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New parameterization of peridotite melting and the geochemistry of mantle magmas for applications in geodynamic models

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To rigorously test numerical models of mantle convection and melting, model predictions must be quantitatively compared to real data. Nevetheless, in terms of comparing predicted compositions of mantle melting with geochemical data significant challenges remain. For example, coupling thermodynamic models of mantle melting such as Perple_X or pMELTS with numerical simulations is computationally expensive or unstable, and presents serious restrictions in terms of the mapped p-T conditions. On the other hand, simple peridotite melting parameterizations are mostly restricted to predict the degrees of melting, and so far unable to constrain the major-element composition of primary magmas. The potential to test predictions of major-element compositions is imperative for integrating geochemical observations with modeled physical properties of the source. Here, we present a new mantle melting parameterization based on fitting of melting experiments of peridotites and of selected thermodynamic model results (obtained from pMELTS) to fill gaps in the experimental database. The fitting parameters are pressure, temperature, critical porosity, water content and the initial pressure of melting. Based on these, the parameterization predicts the amount of melt retained in the mantle rock, the total degree of melting, plus major element compositions in the form of wt% of oxides: SiO_2, TiO_2, $Al2O_3$, FeO, MgO, CaO, Na2O and K2O (in addition to H_2O). While our parameterization is less precise and lacks the intrinsic self-consistency of thermodynamic models, it is highly applicable for large geodynamic problems, due to a high degree of stability and low computational costs as it is based on simple polynomic functions. Most importantly, the mapped p-T space is much greater than any that of any existing thermodynamic models or parameterizations that account for the effects of H_2O. Finally, we show the first applications of our parameterization as it is coupled to geodynamic models of flow and melting at e.g. a mid-ocean ridge. Our goal is to use this parameterization to compare numerical-model predictions in various geodynamic settings with fluid inclusions of actual primary melts.