

Stable isotope geochemistry of strontium

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Strontium has four naturally occurring isotopes (⁸⁴Sr, ⁸⁶Sr, ⁸⁷Sr and ⁸⁸Sr). Among them, ⁸⁷Sr is a daughter nuclide of radiogenic ⁸⁷Rb, and its abundance changes due to the contribution of the radiogenic growth of ⁸⁷Sr produced by the beta-decay of ⁸⁷Rb; the radiogenic growth of ⁸⁷Sr has provided important constraints of the age and sources in cosmochemical and geochemical materials. Moreover, the isotopic composition of other Sr isotopes, such as ⁸⁴Sr, ⁸⁶Sr and ⁸⁸Sr may also vary due to mass-dependent isotopic fractionation through various physicochemical reactions in nature. This mass-dependent isotopic fractionation can provide key information about the sequence and/or mechanism of sample formation. The field of science that deals with them is widely known as stable isotope geochemistry. However, the application of stable isotopes of Sr has been retarded, mainly due to difficulty in obtaining an accurate and precise ⁸⁸Sr/⁸⁶Sr isotopic ratio. In the conventional isotopic analysis of ⁸⁷Sr/⁸⁶Sr, the ⁸⁸Sr/⁸⁶Sr isotopic ratio has been normalized to 1/0.1194 to correct the ⁸⁷Sr/⁸⁶Sr ratio for the mass-discrimination effect; the natural variation in the ⁸⁸Sr/⁸⁶Sr ratio has been neglected.

In this study, we present a method to determine ⁸⁸Sr/⁸⁶Sr and ⁸⁷Sr/⁸⁶Sr simultaneously. The former variation reflects the mass-dependent isotopic fractionation through the physico-chemical processes, and the latter originates from decay of the parent nuclide ⁸⁷Rb as well as the mass-dependent isotopic fractionation. In order to determine the mass-dependent isotopic fractionation, the mass-discrimination effect on ⁸⁸Sr/⁸⁶Sr was externally corrected by an exponential law using Zr. For the radiogenic growth of ⁸⁷Sr/⁸⁶Sr, the mass-dependent isotopic fractionation effect on ⁸⁷Sr/⁸⁶Sr was corrected by a conventional correction technique using the ⁸⁸Sr/⁸⁶Sr ratio. The reproducibility of the ⁸⁸Sr/⁸⁶Sr and ⁸⁷Sr/⁸⁶Sr measurements for a high-purity Sr chemical reagent was 0.006% (2SD, n = 20) and 0.007% (2SD, n = 20), respectively. Strontium isotopic ratios (⁸⁸Sr/⁸⁶Sr and ⁸⁷Sr/⁸⁶Sr) were measured on geochemical reference materials (igneous rock: JB-1a, JA-2 and JG-2; carbonate mineral: JLS-1, JDO-1, JCP-1 and JCT-1) and one seawater sample. The resulting ⁸⁷Sr/⁸⁶Sr ratios obtained here were consistent with previously published data within the analytical uncertainties. The resulting ⁸⁸Sr/⁸⁶Sr ratios for igneous rocks and carbonate minerals showed enrichments of the lighter Sr isotopes over the seawater sample. The ⁸⁸Sr/⁸⁶Sr ratio of geochemical samples could reflect the physico-chemical processes for the sample formation. Also, a combined discussion of ⁸⁸Sr/⁸⁶Sr and ⁸⁷Sr/⁸⁶Sr of samples will render multi-dimensional information on geochemical processes.

Keywords: Stable isotope geochemistry, Strontium, Isotopic fractionation