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Relating airborne gamma-ray spectrometry to chemical weathering history in a small watershed

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We have studied a small watershed (150 km^2) located in the Armorican massif (France) mainly composed of weathered micashists using airborne gamma-ray spectrometry combined with geochemical data of rocks, soils and sediment loads. The objectives of our study were to characterize chemical and physical erosion patterns, to map the weathering products and to estimate a mass balance for erosion based on airborne data.

There is clear indication based on the airborne gamma spectrometry data that the samples from the top of the weathering profile are characterized by low K/Th ratios. In contrast, the bottom of the weathering profile has higher K/Th ratios which are similar to the pristine bedrock.. Interestingly, the sediment load from the river is characterized by high K/Th ratios, demonstrating that the present-day physical erosion takes place in the valleys rather than on the plateaus. From bottom up, we distinguish three superimposed layers according to their K/Th ratio. The fractured layer has the original micashists chemical composition revealed by the K/Th highest ratios. The saprolitisation layer is characterized by lowering K/Th ratios along with a raising position within the weathering profile. The shallowest level, where the K/Th becomes low and constant, is identified as saprolite.

Founded on this sketch, we have used the airborne gamma spectrometry data to quantify the net mass of potassium leached from the micashists to the saprolite. We assume Th is an immobile element whose budget is preserved in the weathering profile [2]. Our calculation yields an estimate of palaeoweathering rate over the whole watershed based on the K and Th budget. Airborne gamma-ray spectrometry data (52186 pixels) associated with field measurements allow the estimation potassium loss, ranging from 0 to 12 kg/m^3 during 30 to 45 My. The integrated palaeoweathering rates in our case study range from 54 to 76 t/km²/a.

References

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River chemistry and drainage basin geology

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Introduction

Of the three most important factors controlling the chemical and isotopic composition of continental runoff - rainfall, topography and lithology - digital data with global coverage at reasonable spatial resolution are only available for the first two parameters. We have therefore initiated a program to investigate the controls bedrock geology exert on river chemistry.

Linking geology and river isotope chemistry

We have used digital geologic maps of North America and East and Southeast Asia to compute the lithologic composition and age structure of major river basins. The spatial scale of our analyses varies from 1:2.5 Mio to 1:5 Mio, resulting in polygon sizes of 100 to 1000 square kilometers, equivalent to ~15' grid resolution.

Using the large chemical and isotopic data set for the Fraser River, BC, [1] and bedrock data for the Fraser drainage basin and its tributaries, we found a remarkably linear positive correlation between the dissolved $^{87}Sr/^{86}Sr$ and the area-weighted bedrock age in the respective tributaries. Particulate $^{143}Nd/^{144}Nd$ correlates inversely with area-weighted bedrock age. These correlations may reflect binary mixing of old continental and young mantle-derived components, representing Precambrian to early Paleozoic sediments/metasediments in the upper Fraser basin and young volcanic rocks in the Coast Range. The data indicate that relatively precise predictions of the riverine Sr and Nd isotopic composition can be made solely based on the bedrock data. In an attempt to parameterize the global Sr and Nd isotopic composition of continental runoff, we are currently testing whether this finding can be extrapolated to other river basins.

Another interesting finding is that the difference between the Sr and Nd model ages of particulate riverine matter increases systematically with the abundance of sedimentary bedrock in a drainage basin. In tribuatry basins dominated by sedimentary rocks Sr model ages of riverine particulate matter approach those of area-weighted bedrock ages (i.e., stratigraphic age). This is indicative of the canibalistic recycling of the sedimentary reservoir and the relative ease with which the Rb/Sr system is disturbed during weathering.

References

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