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Detecting pyroxenite melting using Ge/Si ratios and U-series isotopes in oceanic lavas

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With deeper onsets of melting and elevated melt productivity, even minor quantities of pyroxenite in the upper mantle are expected to contribute disproportionately to oceanic lavas, but pyroxenite partial melts remain difficult to uniquely fingerprint or quantify using geochemical methods. Recent research has suggested that low Ge/Si values may uniquely record pyroxenite partial melting due to Ge sensitivity to pyroxenite compositions and residual mineralogy [1], but the technique would benefit from comparison to other techniques that detect pyroxenite melting in other ways (e.g., through sensitivity to melting rates).

Uranium-series isotopes likely record the combined effects of high garnet abundances and high melting rates in pyroxenites through elevated (^{230}Th/^{238}U) and low (^{226}Ra/^{230}Th) and (^{231}Pa/^{235}U) (e.g., [2], and references therein). While this approach is supported by geochemical modeling and is potentially powerful, U-series disequilibrium analysis is only effective in definitively young, fresh lavas, making it applicable in only limited circumstances. However, U-series offer an opportunity to ground-truth Ge/Si techniques by direct comparison with evidence for rapid pyroxenite melting, with the added benefit that Ge/Si is easily measured across geologic settings, ages, and sample types.

We present preliminary Ge/Si results for a suite of North Atlantic mid-ocean ridge basalts with existing (^{230}Th/^{238}U), (^{226}Ra/^{230}Th), and (^{231}Pa/^{235}U) measurements. Our initial findings suggest that low Ge/Si aligns with both high (^{230}Th/^{238}U) (recording residual garnet) and low, age-constrained (^{226}Ra/^{230}Th) and (^{231}Pa/^{235}U) (products of rapid melting). On the other hand, samples with high (^{230}Th/^{238}U) and high (^{231}Pa/^{235}U), which likely record slow, deep garnet peridotite melting, and with low (^{230}Th/^{238}U) and high (^{226}Ra/^{230}Th), or slow, shallow spinel peridotite melting, have notably higher Ge/Si. These results offer preliminary support for Ge/Si as a uniquely sensitive indicator of pyroxenite partial melting.

References:

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