

A heavy stable isotope approach to tracing mantle source and process

CAROLINE R SODERMAN¹, SIMON MATTHEWS¹,
OLIVER SHORTTLE¹, MATTHEW G JACKSON², PROF.
JAMES M.D. DAY³ AND HELEN M. WILLIAMS¹

¹University of Cambridge

²University of California Santa Barbara

³Scripps Institution of Oceanography

Presenting Author: cs801@cam.ac.uk

The geochemistry of basaltic mantle-derived partial melts suggests that they sample lithological heterogeneities originating throughout Earth's mantle, with recycled crust accounting for a significant part of this variability. Heavy stable isotopes (those from Mg and upwards in mass [1]) offer a new tool to complement existing tracers of mantle heterogeneity and lithology (e.g., major and trace elements, radiogenic isotopes), because mineral- and redox- specific equilibrium stable isotope fractionation effects can link the stable isotope ratios of melts to their source mineralogy and degree of partial melting [2, 3].

We have developed a quantitative model, combining thermodynamically self-consistent mantle melting and equilibrium isotope fractionation models, to explore the behaviour of the Mg-Ca-Fe-V-Cr stable isotope systems [4]. We can use this model to investigate the behaviour of the stable isotope ratios of these elements during melting of recycled crust (pyroxenite) and peridotite mantle lithologies, to better understand the insights that heavy stable isotope data from basalts will provide into mantle source and process. Here we show how such a combined model of stable isotope behaviour in melts can be used to address two main topics:

- How sensitive are stable isotopes in basalts to lithological variations within their mantle source? We present a case study from the Galápagos mantle plume, using Fe isotopes to identify the changing balance between peridotite and pyroxenite-sourced melts as a plume cools through time [5].
- What insights can a multi-isotope approach provide into OIB and MORB petrogenesis? We present Fe-Mg isotope data from Cook-Austral seamounts that may be associated with EM1-type rejuvenated volcanism [6], together with a global dataset, to show how combined isotope systems can provide insights into mantle source and process.

[1] Ibañez-Meija & Tissot (2021) *Elements* 17, 379–382

[2] Williams & Bizimis (2014) *EPSL* 404, 396–407

[3] Soderman *et al.* (2021) *GCA* 292, 309–322

[4] Soderman *et al.* (2022) *GCA* 318, 388–414

[5] Soderman *et al.* (2023) *Science Advances*, *In press*

[6] Jackson *et al.* (2020) *J. Pet.* 61, ega037