

## Fingerprinting rare earth resources using stable Nd isotopes

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Rare earth elements (REE) are a critical resource as the world aims to lower carbon emissions and transition towards green energy systems. Considering the UN's Sustainable Development Goals, extraction and production of REE needs to be responsible, environmentally considerate, and traceable. To address the geological provenance and traceability of processed REE products, we have employed a novel double-spike (<sup>145</sup>Nd-<sup>150</sup>Nd; with demonstrated high-precision, i.e. long term reproducibility c. 0.015‰ on  $\delta^{146}\text{Nd}$ , [1]) MC-ICP-MS technique for combined stable and radiogenic Nd isotope fingerprinting of three prospective REE deposits from Queensland, Australia. Here we present the first Nd-isotope characterisation of these types of deposits globally.

Tailings from the abandoned Mary Kathleen uranium mine contain highly elevated total REE concentrations of up to 4 wt.% which are dominantly hosted by allanite, andradite garnet, and apatite, which remain after uranium extraction from the primary ore using sulphuric acid treatment. The Mary Kathleen tailings exhibit a consistently light stable Nd isotopic composition of between c.  $-0.11 \pm 0.01$  and  $-0.09 \pm 0.01$  ‰  $\delta^{146}\text{Nd}$ . In contrast, phosphorite samples (including primary apatite ore and slime/phosphogypsum by-products) are isotopically heavy with average signatures of c.  $+0.08 \pm 0.02$  and  $+0.12 \pm 0.02$  ‰  $\delta^{146}\text{Nd}$ , respectively. The lightest Nd-isotopic signature was obtained from a suite of REE and HFSE enriched alkaline rocks from the Peak Range Volcanics with values of c.  $-0.13 \pm 0.02$  ‰  $\delta^{146}\text{Nd}$ .

These preliminary results indicate that different REE-sources demonstrate variably fractionated Nd isotopic signatures that deviate significantly from the composition of bulk silicate earth ( $-0.024 \pm 0.031$ ‰) [2] and previously characterised igneous reservoirs (c.  $-0.04$  to  $+0.02$  ‰  $\delta^{146}\text{Nd}$ : e.g. [2], [3], and references therein) making the technique a potentially valuable tool for fingerprinting both REE resources and REE-extraction products. Work to constrain the host mineral phases responsible for these distinctive signatures is ongoing.

[1] McCoy-West et al. (2020), *J. Anal. At. Spectrom.* **35**, 388-402.

[2] McCoy-West et al. (2021), *GCA* **293**, 575-597.

[3] Bai et al. (2021), *J. Anal. At. Spectrom.* **36**, 2695-2703.