HOT SPOT PHASE RELATIONS IN THE TISSINT METEORITE

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Introduction: The martian meteorite, Tissint, is an olivine-phyric shergottite [1] exhibiting shock-induced features (shock veins and shock-melt pockets). Here we report on newly discovered shock-induced phase assemblages in Tissint's melt pockets.

Analytical Methods: A thin section of Tissint was examined by optical and electron microscopy. Mineral compositions were determined by energy dispersive X-ray spectrometry (EDX). Crystal structures were verified by Raman spectrometry and transmission electron microscopy on FIB slices.

Results: *Olivine-Ringwoodite-Magnetite*. Raman spectra of olivine clasts at the interface with melt reveal an intergrowth of olivine and granular ringwoodite with nano-particulate magnetite. In addition, Raman and EDX analyses of an olivine-like clast (with high contrast in BSE imagery) within the melt pocket reveal nano-magnetite embedded in an amorphous phase of (Mg-Fe) silicate with a bulk composition similar to ahrensite [2]. Collectively, their electron diffraction patterns indicate orthorhombic, cubic spinel and inverse cubic spinel ($Fd\bar{3}m$) structures of olivine (Ol), ringwoodite (Rwd) and magnetite, respectively.

CAS+Stishovite+Majorite. Raman and electron diffraction data from intergrowths at the crystal-melt interface comprise ~100 nm crystals of (Ca,Na) aluminosilicate [$(Ca_xNa_{1-x})Al_{3+x}Si_{3-x}O_{11}$] or CAS [3], 30x100 nm stishovite (Sti), and clusters of elongate crystals (~50 x 950 nm) of majorite-pyrope solid solution (Maj-Prp_{ss}). Untransformed solid clasts have the composition of labradorite-bytownite and augite, respectively. The diffraction pattern indexes the CAS as the Ba-hexaferrite structure, with an hexagonal unit cell and lattice parameters a = 5.40 Å, and c = 12.7 Å [4]. Maj-Prp_{ss} displays dendritic textures radiating into a glass matrix of pyroxene- or plagioclase-compositions. TEM results yield the tetragonal $I4_1/a$ space group consistent with majorite from the Catherwood and Coorara meteorites [5,6]

Discussion: The restriction of certain shock-induced polymorphs to melt pockets within Tissint suggests formation via hot-spot generation (i.e., focused shock). Quenching of the melt pocket under pressure generated new phases; whilst surviving solid fragments underwent solid-state transformations to HP-HT phases (e.g., Ol to Rwd). Transformations in the Ca-Al ferromagnesian silicate phases were probably due to dissolution reactions and precipitation at crystal-melt interfaces between solid clasts and the melt matrix. The assemblage CAS+Sti+Maj-Prp_{ss} and the formation of dendritic majorite indicate heterogeneous nucleation and diffusion-controlled growth, with mobilization of Mg, Fe, Ca and Al at the reaction zone. Based on results from HP-HT experiments [3,4], the precipitation of CAS+Sti+Maj-Prp_{ss} probably occurred at ~14-19 GPa and 1600-2000 ^{o}C.

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