The genetics of a microbe-mineral interaction

R. VAN HOUDT[1], K. OLSSON-FRANCIS[2]*, N.M LEYS, M. MERGEAY AND C.S. COCKELL[1]

[1]Unit of Microbiology, SCK•CEN, Mol, Belgium.
[2]CEPSAR, Open Univeristy, Walton Hall, Milton Keynes, UK (*correspondence: k.olsson@open.ac.uk)

Microbial activity has been linked to volcanic rock weathering. It is thought that the process is generally driven by the nutrient requirement of the microbial community and occurs as a result of the sequestration of bio-essential elements. Although we know that metabolising bacteria influence rock weathering, the molecular processes invloved are unknown.

For the first time, we have used DNA microarray technology to investigate the genes involved in weathering, in particular the sequestering of iron using the heavy metal resistant bacterium, *Cupriavidus metallidurans* CH34. Extensive studies have characterised the heavy metal resistant and iron uptake mechanisms of this bacterium. CH34 employs siderophores, which are iron-chelating compounds, to sequester iron in iron-limited conditions. Furthermore, plasmid-based heavy metal resistant genes are expressed in the presence of certain heavy metals.

For this study we grew CH34 in MM284 (iron) and MM284 (iron-limited) with and without volcanic basalt. Low levels of heavy metals were detected in the basalt, using ICP-MAS. Microarray analysis demonstrated that siderophore genes were not differentially expressed when grown in MM284 (iron-limited) with basalt. This was in concurrence with siderophore measurements using the CAS assay. Instead, a large number of porins and membrane transporters in concomitantly with genes associated with biofilm formation were up-regulated. Furthermore, genes linked to heavy metal resistance were up-regulated. This included the plasmid borne cation efflux metal resistant operons, *czc* (resistance to Cd^{II}, Zn^{II} and Co^{II}), and *cnr* (resistance to Co^{II} and Ni^{II}).

The findings in this paper are the first insight into the molecular processes involved in microbial weathering. Some of the earliest environments on the Earth were volcanic. Therefore, these results not only elucidate the mechanisms by which bacteria might have sequestered nutrients on the early Earth but also provide an explanation for the evolution of multiple heavy metal resistance genes long before the creation of contaminated industrial biotopes by human activity.

Modeling the subduction factory: The ins and outs from a thermal and dynamical perspective

P.E. VAN KEKEN[1], E.M. SYRACUSE[2], B.H. HACKER[3], G.A. ABERS[4], K.M. FISCHER[5], E.A. KNELLER[1] AND M. SPIEGELMAN[4]

[1]Geological Sciences, University of Michigan, Ann Arbor MI 48109-1005, USA (keken@umich.edu)
[2]Geology and Geophysics, University of Wisonsin, Madison WI, 53706, USA (syracuse@geology.wisc.edu)
[3]University of California, Santa Barbara, CA 93106-9630, USA (hacker@geol.ucsb.edu)
[4]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, USA (abers@ldeo.columbia.edu)
[5]Geological Sciences, Brown University, Providence, RI 02912, USA (karen_fischer@brown.edu)

We provide a global comparison of the thermal structure of subduction zones to study the dehydration and melting processes that occur in the slab and mantle wedge. The models use kinematically defined slabs based on updated geometries from Syracuse and Abers [Gcubed, 2006] and use partial coupling downdip from the seismogenic zone to recreate the cold nose observed in heat flow measurements and sesimic attenuation. In all cases the uppermost part of the slab (including the top of the oceanic crust and sediment section) dehydrates before it reaches sub-arc depth, and the overlying mantle is too hot for hydrous minerals to be stable. By contrast, the mantle within the downgoing plate remains cold enough for serpentine to be stable beyond the arc, allowing water to be carried beyond the arc into the deep mantle. The global comparison provides a quantitative estimate for the role of subduction zones in the global water cycle.

Detailed models of dehydration from thermodynamical considerations provides estimates of the flux of volatiles into the mantle wedge, which in turn can be used for hydrological models of the flow of fluid and melt in the mantle wedge. Preliminary calculations suggest the strong role of dynamical pressure and the rheology of the mantle wedge, indicating that the position of the arc provides strong constraints on the constitution of the mantle wedge.

Seismic anisotropy provides further strong contraints on the constitution and dynamics of the wedge. While in some regions the trench-parallel anisotropy appears to be generated by B-type fabric in the cold nose of the mantle wedge, a number of subduction zones suggest the influence of trench-parallel flow induced by geometrical changes in the arc.