# Controls on Fe reduction and mineral formation by a subsurface bacterium

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#### **Experimental approach**

Cells of *Shewanella putrefaciens* CN32, a dissimilatory Fe-reducing bacterium, were grown in defined medium under strict anaerobic conditions (Glasauer et al., 2002) in culture flasks to which nano-crystalline goethite, micro-crystalline goethite, hematite or hydrous ferric oxide (HFO) were added as electron acceptors. Cell growth, Fe metabolism, and mineral formation and partitioning were tracked over time using standard techniques (Glasauer et al., 2002).

#### Results

Under nutrient-limited conditions cells were unable to reduce the crystalline minerals. Reduction of HFO began within 7 d and a variety of minerals was produced. Green rust I was most frequently observed near vivianite and HFO aggregates. Vivianite appeared to form within HFO aggregates, unassociated with cells; the rate of Fe reduction influenced crystallite mean coherence lengths. Nano-crystalline magnetite and goethite (<10 nm) formed within aggregates of HFO sorbed to cells. When the  $[PO_4^{3-}]$  concentration was reduced, Fe reduction was lower and nano-crystalline goethite was the only mineral detected.

#### **Discussion and Conclusions**

The inability of CN32 to reduce the crystalline Fe(III) minerals indicates that energetics of the mineral surface rather than surface area determine reducibility. In addition,  $[PO_4^{3-}]$  plays a key role in mineral transformations through its influence on cell fitness and its contribution to mineral equilibria. The locations of the biogenic minerals with respect to cells reflect the ability of the bacteria to create chemical gradients. Our results highlight the microheterogeneity of mineral formation and show that both abiotic and biogenic pathways of mineral formation should be considered when modeling subsurface environments.

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## Geochemical impacts of combustion wastes in reuse and disposal

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Much of the world relies on thermal combustion processes for primary energy production. Combustion is also increasingly being used for volume reduction of municipal waste, perhaps with recovery of thermal energy. Much attention has been devoted to gaseous and particulate emissions arising from combustion processes but this contribution focuses on solid residues from combustion which, in the case of certain coals, may reach 30 - 40 weight %.

The presentation focuses on three aspects of combustion wastes: characterisation, disposal and prospects for reuse. Characterisation is an often neglected stage. Not only is ash very inhomogeneous but its characteristics also vary with the nature of the combustion process and fluctuate with changes in process conditions. The extent of utilization varies: some, such as coal combustion bottom ash and municipal incinerator ash are mainly landfilled. On the other hand, coal combustion fly ash and iron blast furnace slag achieve relatively high utilisation.

Landfilled materials are often strongly enriched in heavy metals. Leaching tests are usually used to determine potential for toxic or hazardous releases. But on a large scale, in landfills, the behaviour of combustion wastes is like a miniature orebody; a range of geochemical processes operate to achieve both dispersion and concentration of inorganic species. Leaching tests are useful but inadequate to characterise long-term behaviour.

Present day industrial processes do not have as their primary objective reuse or recycling of wastes: wastes are available, but the potential customer is often unable to optimise and tailor waste properties for specific uses. Clearly some compromise is needed; prospects for enhancement of the potential for reuse of wastes are discussed.