Examining the root exudate-induced cycling of reactive manganese species in the rhizosphere

MARCO KEILUWEIT[1,2]*, PETER NICO[3], JEREMY BOUGOURE[2], JENNIFER PETT-RIDGE[2], AND MARKUS KLEBER[1]

[1] Department of Crop and Soil Science, Oregon State Universtity, Corvallis, USA, marco.keiluweit@oregonstate.edu (* presenting author)
[2] Lawrence Livermore National Laboratory, Physical and Life Sciences Directorate, Livermore, USA
[3] Lawrence Berkeley National Laboratory, Earth Sciences Division, Berkeley, USA

Dynamics of reactive metals and soil organic matter (SOM) operating in the rhizosphere can be dramatically different from those occurring in the surrounding bulk soil due to the many interactions between roots, microorganisms, soil particles, and SOM. One of the main driving forces in changing the chemical, biological, and physical properties of the rhizosphere is the exudation of low molecular weight (LMW) organic compounds by the root. LMW exudates represent a significant C flux into soil ecosystems; compounds such as simple sugars, organic acids, and phenols have also been shown to facilitate cycling of redox active metals (e.g., Fe and Mn). This phenomenon is not only observed in aquic and poorly drained soils, but seems to be common in any upland soil with moisture regimes other than aridic or xeric.

In the research presented here we assumed that LMW exudates and microbial activity in the rhizosphere act together to create redox active microsites in soil. We further hypothesize that redox active microsites are short-lived and continuously recreated, thereby generating a steady supply of reactive manganese (Mn) species. This rhizosphere redox cycling may control the availability of reactive forms of Mn that have been mechanistically linked to the oxidative breakdown of complex organic substrates such as lignin.

We tested our hypothesis by examining the effect of different LMW exudates (oxalate, glucose, acetate, and vanillin) on the Mn dynamics of two different soil types in rhizosphere microcosms. Artificial roots allowed for the release of LMW exudates into structurally intact soil at realistic rates. Results from O_2 microsensor measurements as well as bulk and spectroscopic analyses show how root exudates vary in their ability to (i) induce reducing conditions, (ii) influence the activity of lignolytic enzymes, and (iii) affect the abundance and speciation of reactive Mn species in the rhizosphere.

Our results indicate that Mn redox cycling in the rhizosphere may be plant-driven. If confirmed for natural soil environments, the exudates-induced formation of reactive Mn species may have important implications for the turnover of complex biopolymers such as lignin in the rhizosphere.

Ongoing Formation of Continental Crust: Batholiths Are Forever

PETER B. KELEMEN[1*], BRADLEY R. HACKER[2], MARK D. BEHN[3] AND OLIVER E. JAGOUTZ[4]

[1]LDEO, Palisades NY, USA, peterk@LDEO.columbia.edu (*presenting author)
[2]UCSB, Santa Barbara CA, USA, hacker@geol.ucsb.edu
[3]WHOI, Woods Hole MA, USA, mbehn@whoi.edu
[4]MIT, Cambridge MA, USA, jagoutz@mit.edu

We propose that formation of continental crust is a uniformitarian process dominated by arc magmatism and gravitational instabilities that remove dense lithologies and/or add buoyant ones. Rates have varied, lithologies other than arc rocks are present in continental crust (CC), and weathering has modified the composition, but all of these factors are relatively unimportant.

Some arc lavas are geochemically identical to bulk CC. These include andesites and dacites with molar Mg# > 0.5 in the western Aleutian arc, that are the most isotopically depleted arc magmas worldwide. They contain little or no material recycled from older CC. Throughout the Aleutians, sparse data show that intermediate to felsic plutons also have compositions similar to CC. Thus, modern arc processes form voluminous juvenile igneous rocks identical to CC.

The Talkeetna and Kohistan arc crustal sections may have andesitic rather than basaltic bulk compositions. For Talkeetna, there is a gap in exposure from ~ 7 to 20 km paleodepth, so the bulk crustal composition is uncertain. When the missing section is assigned the composition of upper crustal, felsic plutonic rocks, bulk crust is andesitic and calculated seismic sections are similar to the modern IBM arc (Behn & Kelemen JGR 2006; Hacker et al. JGR 2008). For Kohistan, combined barometry and geochemistry yield a more certain, andesitic bulk crust (Jagoutz et al. EPSL 2011, Jagoutz & Schmidt Science 2012). Foundering of dense ultramafic rocks and garnet granulites may help convert basaltic to andesitic arc crust.

Talkeetna and Kohistan (and the central Aleutians, based on geologic and seismic data) have chemically stratified sections, with felsic rocks in the upper crust, mafic rocks in the lower crust, and ultramafic plutonic rocks directly overlying residual mantle peridotite. When such sections undergo subduction, during arc-arc or arc-continent collision, felsic upper crustal rocks with layer thickness more than ~ 100 m will rise as buoyant diapirs, either back up a subduction channel or through the mantle wedge, returning substantial masses of felsic material to overlying arc or continental crust (Behn et al., Nature Geoscience 2011; Hacker et al. EPSL 2011). Similar instabilities likely return andesitic trench sediments (greywacke) to the base of arc crust following subduction erosion.

Based on isotope data, felsic arc batholiths > 50% juvenile material (< 50% older, recycled CC). If such batholiths have been forming at the same average rate since the early Archean, and most of these remain in the crust via buoyancy instabilities as described above, the mass of juvenile felsic material formed in this way could be greater than or equal to the present mass of CC. So far, we have only calculated this approximately for North America. By the 2012 Goldschmidt, we will formalize and evaluate this hypothesis using data on batholiths from all of the continents.