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The pressures and temperatures of meteorite impact: Evidence from micro-Raman mapping of mineral phases in the strongly shocked Taiban ordinary chondrite

Tayro E. Acosta-Maeda,[1,2,*] Edward R.D. Scott,[2] Shiv K. Sharma,[2] and Anupam K. Misra[2]

[1]Department of Geology and Geophysics, University of Hawaii, Honolulu, Hawaii 96822, U.S.A.
[2]Hawaii Institute of Geophysics and Planetology, SOEST, University of Hawaii, Honolulu, Hawaii 96822, U.S.A.

Abstract

Taiban is a heavily shocked L6 chondrite showing opaque melt veins. Raman spectroscopy was used to characterize the high-pressure silicate assemblages in a thin section crossed by a shock-created 4 mm wide melt vein. Raman spectra using different excitation wavelengths allowed identification of mineral phases such as olivine, wadsleyite, ringwoodite, high-Ca clinopyroxene, majorite-pyrope, jadeite, maskelynite, and lingunite. Olivine is Fe depleted in contact with the ringwoodite, which suggests chemical fractionation during a solid-state olivine-ringwoodite transformation. Raman imaging revealed a close correlation between the blue ringwoodite color and the peak observed at 877 cm^{-1}; this signal shows strong near-resonance Raman enhancement when measured with near-IR excitation lines (785 and 830 nm) close to the optical absorption bands of the ringwoodite. We propose that the blue color of the ringwoodite is due to a small amount of iron in fourfold coordination inside the spinel structure, and that yields the observed spectral features in differently colored ringwoodite. Under the formation conditions of the studied silicate pocket, all enstatite transformed to a majorite-pyrope solid solution, whereas the high-Ca clinopyroxene likely remained unchanged. Maskelynite grains in the margins of the pocket often contain lingunite or are totally transformed to jadeite. Based on static high-pressure results, the mineral assemblages in the pocket suggest peak pressure in the 17–20 GPa range with maximum temperature (T_{max}) in the range 1850–1900 K as the formation conditions for this Taiban chondrite during shock.

Keywords: Micro-Raman, resonance Raman, ringwoodite, solid-state transformation, shock metamorphism