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

STEPHANIE A. EWING1, WENBO YANG1, DONALD J. DEPAOLO1 AND RONALD AMUNDSON2

1Center for Isotope Geochemistry, Dept. of Earth and Planetary Sciences, University of California, Berkeley, CA 94720; (saewing@nature.berkeley.edu; wenbo@berkeley.edu; depaolo@eps.berkeley.edu)
2Ecosystem Sciences Division, ESPM, University of California, Berkeley, CA 94720; (earthy@nature.berkeley.edu)

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 (δ44/40Ca) 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 δ44/40CaE 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 δ34S and δ44/40Ca indicates a δ44/40Ca fractionation factor of –0.4‰ in CaSO4. 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 CaSO4 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

M. FACCEnda1, T.V. GERYa1, S. CHAKRABORTY2 AND M. GIORGIO3

1Institut of Geophysics, ETH Hoenggerberg, 8093 Zürich, Switzerland (facenda@erdw.ethz.ch);
(taras.gerya@erdw.ethz.ch)
2Institut für Geologie, Mineralogie & Geophysik, Universität Bochum, D-44780 Bochum, Germany (sumit.chakraborty@ruhr-uni-bochum.de)
3Gruppo di Geologia Strutturale & Geofisica, Università degli Studi di Perugia, 06100 Perugia, Italy (gminelli@unipg.it)

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 retreat process. The upper crust is scraped off by the astenosphere and thrust 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 evidenced by very low depth astenospheric mantle.

The Western Mediterranean formed from the Oligocene times with a mechanism supposedly analogous to our models. We try, therefore, to compare our results with an extensively studed 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.