may also play a strong role in mineral formation in association with such bacterial communities.

Variations in particle size contribute greatly to surface area, hence reactivity of the bacteriogenic iron oxide product. The influence of bacterial community distribution on iron oxide formation therefore has great biogeochemical implications.

References

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