

Proton and lead adsorption onto roots of the grass species *Festuca rubra*

BRIAN GINN AND JEREMY B. FEIN

University of Notre Dame; Civil Engineering and Geological Sciences; 156 Fitzpatrick Hall; Notre Dame, IN 46556 USA (bginn@nd.edu)

Metal adsorption onto biological surfaces can significantly affect metal speciation and mobility in near-surface environments. Cell wall adsorption, whether involving bacterial or root cells, is likely the first step in nutrient acquisition, but can affect the distribution of heavy metals and radionuclides as well. Many previous studies have focused on bacterial cell wall adsorption. However, plant roots can adsorb a range of metals as well. Quantifying metal adsorption onto plant root surfaces will assist in understanding the speciation of metals in complex soil systems, and can provide insights into how plants compete with soil bacteria for metal nutrients.

In this study, we measured proton and Pb binding onto roots of *Festuca rubra*, a species of grass commonly referred to as red fescue. Potentiometric titrations were performed on washed root material, using 0.1 M NaClO₄ to buffer ionic strength. Like bacteria, the roots exhibited continuous buffering behavior from pH 3 to 9. We use a discrete-site non-electrostatic surface complexation model (SCM) to constrain acidity constants and concentrations for root cell wall functional groups from the titration data. The Pb adsorption experiments were conducted at fixed Pb and root concentrations, with fixed ionic strength, as a function of pH. The roots displayed a typical adsorption edge, with the extent of adsorption increasing with increasing pH, and we use the Pb adsorption data to constrain the values of the thermodynamic stability constants for the important Pb-root surface complexes.

Our results indicate that the cell wall material associated with *F. rubra* roots has a different functional group chemistry than the cell wall material associated with bacteria. Nevertheless, plants and bacteria show a similar overall ability to uptake metals. We use the modeling results from this study to estimate Pb distributions in realistic soil systems containing root material, bacterial cells, and mineral surfaces, and we demonstrate that each reservoir can be important in determining the distribution of Pb in soil settings.

Direct evidence of the feedback between climate and weathering

S. R. GISLASON¹, E. H. OELKERS², E. S. EIRIKSDOTTIR¹, M. I. KARDJILOV¹, G. GISLADOTTIR¹, B. SIGFUSSON¹, A. SNORRASON³, S. O. ELEFSEN³, J. HARDARDOTTIR³, P. TORSSANDER⁴ AND N. Ö. OSKARSSON¹

¹Institute of Earth Science, University of Iceland, Reykjavík, Iceland (sigrg@raunvis.hi.is; ese@raunvis.hi.is; ggisla@hi.is; bergur@hi.is; nielso@hi.is)

²Géochimie et Biogéochimie Experimentale — LMTG/Université Paul Sabatier, Toulouse, France (oelkers@lmtg.obs-mip.fr)

³National Energy Authority, Reykjavík, Iceland (asn@os.is; soe@vgkhonnun.is; jha@os.is)

⁴Department of Geology and Geochemistry, Stockholm University, Stockholm, Sweden (peter.torssander@geo.su.se)

The major long term climate moderating process on the surface of the Earth is the link between climate and chemical weathering through the greenhouse effect; the higher the temperature, the faster the weathering rate and CO₂ sequestration. Weathering releases divalent cations to the ocean via riverine transport, either in dissolved and suspended form, where they promote the drawdown of CO₂ from the atmosphere by carbonate mineral precipitation (e.g. Walker *et al.* 1981; Gislason *et al.* 2006). To test this widely held hypothesis, we performed a field study determining the weathering rates of 8 Icelandic watersheds over the past 40 years. The annual average temperature of individual watersheds increased by 0.4 to 1.4 °C. Precipitation increased or decreased depending on the catchment. Riverine transport of weathering products from each watershed has continuously increased. The increase in dissolved riverine inorganic carbon and calcium transport range from less than one percent to 70 percent for the period 1960 to 2000. The riverine suspended inorganic particulate matter in the same catchments for the same period has increased by 2 – 600 percent. These results clearly indicate 1) the strong feedback between climate and Earth surface weathering, and 2) that the climate moderating effect of weathering, and therefore atmospheric CO₂ sequestration, may be far faster than previously thought.

References

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