

## Oxygen and hydrogen stable isotopes in Alpine waters and fine-grained soils near Saas Fee, Switzerland

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Samples of soil and surface water were collected along a transect of 30 km with 1600 m of difference in altitude in the valleys of Saas Fee and Visp in the Swiss Alps. Mineralogical, chemical, and isotopic (O and H) compositions were measured to study the water-rock interactions, clay mineral formation, and the influence of altitude on the isotopic composition of soils during weathering of the parent rock, in order to draw conclusions for the usability of hydrous minerals derived from alpine soils for paleoelevation studies.

Waters have a range of  $\delta^{18}\text{O}$  and  $\delta\text{D}$  values typical of those for precipitation and glacial melt water, decreasing with altitude of the catchments. The major dissolved ions characterize the composition of the substrate lithologies by elevated contents of Ca, sulphate, K, and Mg ions. This is also the case for the mineralogical composition of the soils that corresponds to the occurrence of ophiolitic material in higher elevations and granitic gneisses and schists in lower regions. While phyllosilicates from early-stage weathering and transformation of illite and chlorite to interstratified minerals (vermiculite, illite-vermiculite, chlorite-vermiculite and illite-smectite) are present, their abundance is relatively low. The isotopic composition of the fine earth fraction and the  $< 2 \mu\text{m}$  clay component in the soil was in average identical, and corresponds to the range of values of the host rock material. This suggests that the present climate and this environment do not allow for the neoformation of larger quantities of clay minerals in contact with ambient water.

## Pore scale visualization of chemical gradients at biogeochemical interfaces using micromodels and Raman microspectroscopy

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Biogeochemical interfaces (BGI) are controlling the fate of organic chemicals at the interface between the terrestrial and the aquatic environment. BGI are highly dynamic in the spatial and temporal domain. One of the key features of BGI is their limited temporal and spatial accessibility which is hard to imitate in conventional laboratory test designs.

Processes at BGI can be visualized and quantified using microfluidic structures mimicking the pore topology of the soil, so called micromodels. In combination with Raman microspectroscopy chemical information can be retrieved from a micromodel experiment with a spatial resolution on the order of  $1 \mu\text{m}^2$  and a temporal resolution in the s-range. To increase the sensitivity, silver nanoparticles have been added to the water phase flowing through the micromodel to make use of the amplifying surface-enhanced Raman effect. Currently chemical gradients of moderately lipophilic substances have been acquired with a limit of detection of  $10^{-8}$  mol/L. Challenges to overcome include the interactions between silver nanoparticles and target analytes which might alter the mass transfer rates, and the settling of nanoparticles in the channel.

As high resolution acquisition comes with a limited field-of-view (FoV) and, e.g., the growth of a biofilm outside of the FoV alters the flow pattern, the flow velocity has to be monitored using fluorescent latex beads and single particle tracking. For a fast measurement of well-defined variables, like the pH-value or the oxygen concentration, thin film polymers with encapsulated sensor dyes are chosen.

When looking at microbial growth in porous media, not only the development of a biofilm changes the flow paths and the accessibility to the microbes, but also the development of locally confined gas bubbles, as with *P. denitrificans*. Here, the growth rate is correlated with bacterial activity and the results indicate different bacterial densities in pore bodies and pore throats.