Chromium isotope fractionation during pedogenesis: Influence of redox recycling

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Tracking the fate of Cr and δ^{53}Cr during physical and chemical weathering of soils is central to investigating both naturally occurring Cr(VI) drinking water contamination and the use of Cr as a paleoredox proxy. Cr is a unique system to study because it is possible to monitor variations of both the fluid δ^{53}Cr(VI) as well as the solid δ^{53}Cr(III) in space and time to interpret modern and ancient (bio)geochemical cycling. However, determining fractionation factors from observed isotope patterns is difficult due to multiple transformation pathways, recycling, and inherent heterogeneity in soils. The coupling of Cr-, Fe- and Mn- cycling and the presence of secondary minerals such as Fe-Cr-oxyhydroxides and Mn-oxides in soils indicates that Cr(III) available for oxidation may have been recycled (oxidized and reduced multiple times). Here we present a theoretical study that quantitatively tracks Cr isotopes during pedogenesis by modeling oxidation, reduction, fluid flow and physical denudation. We apply the model to a corresponding field study of solid and fluid speciation, isotope composition, physical and chemical gradients occurring in a modern serpentine mollisol developed on ultramafic bedrock in the Putah Creek watershed of the northern California Coast Range. The model is parameterized using both field and published data. Results demonstrate that increased recycling changes apparent fractionation, depending on fractionation factors assumed. These simulations show that it is difficult to attribute in-situ fractionation factors to specific reactions without careful evaluation of phases, mechanisms and rates. Our modeling methods can also be applied to other elements (such as Fe) and environments (such as groundwater aquifers) to evaluate the spatial variability in isotopic composition imposed by redox recycling.

Seafloor massive sulfide exploration in SW Pacific - A commercial perspective

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The discovery and recovery of seafloor massive sulfides near Galapagos and black smokers at 21ºN on the East Pacific Rise in the late 1970s is arguably one of the great natural science discoveries of the 20th Century. Since then, black smokers have been found in all the world's oceans. Because of the high concentrations of copper, lead, zinc, silver and gold associated with seafloor massive sulfides, they have gone, in the space of less than 30 years, from being a scientific curiosity to a potential new source of metals for commercial use, attracting significant speculative investment by private and public companies and state-owned enterprises. One commercial Mining Licence has been granted in the Bismarck Sea by the Government of Papua New Guinea and further mining licences are likley to follow in other countries' waters along the SW Pacific Ring-of-Fire.

The SW Pacific region is attractive to explorers for two main reasons: firstly, it has convergent plate boundaries with associated volcanic arcs and back arcs which host deposits of massive sulfide that generally contain superior metal grades due to complex crustal melting and fractionation processes; and secondly, countries in the region are able to grant secure title to explore within their territorial waters and Exclusive Economic Zones under existing legislation.

Land-based explorers are finding that new deposits are hard to discover and difficult to permit; and drilling, feasibility, construction and stripping typically takes 10 years or more. By contrast, on the seafloor, new deposits are relatively easier to find, they are high grade, have no or little overburden and mining does not require high levels of infrastructure or capital; and mine scheduling is flexible.

Neptune Minerals holds granted licences and licence applications in seven countries in the SW Pacific. It has completed exploration programs using a combination of hydrothermal plume survey, moderate to high-resolution acoustic seabed mapping, ROV mapping and sampling, geophysics, drilling and spot sampling, making and assessing a number of new discoveries. The company's 'baby step' approach to its exploration, environment and social licences is akin to adopting a precautionary approach.

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