

Solute compositions and fluid residence times along an erosional gradient, Middle Fork of the Feather River, CA

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The residence time of water in the subsurface is known to be an important control on chemical weathering rates because longer contact times allow for waters to dissolve more minerals. A second control on weathering rates is erosion, which accelerates mineral dissolution by supplying fresh mineral to the soil environment from the bedrock below. However, on hillslopes erosion can also dramatically impact the hydrologic conditions. The rate of erosion may influence the slope of the terrain, the hydraulic gradient, and the amount of weathering products (e.g. clays and Fe-oxides). These effects result in shorter contact times and potentially decreased solute fluxes from rapidly eroding landscapes.

One conceptual model for assessing the relative importance of hydrologic and erosional processes is to consider the fluid residence time required to reach chemical equilibrium (which would determine the maximum solute flux) relative to the actual average fluid residence time of water in the hillslope. Weathering systems where these thermodynamic and physical time scales are closely matched should have the maximum rates of chemical denudation.

To test this model, we have studied the chemical and physical compositions solids and waters from three soil-covered hillslope transects within a tributary basin of the Middle Fork Feather River, CA. One of the hillslopes is located above the knickpoint, while the others are adjacent to and below the knickpoint. Water contents and solute chemistry are fairly constant across each hillslope but variable between hillslopes. In general, the solute concentrations are lowest in the soils of the steeper hillslopes suggesting that water residence time is an important factor.

A new methodology to experimentally determine water incorporation into upper mantle olivine and pyroxene

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This study explores experimentally the incorporation of water in olivine and pyroxene near the solidus of fertile lherzolite compositions at 2.5 and 4 GPa. A sensor-layer of olivine or pyroxenes was added to both sides of lherzolite material and their water contents were determined by Fourier-transform infrared spectroscopy. The IR absorption bands of the sensor crystals after the experiment are different from the bands present in the starting material, indicating that the sensor minerals equilibrated with the lherzolite material. The similarity of absorption characteristics in experimental runs to those from mantle derived rocks (summarised in the PULI spectral database) indicates that hydrogen defects in the sensor minerals can be successfully reproduced in chemically complex systems. Olivine, orthopyroxene and clinopyroxene contain 30-190, 290-320 and 910-980 ppm of water under the studied P-T conditions. The partition coefficients between orthopyroxene and clinopyroxene ($D^{cpx/ox}$) are 2.7 and 3.5 at 2.5 and 4 GPa respectively, while values of $D^{cpx/ol}$ are ~ 7 and ~ 5 , at 2.5 and 4 GPa respectively. Olivine and pyroxenes in our water-rich experiments display higher water concentrations than what is documented for most peridotites. They overlap only with the most water-rich natural samples from supra-subduction environments. Our experiments reproduce closely water-saturated conditions in the upper mantle in chemically analogue complex systems. Thus, our experimental strategy may be generally applied in the future for mapping out phase relations and maximum effective water storage capacity of the upper mantle.