

The biogeochemistry of rare earth elements in low-temperature, natural waters

KAREN H. JOHANNESSON

Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA, USA, kjohanne@tulane.edu

The value of the lanthanide series (also known as the rare earth elements, REE) as tracers of geochemical processes largely stems from their uniform trivalent charge (Ce^{4+} and Eu^{2+} can also occur), and the gradual decrease in their ionic radii with increasing atomic number (i.e., the lanthanide contraction) that accompanies the progressive filling of the 4f-electron shell across the lanthanide series. As a consequence, the REEs exhibit strong fractionation as a group due to size and charge, as well as substantial “within-group” fractionation resulting from the lanthanide contraction. These unique properties can therefore enable investigations of both complex and subtle geochemical processes that other, single element or single compound (i.e., molecules) tracers cannot distinguish. Chemical weathering, solution and surface complexation, and oxidation-reduction reactions [1, 2, 3] all play important direct and/or indirect roles in fractionating the REEs in low-temperature environments, and some biological processes may also fractionate REEs [4]. The REEs are increasingly important economic resources as they are critical in many developing “green technologies” and in the production of several of today’s “high-tech” electronic devices. Here, the biogeochemistry of the REEs in natural terrestrial waters is discussed with emphasis on the processes that fractionate the REEs in groundwater systems, including recent investigations at the land-sea interface within subterranean estuaries.

[1] Nesbitt (1979) *Nature* **279**, 206, [2] Quinn et al. (2006) *Geochim. Cosmochim. Acta.* **70**, 4151, [3] Johannesson et al. (2011) *Geochim. Cosmochim. Acta.* **75**, 825, [4] Pol et al. (2014) *Environ. Microbiol.* **16**, 255.