THE FUKANG PALLASITE: EVIDENCE FOR NON-EQUILIBRIUM SHOCK PROCESSING.

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Introduction: Pallasites are primarily composed of olivine and FeNi-metal. Most researchers agree that this mixture formed after differentiation but before solidification of the core of an asteroid. A variety of origins for pallasites have been put forward, including crystallization near the surface of an externally heated asteroid [1]; crystallization of an impact melt [2]; and nebular condensation [3]. However, the leading theory is that pallasites were generated at the core–mantle interface of a differentiated asteroid. Two mechanisms have been proposed. The first is an equilibrium process, where the intercumulate silicate melt between cumulate mantle olivine is replaced by molten metal [4-5]. The alternative scenario involves a nonequilibrium, impact-induced shock wave, which resulted in violent mixing of cumulate olivine crystals and molten metal. A combination of these two mechanisms has also been proposed [6]. Here we report the results of our initial investigation of the Fukang pallasite, an ~1000 kg mass recently recovered from the Gobi desert.

Techniques: Several polished slabs of Fukang were analyzed. In addition, we prepared several thin sections of olivine-rich areas. Elemental distributions were obtained via wavelength dispersive X-ray mapping using the Cameca SX-50 electron microprobe at U of A. Extensive quantitative analyses of all phases were obtained using appropriate standards.

A suite of major, minor, and trace elements were analyzed in ~100 mg splits of metal blocks and residual cutting dust. INAA was performed at the UA Nuclear Reactor Laboratory and Gamma-Ray Analysis Facility. Major, minor, and trace elements were analyzed using a Thermo Finnigan Element2 ICP-MS. A series of certified solution standards as well as the Canyon Diablo iron meteorite were used as standards.

Results: The most noteworthy observation of the macroscopic specimen is its enormous mass and the presence of large olivine "clusters" heterogeneously distributed throughout the entire specimen (Fig. 1). They range in size from <5 mm to several centimeters. Fukang contains several regions of "massive" olivine clusters up to 11 cm in diameter with thin metal veins only a few mm in width. Olivines vary in shape from rounded to angular. A subset of the olivine grains are highly fractured and exhibit a "cloudy" appearance. Other olivines are unfractured and clear. The degree of fracturing and optical clarity is unrelated to olivine composition (Fo = 86.4; Fe/Mn = 40.4). One notable difference is that the fractured olivine grains contain relatively large (>100 μm) inclusions of silica, Fe-metal, and an orthoclase-normative glass (Fig. 2). We did not observe zoning for Al, Cr, Ca, Mn, or Fe. Vermicular troilite and thin veins of kamacite and troilite occur in many olivines.

The groundmass is mostly kamacite with some occurrences of kamacite mantles surrounding taenite cores, rounded taenite adjacent to kamacite, and numerous regions of "comb plessite". In larger fingers of metal, the normal "M"shaped Ni distribution is disturbed and chaotic in the center. The trace-element abundances in bulk Fukang metal are given in Table 1.

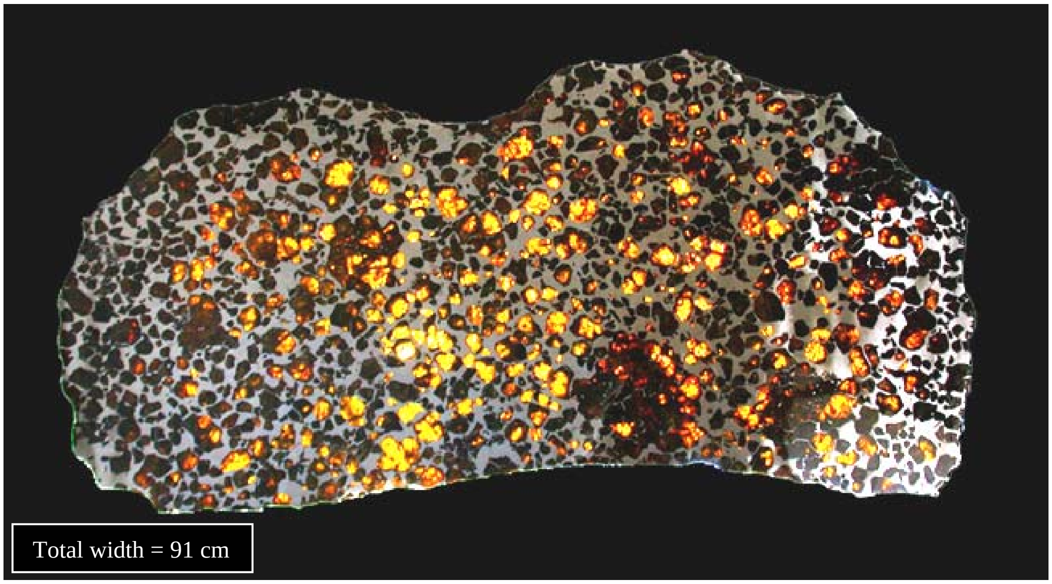
Schreibersite is enclosed by wide kamacite bands and also occurs as mantles adjacent to olivines. Two populations of schreibersite are present with Ni concentration = 26% and 35% near chromite. Zoning between these two end-members is observed in some schreibersite grains (Fig. 3-4).

Minor phases include euhedral chromites up to 0.5 cm across, rounded whitlockite adjacent to olivine, and troilite heterogeneously distributed as thin veins. Several regions ranging from <100 microns to several millimeters were observed adjacent to chromite that contain a complex mixture of olivine, low-Ca pyroxene, troilite, and whitlockite. An unusual feature is a large (~5mm) phosphate in a large olivine mass.

Conclusions: All analyses of this meteorite indicate an assignment with Main Group pallasites. Evidence of shock and annealing on a subset of the Fukang olivine grains is exhibited by the two texturally distinct populations. In addition, complex, symplectic intergrowth regions in the olivine are associated with thin kamacite veins. Fine-grained, multiphase sulfides connect kamacite with feeder veins. Fractured schreibersite occurs within kamacite veins along with phosphate and olivine fragments; as if entrained in the flow of the melt. Curved fractures occur in some olivines that were once filled with kamacite. There are jagged interfaces between schreibersite and chromite. Fractured olivines contain connecting kamacite; the large clusters observed have relatively thin (<50um) connecting kamacite veins that may indicate that shock forced the metal out and compacted the olivine

References: [1] Mittlefehldt (1980) Earth Planet. Sci. Lett. 51, 29-40 [2] Malvin et al. (1985) Meteoritics 20, 259-273 [3] Kurat (1988) Philos. Trans. R. Soc. Lond. A325, 459-482 [4] Buseck (1977) GCA 41, 711-740. [5] Wood (1978) LPSC XII, 1200-1202 [6] Scott and Taylor (1990) LPSC XXI, 1119-1120.

Fig. 1


Total width = 91 cm

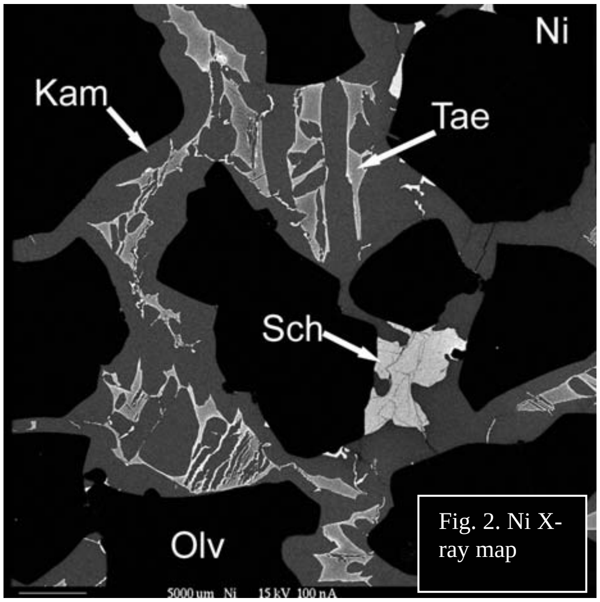


Fig. 2. Ni X-ray map

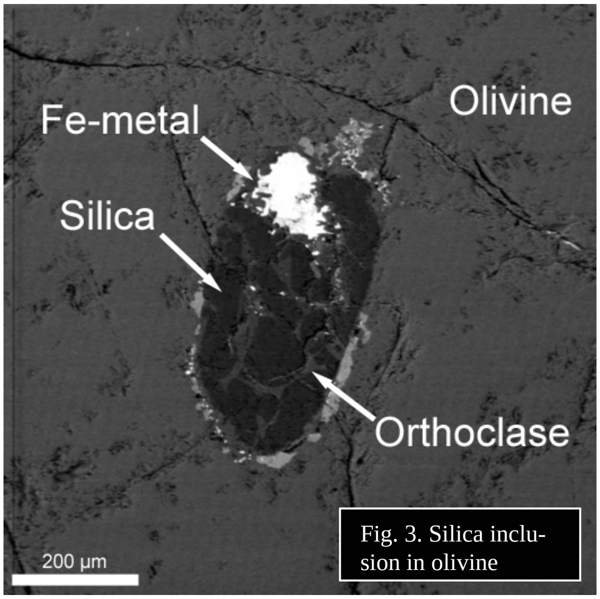


Fig. 3. Silica inclusion in olivine

Fig. 4. Ni zoning profile in schreibersite

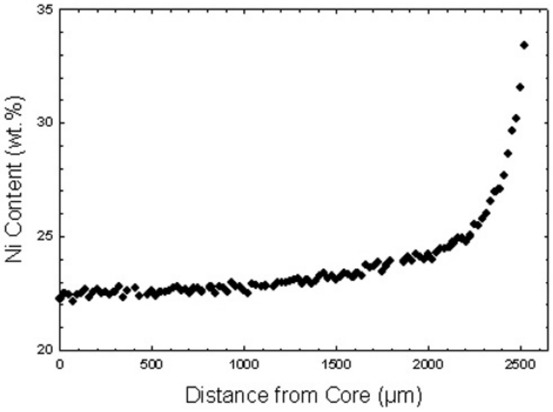


Table 1. Fukang Metal Bulk

	ICP-MS	INAA
Fe (wt%)	89.9	89.5
Ni (wt%)	9.0	10.0
P (wt%)	0.62	NA
Co (wt%)	0.51	0.52
Ge (μg/g)	41	<500
As (μg/g)	26	22.6
Ga (μg/g)	19.1	20.3
Pd (μg/g)	5.1	NA
Au (μg/g)	2.6	2.5
Ir (μg/g)	0.043	0.048

NA = not analyzed