TISSINTITE, (Ca,Na,□)$AlSi_2O_6$: A SHOCK-INDUCED CLINOPYROXENE IN THE TISSINT METEORITE.

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Introduction: During a nanomineralogy investigation of the Tissint Martian meteorite, we discovered the new shock-induced mineral tissintite, (Ca,Na,□)$AlSi_2O_6$ [1,2], which is named after Tissint, Morocco, where the host meteorite fell. This phase provides new insights into shock conditions and impact processes on Mars. Here, we emphasize the origin of tissintite (IMA 2013-027) and demonstrate how nanomineralogy can play an important role in meteorite and Mars rock research.

Tissintite, $(Ca,Na,\square_{¼})AlSi_2O_6$, is an extraordinarily vacancy-rich high-pressure *C2/c* clinopyroxene (cpx; 21-30% of the M2 sites are vacant) with a composition very close to that of plagioclase (plag). The relationship between a plag and tissintite of the same composition can be described as $¾(Ca_xNa_{1-x})(Al_{1+x}Si_{3-x})O_{8(plag)} = (Ca_{3x/4}Na_{3(1-x)/4}\square_{1/4})(Al)(Al_{(3x-1)/4}Si_{3(3-x)/4})O_{6(cpx)}$. This relation holds for $1 \geq x \geq 1/3$. Tissinite can also be thought of as the Ca-analog of jadeite with ~¼ of the M2 sites being vacant. The phase exhibits considerable solid solution towards the Ca-Eskola pyroxene component, $(Ca_{0.5}\square_{0.5})AlSi_2O_6$, more than any other known synthetic or natural cpx. It occurs in maskelynite as inclusions within, or in contact with, shock melt pockets.

Origin and Significance: Tissintite and similarly vacancy-rich cpx have, to our knowledge, never been synthesized in static experiments, nor reported previously in nature. [3] argued that substantially higher than observed vacancy concentrations in cpx were achieved in ultra-high-pressure metamorphic rocks, but if so, they shed vacancies during decompression, perhaps through the commonly observed exsolution of silica. In general, the rarity of vacancy-rich cpx in high-pressure terrestrial rocks likely reflects the greater stability of various silica-bearing phase assemblages. In Tissint, tissintite was able to form as a metastable phase during a shock event that was just severe enough to allow nucleation and growth of cpx in plagioclase composition amorphous materials heated by adjacent shock melt pockets. Conditions were, however, not so severe that other more stable phases could nucleate and grow at the expense of or in place of tissintite. Diamond anvil experiments at 8-26 GPa on the amorphization of and crystallization in natural albite (An2) and labradorite (An58) [4] show that cpx nucleates and grows first but that continued heating leads to crystallization of stishovite, garnet, and $CaFe_2O_4$-structured $NaAlSiO_4$. Based on [4], the kinetics of nucleation and growth of tissintite are slower for more sodic plag, so tissintite is most likely to be found in depleted olivine phyric shergottites like Tissint that consistently contained plag with calcic rims where they came into contact with melt pockets or veins during shock.

References: [1] Ma C. et al. (2014) *LPSC* 45, A1222. [2] Ma C. et al. (2014) *8th Int. Conf. on Mars*, A1317. [3] Katayama I. et al. (2000) *Am. Min*. 85, 1368–74. [4] Kubo T. et al. (2010) *Nature Geosci*. 3, 41–4.