Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20662

Model constraints on harzburgite in mantle source regions

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The recycling of lithospheric material into the mantle by subduction, and the subsequent melting of this recycled material beneath mid-ocean ridges and ocean islands is a fundamental process in the ongoing differentiation of the Earth. Much of our understanding of lithosphere recycling comes from studies that apply mantle melting models to constrain mantle potential temperature and the proportion of recycled material required to match oceanic basalt composition and crustal thickness [1-4]. While this approach has been fruitful for constraining the relative abundances of fertile recycled basaltic crust (present as pyroxenite) and lherzolite, constraining the amount of highly depleted peridotite (harzburgite) is more difficult because it contributes little, if anything, to melt production. Despite this challenge, recent studies [2,3] have estimated harzburgite abundances by applying a combination of three constraints: crustal thickness, proportion of pyroxenite-derived melt comprising the crust (Xpx; derived from basalt compositions), and either olivine crystallization temperatures or source buoyancy to mantle melting models. These studies conclude that >40% harzburgite is present in the sources for MORBs and OIBs, including Iceland basalts. This contrasts with work showing that basalt compositions and crustal thicknesses at Iceland do not require harzburgite in the mantle source [4]. These diametrically opposed views are rooted in model assumptions that require closer examination. To explore the effects of model assumptions, we have extended our mantle melting code, REEBOX PRO [5], to encompass the range of assumptions made in previous models, including the incorporation of olivine crystallization temperatures, batch polybaric melt productivity, and source compaction accompanying melt extraction. Combining REEBOX PRO with Markov chain Monte Carlo sampling, we provide a rigorous assessment of the sensitivity of inferred harzburgite abundances to model assumptions and further illustrate the value of using basalt compositions, instead of Xpx, as a model constraint.

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