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A new mineral with an olivine structure and pyroxene composition in the shock-induced melt veins of Tenham L6 chondrite

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Abstract

We report a new mineral that occurs in shock-induced melt veins of the Tenham L6 chondrite. The new mineral, identified by transmission electron microscopy (TEM), occurs as acicular nanocrystals in a glassy matrix at the edge of shock-induced melt veins that crystallized during rapid quench at high pressure. The elongate crystals have aspect ratios up to 25. Widths range from ~5 to ~40 nm and lengths are up to 500 nm. Energy-dispersive X-ray spectroscopy (EDS) analyses provide the relative cation abundances that are consistent with a pyroxene-like stoichiometry: $Na_{0.06}Ca_{0.02}Mg_{0.71}Fe_{0.20}Al_{0.11}Si_{0.94}O_3$. Selected area electron diffraction (SAED) patterns from single-crystal and polycrystalline aggregates indicate an olivine structure with refined cell parameters: a = 4.78, b = 10.11, and c = 5.94 Å and a calculated density of 3.32 g/cm^3. Synchrotron X-ray microdiffraction data are consistent with an olivine structure and provide similar cell parameters: a = 4.778, b = 10.267, c = 5.937 Å. The pyroxene composition represents a large deviation from olivine stoichiometry, $(Na_{0.08}Ca_{0.03}Mg_{0.95}Fe_{0.26}Al_{0.15}Si_{0.25}\square_{0.28})_2Si_1O_4$, with 0.28 formula units of vacancies (□), 0.11 of Na^+ plus Ca^{2+}, and 0.25 of Si^{4+}, in octahedral sites. Our observations indicate that a metastable and nonstoichiometric olivine structure can crystallize from a silicate melt during rapid quench. Trace amounts of such defects may be present in stable olivines in the deep upper mantle.

Keywords: Shock-induced, Tenham, olivine, melt vein