Non-biological fractionation of Ca isotopes in soils of the Atacama Desert, Chile

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Stable Ca isotopes hold great potential for weathering studies, but their successful interpretation will require improved understanding of processes that fractionate Ca isotopes in terrestrial surficial environments. It has been demonstrated that both biotic uptake and abiotic precipitation fractionate Ca isotopes. To consider abiotic effects in a natural context, we measured Ca stable isotope ratios ($\delta^{44/40}$Ca) in an ancient (2My), nearly abiotic, hyperarid soil in the Atacama Desert. The primary source of mobile Ca in this soil is atmospheric deposition, and the primary mechanism of isotopic fractionation appears to be precipitation of sulfate and carbonate minerals. Most of the accumulated Ca in the upper meter of this soil (2.9 kmol m^{-2}) is present as sulfates (2.5 kmol m^{-2}). Sulfate-associated $\delta^{44/40}Ca_E$ values (vs. bulk Earth) increase with depth (1.4 m) from a minimum of -1.91‰ to a maximum of +0.59‰. Linear correlation between sulfate-associated $\delta^{44/40}$Ca and sulfate-δ^{34}S indicates a $\delta^{44/40}$Ca fractionation factor of –0.4‰ in $CaSO_4$. The overall depth trend in Ca isotopes is reproduced by a transport model that considers repeated small and infrequent rainfall events. The lowest Ca isotope values occur at shallow depths and are reproduced by a Rayleigh model, using measured soil Ca concentrations and the Ca fractionation factor predicted by the relationship with S isotopes. This indicates that the primary mechanism of fractionation in $CaSO_4$ is incremental and effectively irreversible precipitation with downward transport during repeated small rainfall events. This work demonstrates that significant inorganic Ca isotope fractionation in terrestrial settings can be a function of transient conditions of water supply, solution chemistry, and dissolved transport. These conditions are ubiquitous in weathering environments and should be considered in the interpretation of Ca isotope values.

Numerical modeling of continental plate retreating and crustal recycling

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Numerical experiments of oceanic subduction followed by continental collision reveal continuous subduction of the downgoing plate. When the continental plate arrive to the trench, slab pull and ridge push forces drag it into the mantle. When slab pull overcome plates coupling, the subducting plate detaches from the upper one and starts to retreat. Relatively buoyant mantle astenosphere wedges between the two plates facilitating the continental plate retreating process. The upper crust is scraped off by the astenosphere and thrusted over the pro-foreland; on the other hand, the lower crust is dragged into the deep mantle with important consequences for crustal growth models. Models with a weak lower crust exhibit a complete delamination of the lithospheric mantle from the continental crust. At the surface, we have development of a system characterized by two different tectonic regimes: the pro-foreland is dominated by compressional tectonics, while backward crustal thinning is evidenciate by very low depth astenospheric mantle.

The Western Mediterranean formed from the Oligocene times with a mechanism supposely analogous to our models. We try, therefore, to compare our results with an exstensively studied belt of this area, the Appennines. The geological record and geophysical data show indeed interesting similarities with the models, supporting the idea that the Western Mediterranean is the result of a retreating oceanic and, ultimately, continental plate.