

Low-degree partial melts trapped within upper mantle minerals

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The study of glass inclusions inside mantle minerals provides direct information about the chemistry of naturally occurring mantle-derived melts and the fine-scale complexity of the melting process responsible for their genesis.

Geochemical studies of mantle-derived magmas erupted at the Earth surface have shown that one of the main factors controlling their chemistry is the degree of partial melting. However, geologists rarely have direct access to pristine mantle melts, and laboratory experimental partial melting of peridotite essentially documents the chemical composition of large melt fractions. Therefore, several aspects of melting models remain hypothetical. In particular, the major element composition of the lowest melt fractions from upper mantle peridotite is still a matter of debate.

Here, the approach was to identify and examine directly near-solidus mantle melts preserved as quenched glass inclusions in minerals in upper mantle xenoliths. Contrary to interstitial glass samples found in xenoliths which are open systems and, consequently, are prone to chemical modification during ascent of the host xenolith, melt/fluid inclusions inside minerals behave as closed and isochoric systems. Previous studies of glass inclusions in xenoliths have shown that high-silica glasses are a common feature of spinel lherzolite minerals (Schiano and Clocchiatti, 1994), and a general link between these silica-rich inclusions and the character of near-solidus partial melts of peridotite has been suggested.

The new contribution of this study is the documentation of a series of glass inclusions in mantle minerals which, after homogenization by heating, show a continuous suite of chemical compositions clearly distinct from that of the host lavas (Schiano *et al.*, 1998). The compositions range from silicic, with nepheline-olivine normative, 64wt.% SiO₂ and 11 wt.% alkali oxides, to almost basaltic, with quartz normative, 50 wt.% SiO₂ and 1–2 wt.% alkali oxides. An experimental study of

the inclusions indicates that trapped melts represent liquids that are in equilibrium with their host phases at mantle temperature and pressure (T 1230°C and P 1.0 GPa for melts trapped in olivine). Quantitative modelling of the compositional trends defined in the suite shows that all of the glasses are part of a cogenetic set of melts formed by fractional melting of spinel lherzolite, with F varying between 0.2 and 5%. The initial highly silicic, alkali-rich melts preserved in Mg-rich olivine become richer in FeO, MgO, CaO and Cr₂O₃ and poorer in SiO₂, K₂O, Na₂O, Al₂O₃ and Cl with increasing melt fractions, evolving toward the basaltic melts found in clinopyroxene.

These results confirm the connection between glass inclusions inside mantle minerals and partial mantle melts. Furthermore, the results extend previous studies arguing in favour of silica-rich melts at low degree of melting, in establishing that near-solidus primary melts of peridotite could have SiO₂ contents > 60 wt.% for MgO contents < 1 wt.%. The composition of the primary melts is inferred to be dependent on pressure, and to reflect both the speciation of dissolved CO₂ and the effect of alkali oxides on the silica activity coefficient in the melt. At pressures around 1 GPa, low-degree melts are characterized by alkali and silica-rich compositions, with a limited effect of dissolved CO₂ and a decreased silica activity coefficient caused by the presence of alkali oxides, whereas at higher pressures alkali oxides form complexes with carbonates and, consequently, alkali-rich silica-poor melts will be generated.

References

- [1] Schiano, P. and Clocchiatti, R. (1994) *Nature*, **368**, 621–4.
- [2] Schiano, P., Bourdon, B., Clocchiatti, R., Massare, D., Varela, M.E. and Bottinga, Y. *Earth Planet. Sci. Lett.*, in press.