Cosmogenic nuclide budget in a glaciated mountain range (W. Alps)

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Obtaining a long-term basin-averaged denudation rate by measuring the cosmogenic nuclide concentration in river sediment provides a much-desired tool for geomorphologists. However, this method is only valid in catchments dominated by shallow subaerial processes (e.g. creep, shallow landsliding) at steady-state. In particular, caution should be used in applying this method to basins with sediment sources from high-altitude mountain ranges or other glaciated areas.

Glacial processes, such as ice-shielded subglacial erosion and catastrophic failure from headwall backwearing, produce sediment with cosmogenic nuclide concentrations that are not expected to reflect erosion rates. Deglaciated areas, even if currently dominated by hillslope processes, are also likely to present problems due to 1) storage of glacial sediment and 2) not yet having achieved steady-state erosional loss of cosmogenic nuclides over the short interglacial period.

This study is aimed at probing the cosmogenic nuclide budget in a high-latitude mountain range. Different sediment sources were sampled along a NS transect through the Western Alps from the highland (1 mm/yr uplift) to the foreland (no uplift, net deposition). Samples include: subglacial outwash; intraglacial sediment; moraines (surface and deeply buried material); currently glaciated, formerly glaciated and never glaciated catchments; and large river samples that integrate these sediment sources. Cosmogenic nuclides should provide a tool to trace sediment provenance, with the concentration in sediment derived from a mixture of two sediment sources constraining the relative contribution from each. The initial fluvial concentration at the glacier mouth should be very low, and increase after injection of higher concentration sediment from moraines and deglaciated and never glaciated landsurfaces. Indeed, modern subglacial sediment has very low concentrations of a few hundred atoms $^{10}Be/g$ SiO_2, essentially dead within measurement error. Sediment derived from most subaerially exposed landsurfaces has concentrations an order of magnitude higher, at least several thousands of atoms $^{10}Be/g$ SiO_2. As expected, deglaciated catchments have lower concentrations than otherwise similar never glaciated ones. Interestingly, the concentration of last glacial maximum (LGM) subglacial sediment, as measured from a deep shielded LGM moraine, is significantly higher than modern subglacial outwash (couple thousand vs. ~zero atoms $^{10}Be/g$ SiO_2). Possibilities include incorporation of supraglacial sediment, and incomplete erosional removal of cosmogenic nuclides at the extremities of the glacier during the LGM.

Surface complexation modeling for the description of solution chemistry, adsorption, and colloidal aggregation

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Colloids are ubiquitous in most water bodies and chemicals in solution tend to interact (adsorb) with them. Thus, the regulation of chemicals in solution is intimately related to the fate of colloids. Conversely, the fate of colloids depends on the solution chemistry. When chemicals adsorb onto a colloid, they modify its surface properties, affecting the ability of colloids to attach upon contact, which change aggregation rates and aggregate morphology.

Adsorption and aggregation experiments were conducted on a model system of hematite, background electrolyte (NaCl), and three different adsorbates (picolinic acid, pyromellitic acid, and lead). The triple layer surface complexation model (TLM) was used to satisfactorily model all the adsorption data. The optimized TLM fitting parameters were used to evaluate the effect of adsorption on the electrostatic properties of the hematite surface and to estimate surface potentials for different chemical scenarios. The surface potentials were used to calculate interparticle forces between two approaching colloids. Based on these calculations, it was predicted that hematite stability was very sensitive to pyromellitic acid adsorption. The estimates also predicted that hematite stability was indifferent to picolinic acid and lead adsorption, despite large differences between their adsorptive behavior. Experimental stability factors determined using dynamic light scattering (DLS) data were consistent with the stability trends predicted by the estimated interparticle forces. The results of this work indicate that the TLM description of the charge/potential relationships at the solid/aqueous interface provides useful information on particle stability.