

Basalt weathering laws and the impact of basalt weathering on the global carbon cycle

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Continental chemical weathering is a key process of the Earth global geochemical cycles. Of particular interest is the CO₂ cycle, since atmospheric CO₂ is a greenhouse gas directly impacting on the climate. Over geological time scales, this cycle is driven by two processes : the CO₂ degassing through volcanism and metamorphism, and the consumption through chemical weathering of silicate rocks and the storage of organic carbon in oceanic sediments.

Investigating the geochemistry of river waters draining several basaltic provinces, we emphasized the very important contribution of basalts to the global flux derived from continental silicate weathering. We demonstrated that the chemical weathering rate of volcanic rocks is 5-10 times higher than the chemical weathering of granite and gneiss. Moreover, we proposed a parametric law quantifying the atmospheric CO₂ flux consumed by basalt weathering, as a function of continental runoff and temperature. Coupled with geological and geomorphic data, this allows us estimating the atmospheric CO₂ consumption flux related to basalts to represent 30% of the global flux derived from continental silicate weathering [1].

Since first-order effects that influence basaltic weathering on the global scale are relatively well constrained [1], 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). It is noteworthy that the chemical signatures of rivers draining basalts differ from those of rivers draining other silicate rocks. Finally, we will show how the introduction of new weathering laws, based on the studies of river waters, leads to the implementation of new models of past atmospheric CO₂ [2].

References

- [1] Dessert et al. (2003) *Chem. Geol.* **202**, 257-273.
[2] Dessert et al. (2001) *Earth Planet. Sci. Lett.* **188**, 459-474.

The Mackenzie River Basin: Limited atmospheric CO₂ consumption by rock weathering

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Chemical weathering of rocks is considered as the main sink of atmospheric CO₂ at geological time scale. CO₂ consumption by rock weathering is classically estimated after mass budgets based on major ions chemistry in river waters. These calculations usually do not take into account water acidification by oxidative weathering of reduced material containing sulfur, such as pyrite. During oxidative weathering of sulfide, both sulfate and protons are added in solution. These protons will react with rock minerals and dissolve them in the same way that protons coming from CO₂ dissolution. In order to quantify this supply of protons and to refine the real CO₂ consumption by rock weathering, we need to constrain the origin of dissolved sulfate.

We present results on the Mackenzie River Basin, one of the largest river system, which shows high dissolved sulfate concentration and which is well known to contain both gypsum and sulfide mainly in reduced black shales. To identify sulfate sources, S and O isotopic measurements of sulfate molecules have been performed. $\delta^{34}\text{S}$ values range from 9.87‰ to -18.47‰ but do not allow to decipher between gypsum or sulfide oxidation origin, mainly for positive data. The $\delta^{18}\text{O}$ compositions of sulfate coupled to $\delta^{34}\text{S}$ are consistent with a major contribution of sulfide oxidation all over the basin, except for a few samples which tend to gypsum composition. Assuming that protons originating in pyrite oxidation react preferentially with carbonate rocks, we can calculate the net fluxes of CO₂ during chemical weathering. Atmospheric CO₂ fluxes are obtained after calculation of the assessment of carbonate weathering by sulphuric acid and silicate weathering by carbonic acid. Results suggest that there is a very limited atmospheric CO₂ consumption by chemical weathering in the Mackenzie Basin.