# Microbial transformation of radionuclides - the radionuclide biomineral interface.

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Microbial processes can have a profound effect on the solubility of radionuclides in natural and engineered environments. The scope of these processes is significant with clear evidence that radionuclide solubility may be altered enzymatically via mediated redox reactions, by indirect redox reactions with, for example, Fe(II)-bearing biominerals andfor non-redox active species, even by incorporation reactions into neo-formed biominerals formed as physicochemical conditions change. Understanding these reactions is important across radionuclide impacted environments from contaminated land environments where bioreduction and biomineralisation processes may be harnessed to control radionuclide mobility, through nuclear facilities where biological processes are often poorly constrained yet may be critical in long term management and control of radionuclides, and finally to radioactive waste disposal scenarios where there is a paucity of information on the influence of microbial processes on bio-mineralisation and radionuclide behaviour under geological disposal facility conditions.

Recent work exploring the behaviour of Sr, U and Np will be discussed with a focus on (bio)mineralisation, reduction and reoxidation reactions and their impact on radionuclide behaviour. The products of biomineralisation in terms of bulk element cycles and (bio)geochemistry will be discussed in the context of radionuclide solubility. Studies relevant to a range of environments including radioactively contaminated land, nuclear legacy ponds, and high pH environments relevant to environments expected in geological disposal of cementitious waste forms will be discussed. The biogeochemical fate of radionuclides across these systems and in the sometimes "extreme" environments that these systems pose will be highlighted.

# Critical zone weathering of glacial till in the Prairie Potholes Region: A major control on wetland ecology

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The Prairie Potholes Region (PPR), a vital ecosystem in North America comprising a 715,000 km$^2$ region in the north-central U.S. and south-central Canada, is characterized by millions of closed-basin wetlands. Sulfate is the dominant anion in these wetlands. A thick oxidized brown (iron oxide-bearing) zone which transitions to unoxidzed, gray till has been widely reported in the PPR.

The objective of this study is to characterize till alteration in the 92 hectare Cottonwood Lake Area (CWLA) near Jamestown, ND, where Pleistocene-age glacial till overlies pyrite-rich marine shale. We studied the geochemistry and mineralogy of three cores drilled along a topographic gradient from an upland position (ground surface at 569 m) to the edge of a low lying discharge wetland (ground surface at 560 m) referred to as P1, whose anion content is dominated by $SO_4^{2-}$. A brown-gray transition was recognized whose depth systematically decreased from 13.3 m in the upland core to 7.3 m at the wetland edge. We also analyzed archived cutting samples from a groundwater well drilled in 1978 near the margin of wetland P1. This well penetrated to bedrock at 136 m and the brown-gray transition was observed at 12.3 m.

Semi-quantitative X-ray diffraction (XRD) analysis of material from the cores and cuttings detected gypsum in the brown zone that ranged from trace amounts to 8 wt % with the highest concentrations at or below the water table. Gypsum was below detection (<1 wt%) in the samples from the gray zone. These results were confirmed by water leaches for soluble sulfates. Using a terrain conductivity meter, the electrical conductivities of subsurface were measured along a transect parallel to the core samples. The brown zone was more conductive than the gray zone (120-150 mS/m vs. <120 mS/m) likely due to the presence of gypsym. Both XRD and quantative reductive dissolution assays showed that gray zone samples, including those from the deep well, contain pyrite in the range 0.3 to 1.1 wt %.

We conclude that shale-derived pyrite in the till has been slowly oxidized to $SO_4^{2-}$, which is leached to groundwater and responsible for the consistently high content of S in the CWLA wetlands. These weathering processes drive groundwater and wetland geochemistry, resulting in dramatic variations in salinity over short distances depending upon where individual wetlands reside in local groundwater systems. Variations in wetland chemistry influence the flora and fauna that inhabit the wetlands. Therefore, understanding the long-term alteration processes in the till has a close link to wetland ecology in this region that is known as the duck factory of North America.