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Evidence of favored coupled gypsum dissolution - calcite precipitation during nocturnal CO_2 uptake in a biocrusted dryland soil: an overlooked carbon sink?

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Drylands soils have been increasingly reported to absorb CO_2 at night and to potentially contribute to explain the residual terrestrial carbon sink. However, the biogeochemical processes causing this uptake are still debated. Recent evidence from a semiarid ecosystem suggested that geochemical reactions involving calcite could play a role and be favored by water vapor adsorption (WVA) under drought conditions.

In order to test this hypothesis, we measured continuously the in situ soil-atmosphere CO_2 and water vapor fluxes, temperature and water content within cyanobacterial biological soil crusts. In addition, we analyzed and compared the daytime and nighttime composition of soil water extracted immediately after simulated rainfalls. We calculated the saturation indexes of the most reactive minerals at this site and explored the relationships between variables by statistical modelling.

Our results show that CO_2 uptake by soil was immediately triggered by watering and that coupled gypsum dissolution-carbonate precipitation was favored during those moments. Therefore, we propose the following pathway of carbon transfer from atmospheric CO_2 to soil $CaCO_3$: the decreasing temperature at night favors the dissolution of atmospheric CO_2 in soil water, forming HCO_3^- that combines with the Ca^{2+} inherited from gypsum dissolution to precipitate $CaCO_3$. The continuous removal of HCO_3^- by $CaCO_3$ precipitation generates positive feedback between the mineral precipitation and CO_2 dissolution in soil water, resulting in atmospheric CO_2 removal.

The main factor limiting the process was water availability, but our observations support the possibility that nocturnal WVA by soil might lift this limitation during drought. In addition, dissolved organic carbon seemed to inhibit the CO_2 uptake, and a possible connection with the nitrogen cycle and enhancement by biological soil crusts deserves to be further investigated.

We propose that (1) the weathering of Ca-bearing minerals has been overlooked to explain the nocturnal CO_2 uptake due to the apparent lack of water in drylands, although it can be fueled by non-rainfall water inputs such as WVA; (2) this natural geochemical process has the potential to constitute an active long-term carbon sink, challenging the paradigm according to which soil carbonate accumulation requires centuries to millennia.

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