Steady state chemical weathering in an eroding landscape

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We developed a steady-state chemical weathering model that describes the advection of fresh rock into the weathering zone and the dissolution of minerals during weathering (Waldbauer and Chamberlain, 2005, Ecol. Studies 177). This model has been modified to account for the growth of secondary minerals during weathering (Chamberlain *et al*., 2005, EPSL) and to examine the competing affects of reaction kinetics and rock advection (Hilley *et al*., in review, GCA). To first-order the model predicts chemical weathering rates at spatial scales from global to orogens to individual catchments (Hren *et al*., in press, AJS). Two overarching results come from this analysis. 1) The supply of fresh rock to the weathering zone is the dominant control on weathering rates except under extremes in uplift rates, temperature and precipitation. 2) Landscapes can be quantified as reaction- and supply-limited with much of the Earth's surface between these two extremes. The results of this body of work have implications to CO_2 uptake in both ancient and modern environments. The ability of forest ecosystems to uptake carbon dioxide depends, in part, on the supply of rock-derived nutrients. Of these, phosphorus is particularly important, and we have combined models with field data to predict the P supply to landscapes in different tectonic settings (Porder *et al*., 2007, Ecosystems). Unlike forests on stable cratons, those on tectonically active areas are less likely to be P limited and may have a greater ability to increase productivity as a result of increases in CO_2. On longer timescales, we show that areas of high uplift will have the highest silicate weathering rates contributing to the long-term drawdown of CO_2.

Formation of biomineralized stalks by a marine iron-oxidizing bacterium

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Aerobic, neutrophilic iron-oxidizing bacteria (FeOB) are abundant at Fe(II)-dominated hydrothermal vent systems. They grow by O_2-dependent oxidation of ferrous iron to highly insoluble ferric iron. A distinctive feature of many FeOB is the formation of extracellular structures covered in iron oxyhydroxides. Beyond their distinctive appearance, little is known about the composition or function of these structures. One hypothesis is that these polymers control the precipitation of iron and move it away from the cell, thereby preventing mineral encrustation of the cells.

Mariprofundus ferrooxydans PV-1 is a marine FeOB isolated from iron microbial mats at hydrothermal vents at the Loihi Seamount, Hawaii. *M. ferrooxydans* produces mineralized ribbon-like stalks that are prominent constituents of these microbial mats. Because this morphology is often used as a signature of FeOB activity in both modern and ancient (i.e. fossilized) environments, we need to determine what role it plays in the metabolic process, in order to be able to interpret the meaning of this potential signature and positively link it to the FeOB metabolism.

To this end, we have analyzed the ultrastructure, chemistry, and formation process of the *Mariprofundus ferrooxydans* PV-1 stalk. We developed a microslide culture method for PV-1 and coupled this with in situ light microscopy and time lapse imaging, allowing us to observe cell growth and determine rates of stalk formation. Stalk ultrastructure, mineralogy and cell-stalk-mineral spatial relationships were observed using transmission electron microscopy (TEM). This work showed that the stalks consist of a discrete number of fibrils (25-200 nm wide) mineralized initially by poorly crystalline FeOOH, and later coated with lepidocrocite. The juxtaposition of the poorly crystalline FeOOH within the stalk fibrils, and more crystalline lepidocrocite on the surface implies that organics in the fibrils retard mineral growth. Synchrotron-based scanning transmission x-ray microscopy (STXM) was used to map the spatial distribution of iron, carbon, and nitrogen, and characterize the organic functional group chemistry of the stalk. The element maps show that iron is localized on the stalk, whereas the cell is relatively free of iron. Together these approaches show that the stalks do indeed play an important role by binding ferric iron and transporting it away from the cell in a manner that prevents entombment of the cell in iron oxyhydroxides.