

Isotopic evidence for active weathering in the deeper parts of the critical zone

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The critical zone (CZ) is part of the outermost layer of the Earth in which complex interactions between rock, soil, water, air and living organisms occur. It extends from the vegetation canopy to the bottom of the ground water active zone. Most chemical weathering studies to date have focused on the shallowest, most strongly weathered parts of the CZ. These studies have documented complex soil formation. Chemical weathering in the deeper parts of the CZ, where rock transforms into saprolite, however, have not been studied often, even though there is increasing awareness that solutes in rivers and oceans derive from mineral breakdown in regoliths within the deep CZ. Here we present U series systematic on a sub-recent regolith from Chhindwara, India. It displays a clear overall loss of U (elevated Th/U) and preferential ²³⁴U-deficit (low ²³⁴U/²³⁸U activity) attributable to chemical weathering. Importantly, the ²³⁴U-deficit in this profile explains the substantial ²³⁴U-excess in seawater and provides evidence for active continental nutrient supply to the oceans.

Having documented the clear mineralogic and chemical difference between the breakdown of primary minerals (and glass) to clays in saprolite and the formation of secondary oxi-hydroxides in regolith and laterite, it is now possible to clearly separate the effects of these unrelated mineralogic reactions on the topical metal stable isotope systematics. In this study, the contrasting fractionation in Zn isotopes was investigated. The results provide evidence that the formation of clays in the Chhindwara saprolite does not lead to significant isotopic fraction of $\delta^{66}\text{Zn}$ and lies within the “crustal average” of 0.2-0.3 ‰. Thus, the continental nutrient supply of Zn to rivers and oceans is not accompanied by enhanced isotopic fractionation, whereas $\delta^{66}\text{Zn}$ values that depart from the “crustal average” of 0.2-0.3 ‰ are likely unrelated to the natural supply of Zn from continents.