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Purification and Determination of Ce and U Stable Isotope Ratios Using the Double-Spike Techniques

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Rare earth elements (REEs) have been widely used to study geological processes due to their distinct element patterns and radiogenic decay systems (^{138}La-^{138}Ce, ^{147}Sm-^{143}Nd, ^{146}Sm-^{142}Nd)[1]. With advances in analytical techniques, REE stable isotope fractionations have been increasingly used to clarify lingering ambiguities in REE systematics, with cerium (Ce) being one of the most promising REE stable isotope systems[2-6]. In terrestrial environments, REEs are typically present as trivalent cations but Ce can also exist as Ce^{4+} under oxic conditions, resulting in abnormally high or low abundances relative to adjacent REEs, known as Ce anomalies. Despite the wide use of Ce anomaly in Earth sciences as a redox proxy, its interpretation remains qualitative and sometimes ambiguous. Ce stable isotope ratios can be combined with Ce anomaly to provide more quantitative and clear interpretations.

In this presentation, we introduce a new analytical method for combined high-precision analyses of Ce and U isotopes. Cerium has 4 stable isotopes (^{136}Ce, ^{138}Ce, ^{140}Ce and ^{142}Ce). One challenge in analyzing Ce isotopes is their highly contrasting/different natural abundances, with ^{140}Ce and ^{142}Ce accounting for over 99.5% of total Ce, making ^{142}Ce/^{140}Ce the only measurable isotope ratio. Our double-spike approach uses a ^{136}Ce-^{138}Ce enriched isotope spike, allowing for high precision analyses using all four Ce isotopes. Cerium isotopes are purified and analyzed alongside double-spiked U, another redox-sensitive isotope system . Ce and U isotope ratios have been measured in a series of geostandards, igneous rocks, and oceanic oxic clays with a precision of 0.04 ‰ for $\delta^{142/140}$Ce and 0.07 ‰ for $\delta^{238/235}$U (2S.D.). Further details of the analytical method and isotope data will be presented at the conference.

[1] Lipin & Mckay 2018 Geochemistry and mineralogy of rare earth elements. [2] Nakada et al. 2016 GCA. [3] Bonnand et al. 2019 JAAS. [4] Hu et al. 2021 Sci. Adv. [5] Liu et al. 2021 Anal. Chem. [6] Bai et al. 2022 JAAS.