Batch vs Continuous Melting: Importance of the Melting Regime in Quantifying the Mantle Heterogeneity

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It is generally admitted that oceanic basalts are formed by continuous melting of the mantle [1]. However, most parameterizations are calibrated on batch melting experiments. Using pMELTS [2], I modelled the adiabatic decompression of a heterogeneous mantle (peridotite + pyroxenite) and compared the melt composition and productivity produced by both batch and continuous melting.

Calculations reveal two major flaws in using parameterizations based on batch melting rather than continuous melting:

(1) the proportion of solid pyroxenite in the mantle source might be strongly underestimated. Because most proposed mantle pyroxenite compositions are denser than peridotite [3], an increase in the pyroxenite proportion may affect the buoyancy of the mixture in the upper mantle. Applying the corrected proportion to Iceland, I show that maintaining a positive buoyancy of the mantle source requires either a potential temperature $T_P \approx 1600°C$ notably higher than the recent estimates (i.e., 1450-1510°C [4,5]) or a significant proportion of less dense material, such as harzburgite (e.g., for T_P = 1500°C, buoyancy is maintained if the mantle contained > 20% harzburgite).

(2) The Ni proxy used to constrain pyroxenite abundance in mantle source [6] might not be suitable for continuous melting regime. In fact, the Ni content of the integrated melt produced by continuous melting of a given lithology can be significantly lower than the one produced by batch melting, and Ni-rich, olivine-free pyroxenites might produce melts that are not enriched in nickel when compared with peridotite melts if continuous melting is considered.

REFERENCES: [1] McKenzie (1984) J. Petrol 25; [2] Ghiorso et al. (2002), GGG 3; [3] Shorttle et al. (2014), EPSL 395; [4] Herzberg & Asimow (2015), GGG 16; [5] Matthews et al. (2016), GGG 17; [6] Sobolev et al. (2007), Science, 412-417.