

Decrease of hydrogen incorporation in forsterite from CO₂-H₂O-rich kimberlitic liquid

**VIRGINIE BAPTISTE¹, SYLVIE DEMOUCHEY^{1,*}, SHANTANU KESHAV¹, FLEURICE PARAT¹,
NATHALIE BOLFAN-CASANOVA², PIERRE CONDAMINE² AND PATRICK CORDIER³**

¹Géosciences Montpellier, Université Montpellier & CNRS, CC 60, Place E. Bataillon, 34095 Montpellier cedex 5, France

²Laboratoire Magmas et Volcans, CNRS, 5, rue Kessler, 63000 Clermont-Ferrand, France

³Unité Matériaux et Transformation, Université Lille 1 & CNRS, UMR 8207, Villeneuve d'Ascq, France

ABSTRACT

To test if hydrogen incorporation by ionic diffusion can occur between a volatile-rich kimberlitic liquid and forsterite, results of high-pressure and high-temperature experiments using a piston-cylinder apparatus at 1200–1300 °C and 1 GPa for durations of 1 min, 5 h, and 23 h, are reported here. Kimberlitic liquid in the system CaO-MgO-Al₂O₃-SiO₂-CO₂-H₂O and synthetic forsterite single crystals were chosen as a first simplification of the complex natural kimberlite composition. Unpolarized Fourier transform infrared spectroscopy was used to quantify the concentrations of OH in the crystallographically oriented forsterite. Scanning electron microscopy, electron backscattered diffraction, electron microprobe analyses, and transmission electron microscopy were performed to identify the run products. After 5 and 23 h, a forsterite overgrowth crystallized with the same orientation as the initial forsterite single crystal. The kimberlitic liquid has crystallized as micrometer-scale euhedral forsterite neocrystals with random crystallographic orientations, as well as a nanoscale aluminous phase and a calcic phase. Despite theoretical water-saturation of the system and long duration, none of the initial forsterite single crystals display signs of hydration such as hydrogen diffusion profile from the border toward the center of the crystal. Most likely, the presence of CO₂ in the system has lowered the H₂O fugacity to such an extent that there is no significant hydration of the starting forsterite single crystal or its overgrowth. Also, the presence of CO₂ enhances rapid forsterite crystal growth. Forsterite growth rate is around $2 \times 10^8 \mu\text{m}^3/\text{h}$ at 1250 °C. These experimental results suggest a deep mantle origin of the high OH content found in natural mantle-derived xenoliths transported in kimberlites, as reported from the Kaapvaal craton. In agreement with previous studies, it also points out to the fact that significant hydration must take place in a CO₂-poor environment.

Keywords: Kimberlite, water, hydrogen, diffusion, olivine, point defect