New calculations on water storage in the upper mantle, and implications for mantle melting models

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Water contents in olivine, orthopyroxene, clinopyroxene, garnet, amphibole, mica and coexisting glasses or matrices have been determined from 23 water-undersaturated melting experiments conducted on basaltic compositions at 1–4 Gpa, 1000–1380 °C with 1.7–25 wt% water. Correlations between molar Al and H show that H_2O is accommodated in olivine and pyroxenes via a coupled substitution of $H^+ + Al^{3+} \leftrightarrow Si^{4+}$. For olivine, our work suggests this is prominent at less than 2 GPa, but at higher pressure the substitution $2H^+ \leftrightarrow Mg^{2+}$ dominates (Zhao et al., 2004). For pyroxenes, the hydrogen and aluminium substitution remains more important at higher pressure.

These observations linked with other work (Rauch and Keppler, 2002; Bromily et al., 2004; Zhao et al., 2004) allow a new calculation of the maximum storage capacity for water in nominally anhydrous upper mantle peridotite. The resultant potential water content at the critical pressure range for basaltic magma generation increases from ~1200 ppm at 2 GPa to ~1800 ppm at 4 GPa. In models of magma generation (Green and Falloon, 2005) this means that no separate hydrous phase will occur in MORB sources, but may be present in hot spot magma sources and more likely present in intraplate magma sources. In the latter 2 cases the effect of significant CO_2 needs to be considered as well (Adam, 1990; Green and Falloon, 2005).

References

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