Oxygen and carbon isotope systematics during natural mineral carbonation in peridotite of the Samail Ophiolite, Oman

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We are investigating peridotite alteration in the mantle section of the Samail ophiolite in Oman. Understanding the natural system provides insights into design of enhanced, *in situ* mineral carbonation for CO_2 storage, and 'negative emissions' via enhanced CO_2 capture from surface waters.

Two processes are being studied: (1) ongoing, low T formation of carbonates + serpentine, and (2) fossil, higher T formation of 'listwanites' composed of carbonates + quartz. The low T system is characterized by alkaline springs (pH > 11) where Ca-OH-rich, carbon-poor waters + atmospheric CO_2 form large travertine terraces. The fossil system, probably active during late Cretaceous emplacement of peridotite over sediments, formed sub-surface tabular bodies up to 200 m thick that were later exposed by erosion.

Far from listwanites, 95% of 40 carbonate veins, exposed by erosion, have measurable ^{14}C with an average 'age' of ~ 25, 000 ka, just slightly older than the average 'age' for ~ 40 travertines. Thus, veins are likely part of the ongoing low T travertine system, and formed in a near-surface horizon that erodes away approximately as fast as it forms, consistent with precipitation of carbonates + serpentine from Mg-HCO_3 rich groundwater to form alkaline spring waters (e.g. [1, 2]). By mass balance, there are 5 to 15 kg carbonate veins per kg of travertine [3].

$d^{18}O$ carbonate-water exchange thermometry, using $\delta^{18}O$ from water in Oman peridotites, yields temperatures of ~ 30-60°C for veins away from listwanite, and up to ~ 170°C for listwanite, broadly consistent with preliminary clumped isotope data on carbonates from the same samples, and with trapping of fluid inclusions at ~ 220°C in Canadian listwanites (e.g. Hansen *et al*. Can Min 2005).

Travertines with ^{14}C ages < 1 ka show correlated $\delta^{18}O$ (30 to 15 ‰ SMOW) and $\delta^{13}C$ (-5 to -25 ‰ VPDB) while older travertines show a small range at the heavy end of this spectrum. Biological or kinetic factors may be responsible for the fractionation in young travertines. This range may be reduced by later recrystallization or filling of porosity.

[1] Barnes & O'Neil *GSA Bull* 1969. [2] Bruni *et al*. *Appl. Geochem*. 2002. [3] Kelemen & Matter *PNAS* 2008

Chemical weathering and chemical denudation as functions of ecosystem development: Mesoscale experiments

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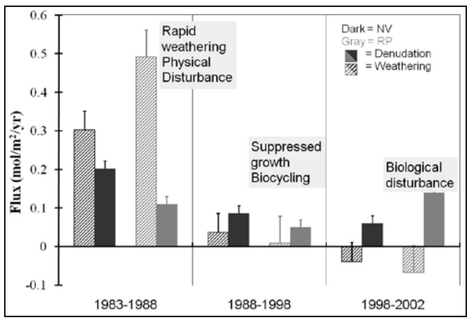
Chemical weathering and chemical denudation are key processes controlling hydrosphere and atmosphere chemistry, as well as C partitioning in ecosystems. There is great interest in the effects of plants on the rates of these processes [1]. We hypothesize that both the rates and mechanisms of plant-driven weathering (and associated denudation) vary, depending on geologic setting and ecosystem phase. Studies of weathering and denudation in 'sandbox' experimental ecosystems [2] showed that initially, pine-driven weathering was 5X the rate of denudation, and twice the rate of weathering and denudation in a reference system with no vascular plants (Figure). After the first 5 yrs, pine-system denudation rates fell even lower, while weathering rates were not different from zero; denudation rates then trebled when aboveground biomass was harvested, consistent with previous watershed-scale experiments [3]. These results and SEM images of pine root systems lead to our hypothesis that the growing trees were adapted to the nutrient-poor experimental conditions via development of mycorrhizospheric biofilms, that attach the root system to mineral surfaces, serving both as symbiotic-microbial habitat and weathering reactor, and efficiently micro-localizing the biology, chemistry, and hydrology of weathering and nutrient uptake at the root-microbe-mineral interface. The harvest disturbance would have starved the biofilms and permitted cation loss by leaching. Such disturbance episodes may explain the relatively large long-term denudation rates attributed to weathering-efficient vascular systems in the Phanerozoic.



[1] Moulton *et al*. (2000) *AJS* **300**, 539–570. [2] Balogh-Brunstad *et al.* (2008) *GBC* **22**, GB1007.