

Geochemical issues in deep underground disposal of wastes

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Historically, significant amounts of toxic and persistent solid and liquid industrial wastes have been buried or injected into the ground, often using existing underground openings or boreholes. In contrast, there are also well-advanced projects for carefully engineered geological repositories for some intractable chemical wastes and long-lived radioactive wastes in many countries. Historical practices have often been poorly controlled, whereas current and future projects will be extremely closely regulated, with long-term safety in mind. Evaluating the long-term performance of new underground disposal facilities and the impacts of past practices involves a thorough understanding of the key geochemical processes that control waste evolution in deep rock-groundwater systems. This presentation reviews the relative importance of these key processes and the circumstances under which they have strong controls on disposal safety. It also assesses the circumstances under which processes are likely to be of less or little concern in estimating safety impacts.

The topics that will be discussed include:

- products of waste degradation and their complexation with groundwater ligands;
- sorption and precipitation of mobile waste species;
- microbially enhanced processes;
- quality of and uncertainties in geochemical databases used in predictive safety evaluations;
- generation and dispersion of gases from solid wastes;
- mobility of waste components in deep groundwater and brine systems;
- chemical degradation of engineered materials used to contain wastes;
- appropriate indicators of toxicity for evaluating the performance of waste repositories at different times;
- natural and chemical analogues for some of the above processes.

How bacteria can induce the formation of nanoparticles of Fe-oxides in their vicinity

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In the last decade, natural precipitates of iron-oxides have been observed to occur in close conjunction with bacterial cells, in various natural environments. Such small particles can likely play a significant role in the cycling of various elements, including contaminants, such as lead or cadmium. It is thus important to understand which parameters control their properties. In particular, the role of bacterial cells is still unclear. Bacterial cells can affect the precipitation of minerals through metabolic processes and through physico-chemical processes, which occur since the bacterial surfaces are in contact with the solution from which the oxides precipitate.

We have oxidized ferrous ions in the presence and in the absence of various kinds of bacterial cells. We have shown that the presence of the cells induces the formation of smaller particles than in the abiotic systems (Châtellier et al., 2001). The general mechanism at neutral pH seems to be the nucleation of crystals in solution, followed by adhesion onto the cell walls and a subsequent sterically hindered growth. However the presence of exocellular polymers, such as intracellular materials from dead cells or the lipopolysaccharide brush of Gram-negative bacteria seems to induce the formation of amorphous nanoparticles of iron-oxides, which nucleate directly in contact with the polymers.

To investigate this question in further detail, we are currently oxidizing ferrous ions in the presence of *Pseudomonas aeruginosa* PA01 at various pH, imposing various kinetics for the reaction by adding the reactants at various speeds, and using various iron/bacteria ratios. Samples are then observed by electron microscopy. Depending on the advancement of our work, we will discuss these recent experiments or focus on the initial work.

References

- X. Châtellier, D. Fortin, M.M. West, G.G. Leppard and F.G. Ferris (2001) *Eur. J. Mineral.*, **13**, 705-714.