What causes the geochemical diversity of arc lavas?

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The enrichment in incompatible elements of arc lavas is a well described feature of convergent margins. However, the details of element transfer from the slab into the mantle wedge is largely unknown, so that the origin of regional trends in arc lava chemistry is not well constrained. One common explanation for chemical along-arc trends is a varying sediment input. However, using a dynamical model for mantle flow and fluid release, we show that for Central America in an open sub-arc system the sediments lose about 2/3 of their chemically bound water at shallow depths ($z<50$km). For fluid mobile elements like B this results in its almost complete removal from the sediments prior to arc melting. Therefore, sediments cannot be the enriched source necessary to explain the observed high values of mobile elements like B. It seems that an additional fluid source lithology is necessary to explain arc lava chemistry. We propose that this fluid source lithology is lithospheric mantle serpentinized as a by-product of flexural faulting at the outer rise. Our modelling results suggest that serpentinites carry more than 3 times the amount of chemically bound water than crust and sediments combined, so that a hydrous fluid released from this lithology can carry enough seawater-transported elements like B to explain the observed enrichment in arc lavas. Furthermore, this high P-T fluid can potentially dissolve enough Be from the overlying sediments (under reducing high-T conditions) to explain the radiogenic Be anomaly typical of many arc lavas.

We have tested these ideas at the Central American subduction zone. Where the Cocos plate subducts beneath Nicaragua at an angle of (~65°) it likely includes a hydrated mantle layer that was serpentinized as a by-product of lithospheric faulting at the outer rise. Beneath Costa Rica subduction is shallower (~40°) and the outer rise is less pronounced, so that mantle serpentinization is less probable. As predicted above, these variations in incoming plate petrology correlate with trends in arc lava chemistry. Nicaraguan arc lavas show high Ba/La, B/La, and ^{10}Be/^{9}Be ratios; these ratios gradually change along strike and reach a regional minimum at Costa Rica.

We conclude that the regional trends in Central American arc lava chemistry are more likely caused by along strike changes in the contribution of a serpentinite derived hydrous fluid than by changes in sediment input. Furthermore, serpentinites are a good slab lithology for transferring chemically bound water through the arc dewatering region to greater depths. Mantle serpentinization beneath the outer rise may therefore play an important role in the global water cycle and in recycling processes at subduction zones in general.

Detrital phosphorus weathering rates and mechanisms: comparing tropical and glacial catchments.

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Continental biogeochemical weathering of apatite is the primary source of phosphorus (P). Variations in weathering intensity may influence the global P flux and therefore primary production rates, which are important with regard to the carbon cycle and climate change. To assess the relative importance of the phosphorus flux in tropical and glacial environments we compared the distribution of phosphorus phases in suspended sediments from the Apure river system, Venezuela with those from meltwater streams of the Oberaar and Rhône glaciers, central Switzerland. Additionally two chronosequences were sampled in the forefields of the Oberaar and Rhône glaciers, comprising Little Ice Age moraines and tills of the Younger Dryas. Iron-bound P, organic P, and detrital P phases are quantified by a sequential extraction (SEDEX) method.

In the glacial suspended sediment detrital P is the main phase. The Apure system suspended sediment becomes impoverished in detrital P and enriched in iron and organic bound P in rivers further from the source. In the glacial Younger Dryas samples the detrital P phase is replaced by organic and iron-bound P. Initial calculations give approximate apatite weathering rates of 0.3 $gm^{-2}yr^{-1}$ for the Little Ice Age moraines and 0.01 g P $m^{-2}yr^{-1}$ for the Younger Dryas tills. These weathering rates are one order of magnitude higher than the continental average value. Our results show that alpine glaciers have potential to accelerate detrital P weathering, especially in the first 100's of years after deposition of glacial sediment. Finally we present a global data set demonstrating that the flux of Total P in meltwaters from presently glaciated catchments is elevated when compared to riverine fluxes from presently non-glaciated catchments.