

The reactivity of microbially-reduced goethite: assessing the potential of a naturally-occurring waste material for mine drainage remediation

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Naturally occurring iron (Fe) oxides are ubiquitous in nature, particularly at abandoned mine sites where extraction processes have resulted in the oxidation of Fe-bearing sulphide minerals. Goethite, an Fe(III) oxide, is stable over a wide range of Eh and pH conditions and is present at several coal mine drainage treatment systems in the South Wales Coalfield, UK.

Microbial investigations at the Ynysarwed mine in the Coalfield revealed the presence of bacteria closely related to known Fe(III)-reducing species within the goethite deposit. Microcosm experiments designed to investigate the activity of these naturally-occurring bacteria were prepared using sodium acetate as the electron donor and the naturally occurring goethite as the electron acceptor.

After 100 days the solid phase Fe(II) content was determined and the results show an increase from ~1.5% Fe(II) in the starting material to ~9% in the microbially-reduced material. No increase in Fe(II) was observed in the kill or live controls. Dilute acid extractions (0.1M HCl) of the material, designed to solubilise Fe(II) weakly bound to the goethite crystal surface, recovered 97-99% of the total Fe(II).

The ability of Fe(II) bound to the surface of goethite to reduce potentially harmful elements has been shown in several studies. The reactivity of microbially-reduced natural goethite and its ability to remove problematic elements, such as zinc (Zn), from natural mine waters through addition of the slurried reduced material (5g L⁻¹ dry weight) was investigated. The results show a 5-fold increase in Zn removal from a circum-neutral mine water when compared to natural goethite. These data show the potential of naturally-occurring mine waste for the remediation of contaminated mine waters.

The Fate of Small Active Margin River POC in the Marine Environment

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Small active margin rivers export a mixture of particulate organic carbon (POC) pools derived from contemporary primary production, aged soils and uplifted sedimentary rocks. These pools are expected to exhibit a wide range of reactivities in the marine environment because of their vastly different ages and diagenetic histories. The stable carbon and radiocarbon isotopic compositions of sedimentary POC and pore water dissolved inorganic carbon (DIC) from the Waiapu River shelf, New Zealand were measured to determine the fate of the exported riverine POC. The Waiapu River exports material that is dominated by fossil C derived from the rapidly eroding Cretaceous to Paleocene mudstones (riverine POC $F_{\text{mod}} \sim 0.3$). Shelf sediments incorporate both riverine and marine POC as indicated by an enrichment in ¹³C and accumulation of ¹⁴C-rich material ($F_{\text{mod}} \sim 1$).

Porewater DIC carbon isotope compositions are controlled primarily by the addition of remineralized organic carbon to a seawater background. In the case of the Waiapu shelf, DIC $\delta^{13}\text{C}$ values indicate preferential oxidation of terrestrial OC nearshore (~60 meters water depth) with a transition to more marine C-supported remineralization further offshore (80-130 m water depth). In all cases, the remineralized C is modern in age, thus no appreciable oxidation of fossil C or aged soil C is evident.

Oxidation of the modern terrestrial OC is far from complete based on POC isotopic data from both the Waiapu and the adjacent Waipaoa system. The terrestrial OC is well preserved in areas of fine-grained sediment accumulation as a result of rapid and episodic deposition. On balance, we argue that small active margin river continental margins have the potential to be efficient carbon sinks regardless of POC age.