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Formation models for mixed paragenesis diamonds

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Diamond-hosted mineral inclusions are diverse, including, but not limited to, sulphides, silicates, oxides, carbonates, and metallic phases and several of these mineral families can be sub-divided into three groups. This is termed inclusion paragenesis (peridotitic, eclogitic and websteritic). The geochemical and petrological diversity of lithospheric diamond inclusions reflects either pre-metasomatic upper mantle heterogeneity or metasomatism coeval with diamond formation. Ambiguity arises because geological context for inclusion-bearing diamonds is rare. These samples are seldom observed in situ with their host rocks and are instead liberated and concentrated by the mining process prior to examination.

On rare occasions single diamonds can contain inclusions from >1 of these paragenetic groups, these are termed mixed paragenesis diamonds. For example, Lai et al. (2022) document two samples containing eclogitic inclusions in their centres (omphacite and Mg-poor garnet) and peridotitic inclusions near the rims (Mg-chromite and olivine) of the same diamonds. These observations have been very difficult to explain in terms of upper mantle heterogeneity. Here we ran thermodynamic models of mantle metasomatism using the Deep Earth Water Model (see Rinaldi et al., 2023). We found that mixed paragenesis diamonds are predicted during fluid mixing in a mantle eclogite or by eclogitic fluids invading carbonated dunite.

Our models explain the occurrence of mixed paragenesis diamonds without the requirement of diamond mobility between parts of a heterogeneous upper mantle. Instead, mixed paragenesis diamonds speak to the diverse geochemical and petrological consequences of fluid-rock interactions in the upper mantle.

References Cited

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