

A record of long-term terrestrialization?

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In modern soils, lithotrophic prokaryotes as well as fungi, lichens, and vascular plants secrete organic acids that enhance rates of chemical weathering. These acids possess a particularly strong binding affinity for Al, potentially as a mechanism for facilitating the release of bioessential elements from aluminosilicate minerals while also minimizing the toxic effects of Al uptake by cells. Preferential Al loss from ancient soils (paleosols) may therefore serve as a robust biosignature for the presence of life on land prior to its appearance in the fossil record.

To test this hypothesis, we use a mass balance approach to quantify Al loss from definitive and chronologically well-constrained paleosols. We use previously-published experimentally determined loss ratios between Al and Mg, a mobile element not affected by organic acids, to calculate expected Al release under abiogenic weathering conditions for each paleosol. Our results show that preferential Al mobilization attributable to organic acid weathering can be detected in 10 paleosols, supporting the presence of a terrestrial biosphere as far back as the mid-Archean. There is no statistically significant change in Al mobility across major transitions such as the Great Oxidation Event in the Paleoproterozoic nor the spread of vascular plants in the mid-Paleozoic. Controversially, this suggests organic acid weathering operated similarly in the Precambrian as it does today.