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An FTIR study of water on Mars inferred from nakhlites and shergottites

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Water content on Mars has traditionally been studied through bulk hydrogen measurements of melt inclusions and apatite crystals. However, these methods may not fully account for magma degassing or post-crystallization dehydration. A promising alternative, previously applied to the Nakhla meteorite, involves analysing pyroxene phenocrysts, which incorporate trace amounts of water during crystallisation via charge-balancing structural defects. Notably, pyroxenes retain these OH-associated defects even after dehydration, allowing for experimental rehydration and to estimate the magmatic water content. This approach enables correction for water loss during volcanic processes or upon ejection, and to provide an estimate of the water content in the parental melts and mantle sources.

In this study, hydrothermal rehydration experiments (2 kbar, 700°C), were conducted for the first time on both nakhlite and shergottite clinopyroxene phenocrysts. Nakhlite clinopyroxenes exhibited water contents of 140–185 ppm, comparable to previous values reported for Nakhla (130 ±26 ppm) [1] and within the range of phenocrysts from terrestrial basalts. In contrast, shergottite clinopyroxenes remained virtually anhydrous. Using clinopyroxene/melt partition coefficients, the parental melt for the nakhlites was calculated at 1.54 ± 0.36 wt. % to 1.79 ± 0.08 wt.%, slightly higher than previous estimates for Nakhla (1.44 ± 0.28 wt.%) [1]. Asuming a low degree of partial melting (~0.5%), the minimum water content of the nakhlite mantle source is estimated at 85 ± 8 ppm, comparable to Earth's MORB source (54–330 ppm ppm H_2O[1]).

For shergottite clinopyroxenes, the lack of detectable water by Fourier Transform Infrared Spectroscopy (FTIR) may indicate concentrations below the detection limit, or that hydrogen is stored in forms other than OH (e.g., H_2), which may not respond to hydrothermal rehydration. These results refine our understanding of Martian magmatic water content and suggest significant variability between nakhlite and shergottite reservoirs.

[1] Weis *et al* (2017) *Geochimica et Cosmochimica Acta* 212, 84–98