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Constraining basalt erosion through river data and numerical modeling

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Basaltic weathering is a major CO₂ sink at timescales of several million years because basaltic rocks dissolve easily [1]. We have estimated that the CO₂ flux consumed by chemical weathering of basalts represents about 30% of the total consumption flux due to silicate weathering [2]. The present study attempts to further characterize the chemical weathering of basalts and to quantify more precisely the flux of carbon transferred from the atmosphere to the ocean during this major surface process.

Since first-order effects that influence basaltic weathering on the global scale are relatively well constrained [2], we are now interested in studying basalt weathering in natural environment at a smaller scale in order to better understand the processes governing chemical weathering of basalts. We particularly emphasize the relationship between the chemical composition of various weathering products transported by the rivers (dissolved and solid loads), the chemical composition of the basaltic rocks, and the climatic parameters (temperature and runoff).

We present a compilation of data on small rivers draining basalts. It appears that the Ca/Na and Mg/Na ratios are relatively high compared to the usually observed values for small streams draining granitoid rocks. We interpreted these high ratios as the result of chemical weathering of volcanic rocks having more Ca and Mg rich chemistries. To confirm this hypothesis, we used a numerical model able to calculate the chemical weathering of basaltic rocks. Starting from the chemical and mineralogical composition of the unaltered rock, the numerical model [3] calculates the evolution of the chemical composition of the draining water and of precipitated secondary phases, as a function of climatic parameters and of the evolution of the source rock through time. The Na-normalized molar ratios calculated by the model compares well to those observed in river waters.

It is noteworthy that the chemical signatures of rivers draining basalts differ from those of rivers draining other silicate rocks. This result should be considered when attempting to characterize the silicate end member and to determine the global CO₂ consumption flux coming from silicate weathering.

References

- [1] Dessert et al. (2001) *EPSL* **188**, 459-474.
- [2] Dessert et al. (2003) *Chem. Geol.* **202**, 257-273.
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Numerical modelling of weathering at the catchment scale

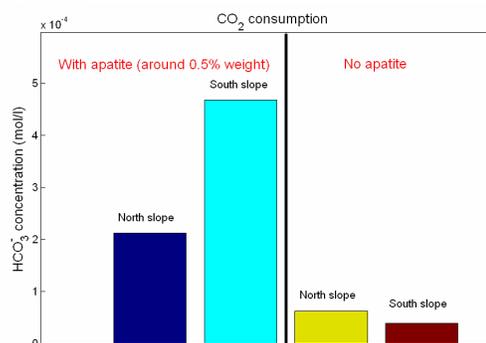
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Chemical weathering of silicate rocks is an important controlling factor stabilizing climate at the million year timescale, and strongly influencing the alkalinity distribution within the ocean. Up to now, large scale silicate weathering has been generally described as a linear function of runoff and an exponential function of temperature. Such kind of parametric laws are largely used in numerical models describing the long term evolution of the Earth climate.

Here we present an effort towards the building up of a mechanistic numerical model describing the weathering processes at the catchment scale (including mineral dissolution/precipitation processes) using laboratory kinetic laws. The WITCH model (**WeatherIng at The Catchment scale**) is coupled to a simple hydrological model and is designed to estimate consumption of CO₂ at the watershed scale, as a function of environmental parameters (such as temperature, drainage, lithology). The model is first applied to the Strengbach catchment (a small granitic catchment located in the Vosges mountain, France, 80 ha), where it reproduces soil water chemistry within 7 soil horizons. Sensitivity studies will then be presented, including the major role of trace mineral (such as apatite) in the CO₂ consumption budget for the watershed. Based on the calculation of the concentration in HCO₃⁻ for waters draining the North and South slopes of the catchment, we calculate that the presence of about 0.5 % weight apatite in the primary rocks is responsible for more than 80 % of the CO₂ consumption for the catchment.



The sensitivity of the consumption of CO₂ through rock chemical weathering to the ongoing climate change will be finally discussed, showing the cumulative impact of increasing temperature and continental runoff over the next century.