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Paleosol lithium isotopes indicate lower clay production in the weathering zone before land plants

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Terrestrial silicate weathering is one of the primary regulators of Earth's climate on geologic timescales, removing atmospheric CO_2 via the chemical breakdown of silicate rocks. Lithium isotopes (δ^7Li), which strongly fractionate during the formation of clay weathering products, can provide a means of tracking silicate weathering across Earth history. Here we present the Li isotope composition of 18 paleosols from the Archean to early Paleozoic, recording Earth's oldest terrestrial weathering environments. Compared to Cenozoic and modern soils, these paleosols exhibit smaller isotopic offsets between weathered regolith and un-weathered parent rock (Δ^7Li). We link this shift to less clay production in soils that predate land plants. Using a simple mass balance model of the weathering zone, we find that the clay-associated Li export flux was consistently lower for these paleosols than for more recent profiles, while the dissolved Li export flux was on average higher. However, our mass balance approach also suggests that parent rock cannot be the only source of Li for numerous profiles. We rule out processes that may uniquely overprint paleosols relative to modern soils (e.g. metamorphic alteration) in all but 2 profiles. Instead, we propose that the most likely processes overprinting weathering signals in these paleosols are the same as those for modern soils, including dust and marine aerosol inputs. If taken as globally representative, these paleosols suggest that terrestrial silicate weathering regimes before land plants were characterized by lower clay production and higher weathering intensity. Given that clay formation can reduce the efficiency of CO_2 drawdown from silicate weathering, the paleosol δ^7Li record supports higher weathering efficiency in the absence of land plants, potentially balancing higher CO_2 outgassing from Earth's interior in the Archean and Proterozoic.