

Natural attenuation processes for groundwater contaminants: Current approaches and understanding

POUL L. BJERG

Environment & Resources, Technical University of Denmark,
Bygningstorvet, Building 115, 2, DK-2800 Lyngby
(plb@er.dtu.dk)

Natural attenuation (NA) has gained acceptance as an approach to remediate groundwater for petroleum hydrocarbon plumes and in some case chlorinated aliphatic solvents. The basic principle of natural attenuation is that naturally occurring processes in the subsurface reduces mass of critical pollutants to avoid risk to down gradient receptors. The critical issue of natural attenuation is to demonstrate quantitatively that the pollutants are subject to mass reduction. The actual disappearance of pollutants should be combined with direct evidence of degradation processes. A range of different tools has been suggested such as depletion of electron acceptors, generation of metabolic by products, formation of degradation products, isotopic techniques and enantiomeric ratios. The applicability of the different tools will depend on the actual compound, concentration levels and degradation pathways.

Landfill leachate plumes from old landfill sites or landfills without leachate collection systems or liners are numerous all over the world. Natural attenuation may be a feasible approach as discussed by Christensen et al. (2000), however, large and complex sources, mixture of pollutants (inorganic and organic) and demonstration of mass removal also challenge the field. Some of the critical pollutants at many landfill sites are herbicides, especially phenoxy acids.

The applicability of NA in plumes with phenoxy acids has been investigated by a combination of field observation studies, field injection experiments (anaerobic, aerobic) and laboratory experiments. Phenoxy acids have been detected at many sites and they are probably persistent in the anaerobic part of many landfill leachate plumes (Rügge et al., 1999; Baun et al., 2002). Aerobic degradation is likely (Broholm et al., 2001), however, field scale documentation is difficult to provide. The key note lecture will address these issues, and suggest directions for future research within NA.

References

- Baun, A.; Ledin, A.; Ask, L.; Bjerg, P.L.; Christensen, T.H. (2002). Submitted.
Broholm, M.M.; Rügge, K.; Tuxen, N.; Højbjerg, A.L.; Mosbæk, H.; Bjerg, P.L. (2001). *Water Resour. Res.*, 37, 3163-3176.
Christensen, T.H.; Bjerg, P.L.; Kjeldsen, P. (2000). *GWMR*, 20(1), 69-77.

Carbon isotope model of the Archean: Significance of deep ocean carbonate precipitation

C. J. BJERRUM¹ AND D. E. CANFIELD²

¹Geological Institute, University of Copenhagen, Denmark
(cjb@geo.geol.ku.dk)

²Danish Center for Earth System Science, Institute of Biology,
University of Southern Denmark, Denmark
(dec@biology.sdu.dk)

The isotope composition of organic matter and calcium carbonate have been widely used to infer the burial ratio of organic carbon to total carbon through Earth history. Since the long-term production of oxygen on earth is controlled by the burial of organic matter, it is of primary importance to have a complete understanding of the carbon isotope system.

We hypothesize that the delayed oxidation of Earth surface after the advent of oxygenic photosynthetic bacteria (>2.7 Ga ago), in part was a result of less burial of organic matter, relative to the total carbon burial, than previously thought. The hypothesis builds upon the observation that carbonated ocean basalt and sea floor carbonate precipitates constituted a likely significant removal pathway of inorganic carbon in the Archean. This removal pathway impacted the isotope composition of the carbonate precipitated in the surface reservoir. This is because the vertical biological organic pump in the ocean results in isotopically depleted DIC in deep waters relative to surface waters. When inorganic carbonate is precipitated into ocean crust it is isotopically depleted relative to the carbonates precipitated in the surface ocean. In the limit with nearly all inorganic carbon precipitated from the deep ocean, inferences on organic carbon burial from the isotope composition of surface ocean carbonates are greatly limited.

We will present carbon isotope calculation based on an extension of the two box isotope model of Kump (1991) and the carbon cycle model of Sleep and Zahnle (2001). Our model result indicates that the Archean isotope record is consistent with a burial ratio of organic carbon to total carbon that is less than 40% of the present ratio. Such low ratios are consistent with the upper values identified by Bjerrum and Canfield (2002) based on analysis of phosphate in BIF's and a simple phosphate-iron- carbon model.

References

- Kump, L., (1991), *Geology* 19, 299-302.
Sleep, N.H. and Zahnle, K., (2001), *J. Geophys. Res.* 106, 1373-1399.
Bjerrum, C.J., and Canfield, D.E., (2002), *Nature*, inpress.