

## Reductive microbial transformations of iron oxides; engineering biominerals for the remediation of metals and organics

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The microbial reduction of Fe(III) minerals at redox interfaces plays a critical role in controlling the mobility of both inorganic and organic species in the subsurface and offers the basis for flexible and robust bioremediation processes. The nature of the Fe(II)-bearing mineral phase formed is especially important in mediating 'indirect' reductive transformations of xenobiotic organics, redox active toxic metals and radionuclides during contaminant clean up.

We have used a range of approaches to optimise bioproduction of the Fe(II)-bearing mineral phase for reductive transformations of organic and inorganic substrates. These include the selection of the optimal Fe(III)-mineral phase for conversion to highly reactive nano-scale biomagnetite, and the incorporation of highly reactive transition metals into or onto the post-reduction mineral. The molecular-scale characterization of the resulting functional bionanominerals using techniques including high-resolution TEM, XPS, Mossbauer spectroscopy, XAS and XMCD will be described as well as their use in the detoxification of model organic contaminants, metals such as Cr(VI) and radionuclides including Tc(VII). Experiments conducted in batch contactors and sediment columns confirm that the optimised biomineral phases can be used effectively for both *in situ* and *ex situ* remediation of a broad range of contaminants.

## Spatial structure and activity of shallow subsurface microbial communities in a Gulf of Mexico methane seep

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At deep sea methane seeps, sulfur-oxidizing bacterial mats of filamentous *Beggiatoa* spp. often serve as visual indicators of the spatial extent of subsurface venting and of the distribution of sedimentary microbial communities [1, 2]. This assumption was tested at Mississippi Canyon block 118 in the Gulf of Mexico, where a core transect across a broad bacterial mat showed a steep decrease in methane- and sulfur- cycling activities just outside the mat. In the active sub-mat community, mRNA transcripts for the key genes of methane production/oxidation (*mcrA*) and sulfate reduction (*dsrAB*) as well as 16S rRNA transcripts showed very little variation with either sediment depth or proximity to the edge of the mat. Immediately outside the mat, this sulfur- and methane-cycling community persisted at 12 cm sediment depth, but was completely inactive or absent in the top 3 cm, where no *mcrA* and *dsrAB* were detected. Instead, 16S rRNA libraries reflected the influence of oxic seawater on the microbial community. Total diversity of archaeal 16S rRNA transcripts increased with depth and proximity to seeping fluids, whereas bacterial diversity had the opposite trend. We conclude that the sulfur-oxidizing *Beggiatoa* mats are a highly conservative proxy for surface-located sulfate-reducing and methane-cycling communities, and an environment that supports a higher archaeal diversity than bacterial diversity.

[1] Joye (2004) *Chem. Geol.* **205**, 219-238. [2] Lloyd (2006) *Appl. Environ. Microbiol.* **72**, 7218-7230.