The effect of diffusion on P-T conditions inferred by cation-exchange thermobarometry

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Mantle xenoliths are used to infer geothermal gradients of the sub-continental lithospheric mantle through cation exchange thermobarometry. This method assumes that cations reach thermodynamic equilibrium at depth and maintain this state during their ascent to Earth's surface. Analyses of the chemical compositions of coexisting minerals suggest that this assumption is not always valid due to diffusion and re-equilibration. Our observations include: 1) element diffusion profiles in minerals; 2) hotter and deeper P-T conditions calculated for the rims of some mineral assemblages than P-T calculations for the cores; 3) more scattered P-T conditions at higher pressures and temperatures. We examined a suite of garnet peridotites from the Kaapvaal craton (Kimberley, South Africa). Rock sections containing garnet, cpx, opx, and olivine were mounted and measured for their major element compositions at Yale University using the JEOL JXA-8530F field emission gun electron microprobe. P-T conditions calculated for these samples using BKN [1] thermobarometry vary from 930–1240°C, 39–52 kbar. More interestingly, zoning is evident in garnet grains with radii varying from 400–1550 μm. This zoning produces P-T differences of 22–144°C and 1.5–6.3 kbar between rims and cores. A multi-component diffusion model was formulated for $Ca^{2+}/Mg^{2+}/Fe^{2+}$ exchange across garnet, cpx, opx, and olivine assemblages as well as Cr^{3+}/Al^{3+} exchange between garnet and cpx. Modeling results are checked against the observed diffusion profiles. Our model suggests that P-T conditions recorded in these mantle minerals depend on the cooling rate, crystal grain size, and geothermal gradient, which might not be the same as the linear regressed line through all calculated P-T conditions.

[1] Brey and Kohler (1990) *J. Petrol.* **31**, 1353-1378.

Insight into effects of elevated CO_2 and soil nutrient levels on biological weathering at the mesocosm scale

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The evolutionary development of large vascular land plants in the Paleozoic is hypothesized to have enhanced weathering of Ca and Mg silicate minerals. This plant-centric view overlooks the fact that plants and their associated mycorrhizal fungi co-evolved. Many weathering processes usually ascribed to plants may actually be driven by the combined activities of roots and mycorrhizal fungi. Here we present initial results from a novel mesocosm-scale laboratory experiment designed to allow investigation of plant-driven carbon flux and mineral weathering at different soil depths, and under ambient (400 ppm) and elevated (1500 ppm) atmospheric CO_2.

Sequoia sempervirens (arbuscular mycorrhizal, AM) and *Pinus sylvestris* (ectomycorrhizal, EM) were studied in two experiments as part of the larger biological weathering project. Each long term (7-13 months) experiment was conducted under similar environmental conditions with the exception of the "soil" substrate in which the trees were grown. One experiment used an organic-poor, low nutrient sand:perlite 50:50 (vol:vol) mix whilst the other used an organic-rich sand:compost (50:50 vol:vol) mixture.

Both species responded differently to elevated CO_2 conditions when grown in organic-poor or -rich substrates. After $^{14}CO_2$ pulse-labeling, the observed carbon flux timing and magnitude were significantly different for both species in the sand:compost study relative to the sand:perlite study. Additionally, the peak carbon flux under elevated CO_2 in the sand:compost system lagged by several hours relative to plants grown under ambient CO_2. Total root biomass was increased under elevated CO_2 in the nutrient poor substrate, but much less so under higher nutrient conditions. Ongoing analyses will elucidate how these disparate responses to elevated CO_2 may affect mycorrhizal biomass and mineral weathering in the mesocosm systems.