Fractionation of Fe and O isotopes in the mantle: Implications for the origins of eclogites and the source regions of mantle plumes

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Oxygen isotopes are widely utilised as tracers of subducted and recycled oceanic crust in the convecting mantle and in the source regions of mantle plumes. This assumes that the $\delta^{18}O_{V\text{-}SMOW}$ values higher and lower than normal mantle (~5.2‰) reported for some ocean island basalts (OIB) and eclogites reflect the involvement of oceanic crust hydrothermally altered at low and high temperatures, respectively, in their genesis.

We have measured Fe and O isotopes in garnet and clinopyroxene mineral separates from 6 eclogite xenoliths from the Kaalvallei and Bellsbank kimberlites, South Africa. Iron isotope compositions ($\delta^{57/54}Fe_{IRMM\text{-}14}$) for garnet and clinopyroxene range from -0.64±0.08 (2 SD) to 0.61±0.08‰ and -0.21±0.08 to 0.57±0.06‰, respectively. Calculated bulk-rock $\delta^{57/54}$Fe ranges from -0.58±0.12 to 0.28±0.1 ‰. Garnet and clinopyroxene δ^{18}O ranges from 3.8±0.2 (2SD) to 5.1±0.2‰ and 4.6±0.2 to 5.9±0.2‰, respectively. Calculated bulk rock δ^{18}O varies from 4.6±0.3 to 5.2±0.3‰. Mineral and bulk rock $\delta^{57/54}$Fe values correlate positively with δ^{18}O, implying that these isotopic signatures were produced by the same underlying mechanism.

One possibility is that the eclogites are derived from oceanic crust with a low δ^{18}O signature produced by high-temperature alteration, which also creates the $\delta^{57/54}$Fe-δ^{18}O trend. However, Fe isotopes only appear to be significantly fractionated during low temperature alteration when Fe is lost from the oceanic crust [1]. Iron isotopes are also unlikely to be fractionated by high temperature alteration as the Fe concentrations in these lithologies are unchanged from their precursors and the low Fe concentrations in hydrothermal fluids would limit isotopic exchange reactions.

It is therefore likely that the $\delta^{57/54}$Fe-δ^{18}O correlations are produced in the sub-continental lithospheric mantle (SCLM) by melting and metasomatic processes. Previous studies have shown that Fe isotopes can be fractionated in the mantle by processes such as partial melting [2]. If the measured variations in $\delta^{57/54}$Fe and δ^{18}O can indeed be produced in the SCLM, the implication is that the low (<5.2‰) δ^{18}O values of some OIB and eclogites cannot necessarily be interpreted in terms of subducted oceanic crust components.

References

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[2] Williams *et al*., (2005), *EPSL* **235** 435-452

Interpreting soil profiles developed on loess using a GCM and a watershed weathering model

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Indicators tracking the global climate warming since the last glacial maximum in continental environments are still sparse, and display a non uniform geographic distribution. A North-South transect in the Mississippi river valley provides a natural environment to explore the climate changes along this transect since 13 ky BP, through the interpretations of pedon scale chemical weathering as applied to a regional landscape. The studied modern soils are interpreted to have developed on loess with pedogenesis commencing between 13 – 10 ^{14}C ky BP. Mineralogical analysis of a sample subset are being compared to XRF elemental analysis to define weathering profiles across the temperature and precipitation gradient.

In order to understand the profiles we have observed and their relationship with the climatic evolution along the transect, we have used the GENESIS global climate model to predict soil temperatue and moisture fluxes along the transect as a function of time. We then used these model outputs to drive the WITCH model to calculate weathering profiles. The WITCH model relies upon laboratory kinetic rate laws, rationalized within the framework of Transition State Theory (TST), to describe mineral weathering (dissolution/precipitation) in natural environments. Additionally, the model accounts for soil CO_2 levels at varying depths and biogenic influences derived from the uptake or release of elements by vegetation. We compare observed soil profiles to soil profiles calculated by WITCH to learn about the effects of temperature and precipitation on weathering over the last 13 ky.