Geophysical Research Abstracts
Vol. 19, EGU2017-12827, 2017
EGU General Assembly 2017

High potential for weathering and climate effects of non-vascular vegetation in the Late Ordovician

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Early non-vascular vegetation in the Late Ordovician may have strongly increased chemical weathering rates of surface rocks at the global scale. This could have led to a drawdown of atmospheric CO_2 and, consequently, a decrease in global temperature and an interval of glaciations. Under current climatic conditions, usually field or laboratory experiments are used to quantify enhancement of chemical weathering rates by non-vascular vegetation. However, these experiments are constrained to a small spatial scale and a limited number of species. This complicates the extrapolation to the global scale, even more so for the geological past, where physiological properties of non-vascular vegetation may have differed from current species.

Here we present a spatially explicit modelling approach to simulate large-scale chemical weathering by non-vascular vegetation in the Late Ordovician. For this purpose, we use a process-based model of lichens and bryophytes, since these organisms are probably the closest living analogue to Late Ordovician vegetation. The model explicitly represents multiple physiological strategies, which enables the simulated vegetation to adapt to Ordovician climatic conditions. We estimate productivity of Ordovician vegetation with the model, and relate it to chemical weathering by assuming that the organisms dissolve rocks to extract phosphorus for the production of new biomass. Thereby we account for limits on weathering due to reduced supply of unweathered rock material in shallow regions, as well as decreased transport capacity of runoff for dissolved weathered material in dry areas.

We simulate a potential global weathering flux of 2.8 km^3 (rock) per year, which we define as volume of primary minerals affected by chemical transformation. Our estimate is around 3 times larger than today's global chemical weathering flux. Furthermore, chemical weathering rates simulated by our model are highly sensitive to atmospheric CO_2 concentration, which implies a strong negative feedback between weathering by non-vascular vegetation and Ordovician climate.