

## Silicate weathering in anoxic marine sediments

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*Weathering of silicate minerals is the major sink for atmospheric CO<sub>2</sub> on geological time scales. It has commonly been assumed that this process is only occurring on land. New results, however, show that silicate minerals are also reactive within marine sediments. Most of the metabolic CO<sub>2</sub> being produced in marine sediments enriched in organic matter is consumed by this reaction with major implications for the geological carbon cycle.*

**C**hemical weathering plays a key role in the geological carbon cycle. It transforms primary silicate minerals such as feldspars into clays and other particulate and dissolved products. Dissolved metal cations (e.g. Mg<sup>2+</sup>, Ca<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>) and silica (H<sub>4</sub>SiO<sub>4</sub>) are released during this reaction while CO<sub>2</sub> is transformed into bicarbonate (HCO<sub>3</sub><sup>-</sup>). The dissolved products are transported into the oceans through rivers and groundwater discharge. Silicate weathering is the most important sink for atmospheric CO<sub>2</sub> on geological time scales. It removes CO<sub>2</sub> from the atmosphere and increases the dissolved bicarbonate load of the oceans. Terrestrial silicate weathering depends on climate and the variables of temperature, runoff, and pCO<sub>2</sub>. The hydrological cycle –including evaporation, precipitation, and runoff– is accelerated under warm surface conditions while high surface temperatures are usually related to elevated pCO<sub>2</sub> values. Due to this threefold link, silicate weathering is accelerated when volcanoes or other components of the solid earth deliver high doses of CO<sub>2</sub> to oceans and atmosphere. Consequently, the partial pressure of CO<sub>2</sub> reaches only moderate levels during periods of enhanced CO<sub>2</sub> degassing. Conversely, with a reduced source of CO<sub>2</sub>, atmosphere

CO<sub>2</sub> concentrations do not fall too low as the resulting lower temperatures reduce the removal rate of CO<sub>2</sub> by weathering. Therefore, the climate sensitivity of weathering reactions acts to stabilize atmospheric pCO<sub>2</sub> on time scales of 10,000 to 100,000 years.

Reactive silicate minerals not weathered on land are ultimately deposited on the seafloor in continental margin sediments. In their new paper, Wallmann et al. (2008) showed that these minerals are reactive within marine sediments. They studied a number of sediment cores taken at the continental slope of Sakhalin Island. The evaluation of down-core solid phase and pore water profiles showed that most of the metabolic CO<sub>2</sub> produced during microbial organic matter decomposition is converted into bicarbonate by reaction with feldspars, volcanic ash and other silicate minerals. The evaluation of pore water data from other continental margin sites showed that silicate weathering is a common process in sediments with high organic matter contents. These new data suggest that the rate of marine silicate weathering may be as high as the rate of continental silicate weathering.

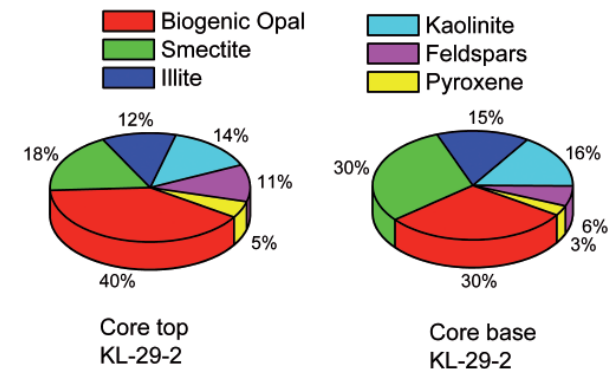


Figure 1. Composition of sediments retrieved at the continental slope of Sakhalin Island. The data show a down-core decrease in the abundance of reactive silicate phases (feldspars, pyroxene).

In contrast to continental weathering, marine weathering is not directly coupled to average global surface temperature and atmospheric pCO<sub>2</sub>. Carbon transformations in sediments are rather fueled by the deposition of particulate organic matter and reactive silicate phases. The consumption of CO<sub>2</sub> in these sediments is, thus, controlled by continental erosion and marine productivity. The negative climate feedback established by the temperature- and pCO<sub>2</sub>-dependent rate of continental weathering is weakened by marine weathering processes since reactive silicate phases which are not consumed on land may be weathered in marine sediments. Marine weathering might, thus, amplify climate change on geological time scales and could, for example, contribute to the draw-down of atmospheric CO<sub>2</sub> observed during the late Cenozoic and glacial periods of the Quaternary.

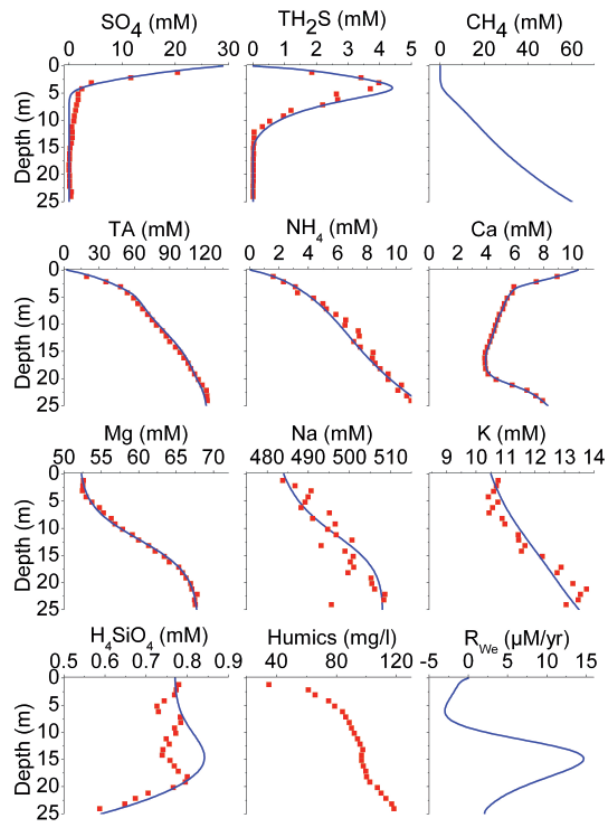


Figure 2. Composition of pore fluids separated from the wet sediments retrieved at the slope of Sakhalin Island. Concentrations of dissolved species measured in these fluids are shown by red dots. The blue lines indicate the results of transport-reaction modeling. TA is total alkalinity which is roughly equivalent to the concentration of dissolved bicarbonate. The rate of silicate weathering (RWE) was derived from the down-core increase in TA and dissolved magnesium concentrations.

The results presented in this study have also implications for applied geosciences. Marine sediments are increasingly used for the disposal of CO<sub>2</sub> separated from natural gas and in coal power plants. The new results imply that terrigenous sediments with high contents of reactive silicate phases might be well suited sites for CO<sub>2</sub> disposal since CO<sub>2</sub> may be rapidly neutralized by marine silicate weathering.

### Reference

Wallmann K., Aloisi G., Haeckel M., Tishchenko P., Pavlova G., Greinert J., Kutterolf S., and Eisenhauer A. (2008) Silicate weathering in anoxic marine sediments. *Geochim. Cosmochim. Acta* **72**, 3067-3090.