Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35692

Planetary controls on olivine-rich rock formations via mantle-melt interactions

SHOUNAK DUTTA, PAUL D. ASIMOW AND KENNETH A. FARLEY

California Institute of Technology

The volumetric abundance of highly olivine-enriched rocks (e.g., dunites with ~90% olivine) on Earth and Mars is difficult to reconcile with standard models of either fractional melting (which leaves harzburgite residues even at high melt fractions) or fractional crystallization (which requires large volumes of ultramafic or highly silica-undersaturated magmas). Reactive mantle-melt interactions, however, can generate dunite by dissolving pyroxenes and precipitating olivine during melt transport. Although well-studied for the terrestrial suboceanic mantle, its efficiency depends on planetary bulk composition and has not been considered for martian mantle compositions.

We compare reactive dunite formation on Earth and Mars using the thermodynamic equivalence between 1-D steady-state reactive porous flow and isentropic batch melting[1], implemented using pMELTS from 2 GPa to 0.01 GPa. For an Earth-like upper mantle composition[2] at a mantle potential temperature (T_p) of 1400°C, complete pyroxene exhaustion without melt focusing requires decompression to ~0.5 GPa. Dunite formation at deeper levels (~ 1.0 GPa) requires an integrated melt focusing factor of ~250, implying melt fluxes exceeding host rock mass by orders of magnitude over melt–rock interaction timescales. This inefficiency explains the dominance of lherzolite and harzburgite in Earth's upper mantle and the concentration of reactive dunite towards low pressures near the base of the oceanic crust.

In contrast, models using a martian mantle composition[3] at T_p = 1450°C yield higher melt fractions at equivalent pressures due to Mars' Fe-rich bulk composition. While 1-D un-focused melting consumes pyroxene by ~0.45 GPa, an integrated focusing factor of only ~32 is sufficient to produce a replacive mantle dunite at ~1.0 GPa on Mars. These results suggest that, if melt focusing operates within the martian mantle, it provides a highly efficient mechanism for generating larger volumes of olivine-rich rocks inside martian mantle compared to Earth. Reactive dunites can be distinguished from fractionally crystallized cumulates through correlations between spinel TiO_2/Cr_2O_3 and olivine Mg# with reactive dunites showing restricted refractory signatures in these mineral-chemical indicators, whereas cumulate dunite yields broader correlated variation.

[1]Asimow & Stolper (1999). *J Petrol*, 40(3), 475–494.

[2]Workman & Hart (2005). *EPSL*, 231(1–2), 53-72.

[3]Dreibus & Wänke (1984). *Proc. 27th IGC*, 11, 1–20.

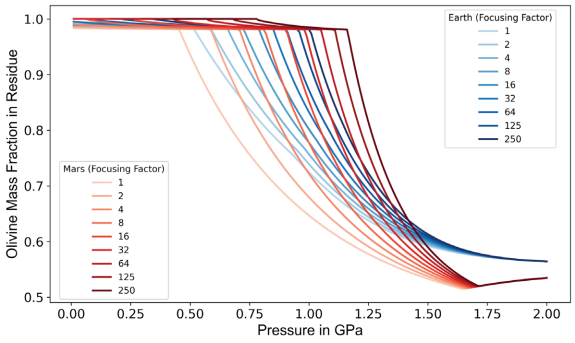


Figure 1. *Olivine mass fraction versus pressure for reactive melt transport models of Earth (blue) and Mars (red) across varying integrated melt focusing factors. Forming a pure dunite residue at 1.0 GPa requires an extreme focusing factor of ~250 for Earth, but only ~32 for Mars, highlighting the enhanced efficiency of reactive dunite generation in the martian mantle.*