

## **The effect of water on equilibrium relations between clinopyroxenes and basanitic magmas: Tracing water and non-volatile incompatible elements in the Earth's mantle**

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Water is known to be an effective flux of mantle melting. Thus knowledge of its distribution and effects is critical for our understanding of geochemical fractionation within the Earth's mantle, since this is largely driven by melt production and migration. However, the influence of water on magmas can be difficult to distinguish from that produced by other factors, such as pressure and temperature. Our approach to this problem has been to compare the compositional and structural properties of clinopyroxene (an important mantle phase) crystallized from both water-rich and water-poor magmas.

High pressure experiments were performed at 1.0-3.5 GPa and 1025-1190 °C on a hydrous intraplate magma (nepheline basanite) at Macquarie University, Australia. Water contents ranging from 5.8 to 16.3 wt. % were dissolved in the coexisting melts. Clinopyroxenes crystallized from these experiments were analysed for major, minor and trace elements by electron microprobe and laser-microprobe ICP-MS at the GEMOC Analytical Facility, Macquarie University, Australia. Crystal chemical structural data, including lattice parameters and structure refinements, were obtained using single-crystal X-ray diffractometry at the CNR-Institute of Geoscience and Georesources, Pavia, Italy. Water concentrations in the melts were estimated from mass balances between run products and starting materials.

Increasing pressure of formation was found to have a marked effect on both the compositions and structural properties of the clinopyroxenes crystallized from the hydrous melts. Augite crystals  $[\text{Ca}(\text{Mg,Fe})\text{Si}_2\text{O}_6]$  become more jadeite-rich ( $\text{NaAlSi}_2\text{O}_6$ ), but less calcic and Ti-rich as pressures of synthesis increase. These changes are accompanied by systematic decreases in cell volumes. Higher temperatures cause increases in both the clino-enstatite/clino-ferrosilite components  $[(\text{Mg,Fe})_2\text{Si}_2\text{O}_6]$  and the Ca-Tschermaks component ( $\text{CaAlAlSiO}_6$ ). Inclusion of these components also reduces cell volumes. Consistent with these changes, patterns of incompatible trace element incorporation also vary with concomitant reductions in the volumes of M1 and M2 sites.

We evaluated the effects of  $\text{H}_2\text{O}$  by applying the single-crystal clinopyroxene barometer of Nimis & Ulmer (Contrib. Mineral. Petrol., 133: 122-135, 1998) to our data. This barometer is distinctive in that it is based on the overall response of the crystal structure (principally cell volume) to pressure, rather than to specific compositional changes. It was also calibrated primarily for anhydrous melt compositions. When applied to our data, the Nimis & Ulmer (Contrib. Mineral. Petrol., 133: 122-135, 1998) barometer systematically underestimates pressures of synthesis, with the underestimation increasing at higher pressure. This is due to the comparatively large volumes of the crystals grown in our experiments. Thus at constant pressure, clinopyroxenes crystallized from  $\text{H}_2\text{O}$ -rich melts have larger unit cell volumes (being comparatively enriched in diopside and hedenbergite) than those crystallized from equivalent anhydrous systems. This may partially be the result of the differential effects of  $\text{H}_2\text{O}$  on the activity coefficients of pyroxene-forming melt components. But it also reflects the comparatively low temperatures of the hydrous experiments and the affect that this has on the activity coefficients of high and low volume components within the clinopyroxene crystal structure.