

Exploring phase relations in high PT experimental charges with phase maps

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High-pressure and temperature (PT) experimental charges are valuable systems made up of minerals, often including quenched melt. They improve our understanding of petrological solid-state and melt formation processes occurring deep within the Earth. We assessed the utility of mineral phase mapping for analysing high PT charges in two sets of piston-cylinder experiments in isobaric prograde conditions:

(1) Partial melting (5 GPa; 1450-1750°C) from a lherzolite composition (GKR-001), and

(2) Layered reaction (3 GPa; 1400-1650°C) from a 50% komatiite + 50% harzburgite composition.

Phase maps were generated by registering backscattered electron scans with four energy-dispersive spectroscopy maps (Ca, Al, Si, Mg) in ImageJ2 and deploying an image analysis pipeline based on trainable pixel-classification in QuPath software and MATLAB scripts[1,2]. For the simple mineral assemblages of complex microstructure, this method produced more accurate phase maps than the default automated mineralogy software of the SEM, which struggled with similar compositions and mean atomic numbers of olivine and orthopyroxene in fine-grained targets.

In (1), the phase maps precisely located the solidus and identified low abundant phases (e.g., 1.2% melt and 1.9% cpx). The equilibrium conditions and the melting reactions (from mass balance) could be verified by analysing local modal mineralogy and mutual neighbouring relationships. For example, the crystallisation of peritectic orthopyroxene, reported in previous melting experiments, was characterised. The approach also demonstrated dependability in assessing the uncertainties of the starting composition, a crucial factor for evaluating Fe loss in high-temperature charges.

In (2), fast mapping the whole charge documented the strong layering of olivine (harzburgite) and orthopyroxene (komatiite) despite their near-identical mean atomic number (Fig.1). Above the solidus, the maps revealed an orthopyroxene-rich layer + melt (the former komatiite layer), followed by an olivine-rich layer (the former harzburgite layer). The interaction between komatiite melt and harzburgite not only produced extra orthopyroxene in the residue but also created compositional gradients, shedding light on deep mantle melt-rock interactions.

We propose phase maps as a valuable tool for documenting high-PT experiments in publications, as they can help identify rare phases, discover reactions and crystallisation kinetics during melt-rock reactions.

[1]Acevedo Zamora&Kamber(2023). Minerals.13(2):156.

[2]Kamber et al.(2025). Preprints.

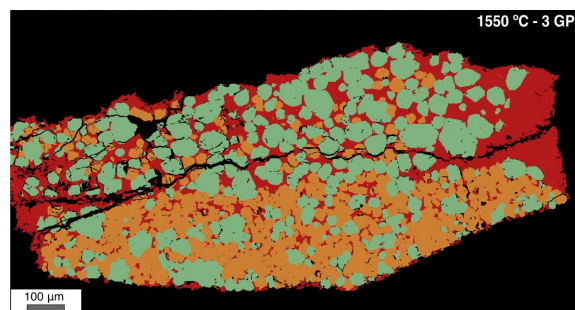


Fig. 1 Reaction experiment (50% komatiite + 50% harzburgite) at 1550 °C and 3 GPa.