Transition metal behaviour in a Deccan basalt weathering profile

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Understanding the detailed behaviour of redox-sensitive elements and their isotope ratios is key for quantifying the processes of rock weathering. The importance of this research field is exemplified by the vital function of several transition metals (Zn, Mn, Mo, Ni, Co, and Cr) which, at higher concentrations, can have toxic effects on cells. In general, metal loss occurs through leaching to groundwater and/or plant uptake, while immobilisation of metals occurs via adsorption and precipitation. Near Chhindwara, India, a sub-recent basaltic weathering profile is exposed that offers in-depth insights into the early to intermediate stages of weathering and consequently the elemental behaviour of transition metals during soil formation. Here we use combined high-precision geochemistry and quantitative mineralogy to show that phyllosilicate development governs the release of Cu, Zn, Co, Cr, and Ni. In addition, the simultaneous formation of oxides influences the accumulation of these metals. In view of moderatly coupled Mn and Cr behaviour, it was expected that this profile would yield evidence for Cr isotope fractionation. However, our new Cr isotope data show minimal fractionation throughout the profile (with values similar to the igneous protolith). These results suggest that weathering intensity and extensive Mn oxide formation may be the key factors for Cr(VI) formation and Cr isotope fractionation. It would follow that tropical environments and/or very specific soil types/horizons may exert a strong control on riverine Cr isotope compositions and dominate the global flux of Cr to the hydrosphere. Regardless, the release of transition metals during phyllosilicate formation supports the idea that transition metals can fingerprint oxygenation events throughout Earth's history. For example, the release of Ni and Co in the profile and changes in the release of these metals from land may indicate enhanced subaerial oxidation in the Precambrian.

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