

NATURAL OCCURRENCE OF A NEW MINERAL WITH AN OLIVINE STRUCTURE AND PYROXENE COMPOSITION IN THE SHOCK-INDUCED MELT VEINS OF TENHAM L6 CHONDRITE

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Here we report a new mineral with an olivine structure and a pyroxene composition, which occurs in shock-induced melt veins of the Tenham L6 chondrite. This new phase was identified with transmission electron microscopy (TEM) using SAED and EDS. It occurs in clusters of acicular crystals in a glassy matrix within shock melt veins. The crystals have a distinctive curvature and aspect ratios up to 25, with width ranging from 5 nm to 20 nm and length up to 500 nm. EDS analyses provides relative cation abundances that are consistent with a pyroxene stoichiometry: $\text{Na}_{0.06}\text{Ca}_{0.02}\text{Mg}_{0.71}\text{Fe}_{0.20}\text{Al}_{0.11}\text{Si}_{0.94}\text{O}_3$. These compositions are similar to that of majorite garnet from the vein center and to that of the vitrified perovskite from the vein edge. Single-crystal and polycrystalline SAED patterns are consistent with the olivine structure and space group (*Pbnm*). The refined cell parameters for this orthorhombic structure are: $a = 4.782 \text{ \AA}$, $b = 10.119 \text{ \AA}$, and $c = 5.946 \text{ \AA}$. The new olivine-structured phase crystallized either at the rapidly quenched margins of large veins or within thin, $< 30 \mu\text{m}$ melt veins. Our hypothesis is that the extremely rapid quench in these samples led to significant under-cooling of the melt to temperatures below the metastable melting curve of olivine. This allowed the rapid crystallization of the new phase with high-entropy compositional features and unusual morphologies.

Our diffraction and EDS data pose a problem of how to accommodate a pyroxene-like composition in an olivine structure. If we write an olivine chemical formula based on an enstatite composition ($\text{Mg}_{1.33}\text{Si}_{0.33}\Delta_{0.33}\text{SiO}_4$), the olivine structure requires 0.33 formula units of Si^{4+} in octahedral sites and 0.33 formula units of octahedral vacancies (Δ). If we do the same with our EDS data from new phase ($\text{Na}_{0.06}\text{Ca}_{0.04}\text{Mg}_{1.01}\text{Fe}_{0.29}\text{Al}_{0.10}\text{Si}_{0.24}\Delta_{1.74}\Delta_{0.26}\text{Si}_{1.00}\text{O}_4$), the olivine structure requires about 0.25 formula units of Si^{4+} in octahedral M1 sites, about 0.25 formula units of vacant M sites (Δ), and 0.10 formula units of Na^+ and Ca^{2+} in M2 octahedral sites.

Our observations demonstrate that the olivine structure can accommodate a pyroxene-like composition with vacancies, Na^+ , Ca^{2+} and excess Si^{4+} in octahedral sites at high pressure and temperature. These defects may also be found in olivine from high pressure liquidus quench experiments. However, such quench products may not have been adequately characterized. If non-stoichiometry and excess silica occur in equilibrated olivines, one might expect them to also occur in hot regions of the deep upper mantle. We suggest that it would be useful to investigate the stability of this phase via *ab initio* calculations and high-pressure experiments.