Biogeochemical reaction networks involved in weathering processes

K. MAHER[1] AND C.I. STEEFEL[2]

[1]Dept. of Geological and Environmental Sciences, Stanford, CA 94305 (kmaher@stanford.edu)
[2]Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, 94720 (CISteefel@lbl.gov)

Biogeochemical reaction networks occur in a range of weathering environments from marine sediments to soils, and are thus central to understanding the rates of mineral-fluid interactions across a broad spectrum of environments. These reaction networks may encompass interactions between organisms, dissolving and precipitating minerals and aqueous diffusive or advective transport. In many cases the consequence of these networks is a system of chemical reactions characterized by very small departures from chemical equilibrium. Networks and the associated feedbacks, along with the small departures from equilibrium, are critical to modeling water-rock reaction rates in most natural systems. For example in soils at Santa Cruz, CA, chemical weathering rates are predominantly controlled by aqueous transport, clay precipitation, and elevated soil gas CO_2 concentrations, as all three components promote departures from chemical equilibrium and thus affect the evolution of the weathering profile similarly. The composition of the weathering profile may in turn affect biological productivity and the availability of carbon. Unless all parameters are known, weathering rates cannot be accurately modeled. Similarly, in marine sediments from ODP Site 984, microbial sulfate reduction produces an increase in pore water alkalinity that in turn drives calcite precipitation. Reactive transport modeling demonstrates that calcite precipitation combined with clay precipitation results in the dissolution of primary minerals and a surprisingly active weathering system that is driven by small departures from equilibrium created by the transfer of components through the reaction network. Collectively, modeling studies across a range of different systems suggests that the apparent discrepancies between laboratory and field reaction rates are attributable to the non-linear approach to chemical equilibrium, which is in turn moderated by the reaction network. Uncertainty in the parameters that describe the reaction network and the feedbacks between different components, such as the rate and surface areas associated with secondary mineral precipitation or the role of organisms, present critical challenges for accurately modeling chemical weathering and elemental cycling in the Critical Zone.

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PGE in the Jormua ophiolite, Finland: Implications for the PGE budget of the sub-continental lithospheric mantle

W.D. MAIER[1]*, P. PELTONEN[2], A. KONTINEN[3] AND S-J. BARNES[4]

[1]Dept of Geology, University of Oulu, Finland 90014 (*correspondence: wolfgang.maier@oulu.fi)
[2]Northland Exploration Finland, Kolari 95900, Asematie 4 (PPeltonen@northlandresourcesinc.com)
[3]Geological Survey of Finland, Kuopio 70211, PO Box 1237 (asko.kontinen@gtk.fi)
[4]Universite du Quebec a Chicoutimi, Canada (sjbarnes@uqac.ca)

Determining the platinum-group element (PGE) budget of the SCLM is important to constrain processes of mantle differentiation and the formation of certain mineral deposits. For example, it has been suggested the portions of the SCLM are enriched in PGE and Au relative to PUM [1]. Our knowledge of the PGE distribution in the SCLM is based mainly on studies of kimberlite-hosted xenoliths. It has recently been proposed that the mantle from which the nodules are derived is non-representative of the SCLM [2]. Mantle sources of kimberlites could have been more metasomatised by asthenospheric melts and fluids. In order to test this model, we analysed 21 peridotite samples from the Jormua ophiolite for their PGE contents, using Ni-sulfide fire assay and Te co-precipitation followed by ICP-MS. We compare the data to PGE data of kimberlite-hosted peridotite xenoliths from the Kaapvaal craton and new xenoliths from Finnish kimberlites. The Jormua ophiolite is a contiguous block of SCLM and thus is likely to be more representative of the SCLM than the xenoliths [3]. The Jormua samples have similar IPGE and Pd contents as the nodules, but Pt is 30% more depleted. The data suggest that the PGE patterns of kimberlite-hosted nodules are not entirely representative of the entire SCLM. The variation in Pt contents of different mantle samples may, in part, be due to introduction of Pt by oxidized metasomatic agents refertilising the mantle. This is consistent with the idea that the kimberlites sample particularly metasomatised portions of the SCLM.

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