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CO2 consumption by weathering processes at high latitudes : the case of the Mackenzie river

Emilie Beaulieu (1), Yves Goddéris (1), David Labat (1), and Yannick Donnadieu (2)
(1) Geoscience Environnement Toulouse (GET), CNRS-Observatoire Midi-Pyrénées, Toulouse, France, (2) LSCE, CNRS-CEA, Gif-sur-Yvette, France

The chemical weathering of the continental surfaces depends on many factors such as the mineralogy of the rocks exposed, the supply of water and its residence time in the soil, pH, temperature of the soil solutions, physical erosion, vegetation. The contribution of other acids than carbonic acid to chemical weathering must also be accounted for. Indeed, sulfide oxidation commonly occurs in watershed, releasing sulfuric acid and hence protons available for weathering. Several studies have shown the need for considering the sulfide oxidation and the subsequent dissolution of other minerals promoted by sulfuric acid in the weathering CO2 consumption budget of a watershed. A recent study has estimed the bicarbonate flux into the ocean released by the reaction between sulfuric acid and carbonate rocks to 60% for the Mackenzie river basin1.
We develop a numerical model describing continental weathering reactions based on laboratory kinetic laws and coupled to a dynamic global vegetation model (the B-WITCH model) applied on Machenzie River basin. The model is first calibrated available field data for the various sub-basin of the Mackenzie watershed. Then, a simulation is performed removing the contribution of sulfuric acid in model, allowing the precise quantification of the role of pyrite oxidation on the weathering budget at the continental scale.
The effective atmospheric CO2 consumption represents 29% of the bicarbonate ions flux carried by the river in the reference simulation, slightly below is lower the estimation by Calmels et al. (2007) (38%, based on isotope data). The proportion of the atmospheric CO2 in the bicarbonate exported by the watershed doubles (55 %) if the sulfuric acid contribution is removed, but the global bicarbonate flux increases by 16%. Our results also confirm the primary control of the chemical weathering budget of the watershed by dissolution of carbonate minerals promoted by sulfuric acid. The chemical weathering in the Mackenzie basin seems to be a poorly efficient carbon sink. However, preliminary tests at 2 times atmospheric CO2 show that the weathering processes in the Mackenzie river are highly sensitive to the ongoing climate change.

1 Calmels et al., Geology, 35, 1003-1006, 2007