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Intergranular melt in natural peridotites: distribution, melt fraction, and composition

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The physical properties of minerals and rocks within Earth's mantle are fundamental components to understand Earth's dynamic. Many properties are affected by the presence of intergranular melt/liquid along grain boundaries (e.g., viscosity or electrical conductivity), which concentrate incompatible elements, such as minor and rare-earth elements (REEs). Unfortunately, data for natural and partially molten peridotites remain either incomplete or contradictory (whole-rock concentrations of minor and trace elements versus recalculated bulk-rock concentrations), or entirely lacking (quantification of intergranular melt composition, melt fraction or type of distribution (films or tubules). In this study, we document the distribution of the intergranular melt/liquids in several peridotites from the Borée Maar (Massif Central, France). The aim is to quantify the melt fraction and calculate their chemical compositions focusing on major elements and a few minor elements to determine potential equilibrium conditions. The very small thickness of the observed melt films (ranging from a few tens of nanometers to a few micrometers) makes it difficult to measure their chemical composition directly by electron microprobe (EPMA). Consequently, these melt films were examined using a scanning electron microscope (SEM) and energy-dispersive spectroscopy (EDS) maps. The raw EDS spectra were treated using a new MATLAB macro that we developed. It enables quantitative EDS-based composition determination (down to 0.1 wt.% with only 5.7% error) for most major and minor elements). Furthermore, our results evidence the presence of different intergranular phases: two melts with distinct textures and compositions, microcrystals of clinopyroxene growing within the intergranular melt films, and bubbles. We also demonstrate that these melts did not originate from infiltration of the host basalt of Borée. The first results validate our proof-of-concept, and we can now constrain the role of these melt film as geochemical reservoirs and their impact on geophysical properties.