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High potential for chemical weathering and climate effects of early lichens and bryophytes in the Late Ordovician

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Non-vascular vegetation in the Late Ordovician may have considerably increased global chemical weathering, thereby reducing atmospheric CO_2 concentration and contributing to a decrease in global temperature and the onset of glaciations. Usually, enhancement of weathering by non-vascular vegetation is estimated using field experiments which are limited to small areas and a low number of species. This makes it difficult to extrapolate to the global scale and to climatic conditions of the past, which differ markedly from the recent climate.

Here we present a global, spatially explicit modelling approach to estimate chemical weathering by non-vascular vegetation in the Late Ordovician. During this period, vegetation probably consisted of early forms of today's lichens and bryophytes. We simulate these organisms with a process-based model, which takes into account their physiological diversity by representing multiple species. The productivity of lichens and bryophytes is then related to chemical weathering of surface rocks. The rationale is that the organisms dissolve rocks to extract phosphorus for the production of new biomass. To account for the limited supply of unweathered rock material in shallow regions, we cap biotic weathering at the erosion rate.

We estimate a potential global weathering flux of 10.2 $km^3\,yr^{-1}$ of rock, which is around 12 times larger than today's global chemical weathering. The high weathering potential implies a considerable impact of lichens and bryophytes on atmospheric CO_2 concentration in the Ordovician. Moreover, we find that biotic weathering is highly sensitive to atmospheric CO_2, which suggests a strong feedback between chemical weathering by lichens and bryophytes and climate.