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Tracking influence of atmospheric oxygenation on continental weathering using Li isotopes

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Continental weathering has exerted profound influences on key processes throughout Earth history. However, the dominant factors controlling variations in continental weathering over deep time remain debated. One hypothesis proposes that rising atmospheric oxygen levels potentially resulting in thickening of surface weathering profiles and an overall increase in global continental weathering intensity. This study proposes that seawater lithium isotopes may serve as a promising proxy for tracking changes in global weathering intensity regulated by atmospheric oxygenation. Conceptually, this study divides marine lithium sinks into two endmembers: complete removal sinks and incomplete removal sinks. Complete removal sinks correspond to closed microenvironments or scenarios involving rapid lithium removal. Because dissolved lithium is completely removed within these microenvironments, these processes exhibit negligible apparent lithium isotope fractionation. In contrast, incomplete removal sinks occur in open environments at the sediment-water interface where lithium is continuously exchanged with seawater during authigenic clay formation, leading to an increase in seawater δ^7Li. Meanwhile, the production of terrigenous detrital aluminosilicates (precursors of authigenic clays) and the riverine lithium input flux are both regulated by continental weathering intensity under varying atmospheric oxygen partial pressure (pO_2). Based on these processes, the study establishes an in-situ weathering kinetics model for regolith profiles and a box model for the marine lithium reservoir, enabling calculation of seawater δ^7Li under different pO_2 conditions. Reconstructions suggest that prior to the NOE (0.8–0.55 Ga), atmospheric pO_2 was generally less than 1% of the Present Atmospheric Level (PAL). Model results indicate that when pO_2 increased from 1% PAL to 100% PAL, the simulated rise in δ^7Li reached up to 22‰, closely matching the magnitude of the Phanerozoic seawater δ^7Li increase inferred from carbonate records.