

Partitioning of water between high pressure phases in the system $\text{MgSiO}_3 + 0.5 \text{ wt.}\% \text{ H}_2\text{O}$

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Recent experimental studies indicate that a substantial amount of water can be dissolved as hydroxyl in most of the nominally anhydrous minerals of the Earth's mantle. Among these phases, magnesium silicate perovskite is believed to constitute about 80% by volume of the lower mantle. Consequently, the physical and chemical behaviour of this phase is of major importance when assessing the properties of the deep mantle. But still, its water content is very poorly known, although trace amounts of OH could greatly affect mantle properties such as melting, transport properties and rheology. The amount of water that can be recycled via subduction zones is also essential to understand the global cycle of water in the Earth. Therefore, we conducted water partitioning experiments in the system $\text{MgSiO}_3 + 0.5 \text{ wt.}\% \text{ H}_2\text{O} + \text{excess silica}$ using a multi-anvil apparatus.

Results

The samples were synthesised at temperatures between 1500 and 1750°C and pressures crossing over the MgSiO_3 -ilmenite to perovskite transition boundary. The recovered samples were investigated by Raman and infrared spectroscopy for phase characterization and analysis of the water content. The samples were found to consist only of MgSiO_3 -ilmenite and/or perovskite coexisting with stishovite and a quenched melt. No dense hydrous magnesium silicate was detected in the charges, probably due to the low water fugacity conditions of these experiments compared to previous studies. The melt quenched into a fine matrix of crystals which made both quantitative chemical analysis and water determination difficult. The FTIR absorption spectra were measured on optically clear crystals and the

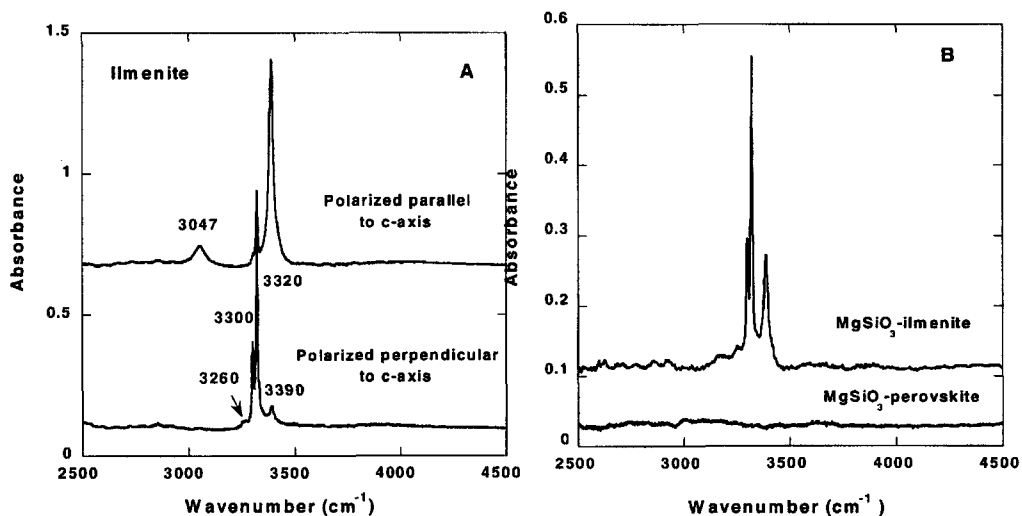


FIG. 1. (A) Polarized FTIR spectra of MgSiO_3 -ilmenite synthesized at 22 GPa and 1600°C. (B) Unpolarized FTIR spectra of MgSiO_3 -ilmenite and perovskite coexisting in a sample synthesized at 24 GPa and 1600 °C. Sample thickness is 50 and 40 μm respectively.

water contents were calculated using the calibration curve of Paterson (1982). As shown in Fig.1(A) the polarized spectra of ilmenite displays five pleochroic bands due to structurally bond hydrogen, three strong ones at 3390, 3320 and 3300 cm^{-1} and two weak at 3260 and 3047 cm^{-1} . The calculated water content for ilmenite is 1750 ppm by weight (4880 H atoms/ 10^6 Si atoms). The unpolarized spectra of stishovite shows the same bands as reported by Pawley *et al.* (1993) at 3313, 3240 and 3111 cm^{-1} . For stishovite coexisting with ilmenite the measured absorbance yields a water content of 35 ppm (55 H atoms/ 10^6 Si atoms). This yields a partition coefficient of water between ilmenite and stishovite of $D^{\text{ilm/stish}} = 50$. In a sample where ilmenite and perovskite coexisted, no water was detected in the perovskite phase while the ilmenite dissolved around 2000 ppm, as shown in

Fig. 1(B), indicating that $D^{\text{ilm/pv}} \gg 1$. Even at lower temperatures where the amount of melt is considerably reduced, MgSiO_3 perovskite is still found to be dry. This result implies that the end member perovskite is not a major host for water in the lower mantle. However, mantle magnesium silicate perovskite contains iron and aluminium as major elements and thus the solubility of water in perovskite has to be studied in more complex systems.

References

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