IMPLICATIONS OF THE PRESENCE OF TRIDYMITE IN THE FUKANG PALLASITE. D. N. Della-Giustina[1, 2], D. S. Lauretta[1], D. H. Hill[1], M. Killgore[1], H. Yang[3] and R. T. Downs[3], [1]Lunar and Planetary Laboratory, Univ. of Arizona, Tucson, AZ 85721, USA. [2]Geophysical Institute, Univ. of Alaska, Fairbanks, AK 99775, USA. [3]The Department of Geosciences, Univ. of Arizona, Tucson, AZ 85721, USA. Email: dellagiu.gi.alaska.edu

Introduction: We report the results of a study of the main-group pallasite Fukang [1]. Fukang was recovered in 2001 in the Gobi Desert, China, with a main mass weight of 1003 kg. Like many main-group pallasites, Fukang consists of rounded to semi-angular olivine grains imbedded in an Fe-Ni matrix; accessory schreibersite is also present. Minor phases include troilite, euhedral chromites, rounded whitlockite, and low-Ca pyroxene.

Observations: Unusual incompatible-element rich silicate inclusions, several tens to hundreds of microns in length, are observed in some Fukang olivine grains (Fig. 1). All inclusions contain silica, K-rich orthoclase-normative glass. Accessory phases differ in each inclusion, but include Fe-metal, phosphates, sulfides, and chromite.

All inclusions are rimmed by an unusual Cr-rich silicate with a stoichiometry closely approximating $(Ca,Mg,Fe)_7(Cr,Al)_3(SiO_4)_6$. Ca zoning (up to 10.5 wt. %) is observed in portions of the Cr-silicate rims, sometimes enriched near the inclusion rim-olivine phase boundary. EPMA of this material show that it is homogenous with Si/O of ~0.25. However, its composition is not consistent with any known mineral. Structural analysis is needed to definitively identify this phase.

Raman spectra of the silica were collected from an un-oriented crystal at 100% power on a Thermo Almega microRaman system, using a solid-state laser with a frequency of 780 nm, and a thermoelectric cooled CCD detector (Fig. 2). The laser is partially polarized with 4 cm^{-1} resolution and a spot size of 1 μm. Raman spectroscopy identified the silica phase as monoclinic tridymite, which was confirmed by a comparison to the results of [2].

A nearly equidimensional crystal (0.05 x 0.05 x 0.04 mm) was dug out from one of the inclusions and mounted on a Bruker X8 APEX2 CCD X-ray diffractometer equipped with graphite-monochromatized MoKα radiation. All collected reflections were indexed using the Bruker program SAINT. XRD analysis determined cell dimensions to be a = 25.938(5), b = 5.0150(9), c = 18.547(3) Å, β = 117.680(9)°, and V = 2136(1) $Å^3$. These parameters agree well with those for monoclinic tridymite reported by [2].

Implications: Tridymite appears to have crystallized directly out of a liquid phase leaving behind the orthoclase-normative glass. The size of the tridymite crystals varies with each inclusion (up to 200 μm) and the crystal shape becomes rounded in larger inclusions. Tridymite is a relatively high-temperature, low-pressure phase. It forms from a melt at pressures less than 0.15 GPa and at temperatures of approximately 870 ºC to 1470 ºC [3]. These constraints help determine the conditions under which the Fukang pallasite formed. The presence of such a low-pressure phase in Fukang allows us to make an upper estimate of the size of the Main-group pallasite parent-body. It also implies that the Fukang parent-body did not undergo significant high pressure shock processing.

We estimate the upper limit on the size of the Main-group parent body using the pressure constraints provided by the presence of tridymite. To model the pressure experienced within a spherical planetismal, as a function radius, we assume hydrostatic equilibrium and integrate the following differential equation:

$$\frac{dP}{dr} = -\frac{\rho g}{r^2}\left(\frac{4}{3}\pi\rho r^3\right)$$

Additionally, we assume that the parent body formed from a chondritic protolith, and that pallasites formed at or near the parent-body core. The model results indicate that the Main-group pallasite parent body was no larger than ~600 km in diameter (Fig. 3). The minimum diameter needed for planetismal differentiation is ~40 km, depending on initial temperature [4].

The composition of olivine grains in Fukang is $\sim Fo_{86}$. The presence of tridymite crystals within an olivine grain is peculiar; silica and forsterite are mutually exclusive minerals that do not form in the presence of one another. According to the olivine (T-X) phase diagram, a solid solution of Fo_{86} forms from a melt at a temperature of ~1700 ºC, exceeding the temperature for which tridymite is stable. This constraint indicates that tridymite formed after the formation of olivine.

The formation of tridymite within an olivine grain may indicate that the Fukang pallasite experienced a reheating event. Reheating may have been caused by molten metal being injected into the olivine phase, or by an external process such as magnetic induction.

Another possibility is that the inclusions present in Fukang represent residual melts of K-rich feldspar, which experienced incongruent melting while entrained in an olivine grain. This may account for the presence of a K-rich orthoclase-normative glass adjacent to tridymite crystals in each inclusion.

References: [1] Lauretta D. S. et al. (2006) *LPS XXXVII*, Abstract #2250. [2] Hirose T. et al. (2005) *Journ. Miner. & Petrolog. Sci., 100,* 55-69. [3] Swamy V. et al. (1994) *JGR, 99*, 11787-11794 [4] Gosh A. et al. (2006) *in:* Meteorites and the Early Solar System II, U of AZ Press.

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Fig. 2 – Raman spectrum of tridymite in Fukang olivine inclusions (intensity vs. wavenumber)

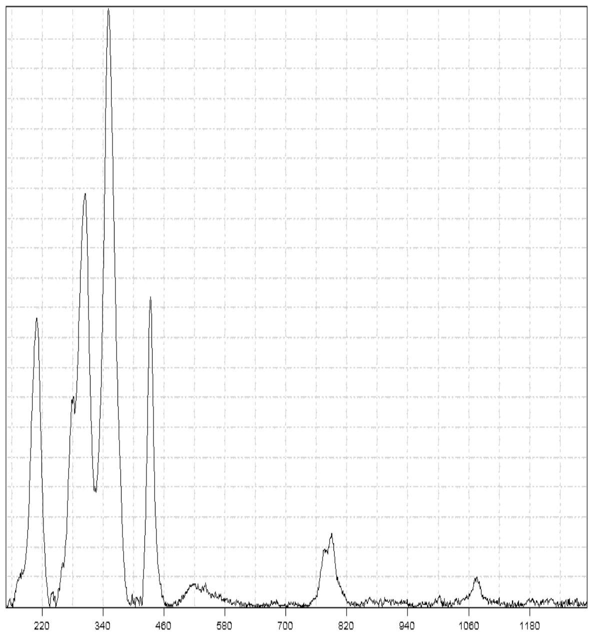

Fig. 3 – Model results illustrating the core pressure as a function of planetesimal radius.

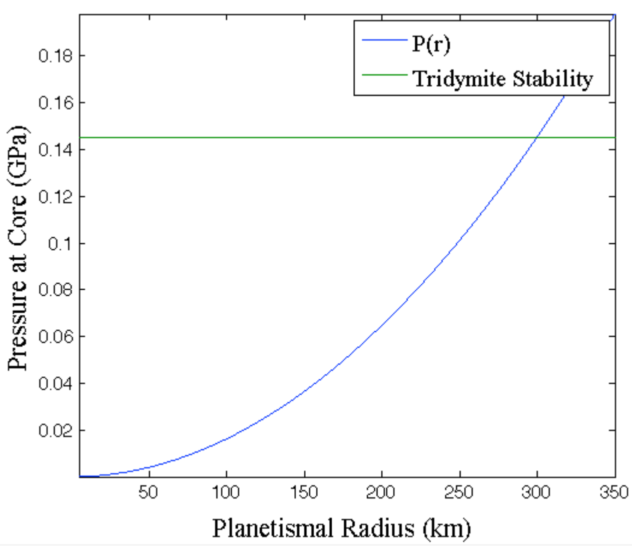

Fig. 1 – Backscattered electron images of inclusions in Fukang olivine