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Understanding the role of gypsum in the global Sr cycle using stable-Sr isotopes

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The strontium (Sr) geochemical cycle is closely intertwined with the long-term inorganic carbon cycle through processes such as volcanism, continental weathering, and carbonate precipitation. Strontium isotopes can offer valuable insights into the oceanic budget of Sr and, therefore, the factors governing long-term changes in atmospheric carbon dioxide and climate. The radiogenic strontium isotope composition of seawater ($^{87}Sr/^{86}Sr$) traces the different input sources of Sr to the ocean, while the stable-Sr isotope system ($\delta^{88}/^{86}Sr$) reflects both input and output fluxes. Gypsum ($CaSO_4 \cdot 2H_2O$), which is a significant component of marine evaporitic deposits and contains substantial amounts of Sr, may have a critical function for the oceanic strontium cycle and seawater $\delta^{88}/^{86}Sr$. This study aims to explore and quantify the stable Sr isotope fractionation in gypsum and the global geological implications of this process.

The Sr isotope fractionation was determined empirically by studying experimentally produced samples of gypsum, precipitated both in the laboratory and outdoors. Experimental samples were compared with natural samples, including modern gypsum and associated pore water from Dohat Faishakh Sabkha in Qatar and Messinian gypsum from Sicily.

The typical Sr isotope fractionation in gypsum is estimated to be 0.22±0.02‰, which contrasts with a negative isotope fractionation for Ca-carbonate precipitation [1]. Gypsum fractionation, however, varies widely (0.04‰ to 0.23‰) depending on the stirring environment. Thus, the use of gypsum as an archive for past seawater $\delta^{88/86}Sr$ should be approached with caution, as careful investigation of the natural samples and their precipitation environment is necessary for robust reconstructions. Additionally, using the typical isotope fractionation value, we suggest that 1) during periods of intense evaporite formation, the removal of Sr to gypsum can cause a detectable global seawater $\delta^{88/86}Sr$ decrease; and 2) gypsum weathering can have a significant impact on riverine $\delta^{88/86}Sr$, enriching it with ^{88}Sr. This can partly explain the higher $\delta^{88/86}Sr$ value of rivers (~0.32‰ [2]) relative to carbonate (~0.20‰ [1]) and silicate (~0.30‰ [3]) rocks.

[1] Vollstaedt et al. (2014), GCA 128, 249–265.

[2] Pearce et al. (2015), GCA 157, 125–146.

[3] Charlier et al. (2012), EPSL 329–330, 31–40