ESQUEL: IMPLICATIONS FOR PALLASITE FORMATION PROCESSES BASED ON THE PETROGRAPHY OF A LARGE SLAB. Finn Ulff-Møller*, Jacquelyn Tran*, Byeon-Gak Choi*, Robert Haag†, Alan E. Rubin*, and John T. Wasson*, *Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095-1567, USA; †Tucson, AZ 85726, USA.

Although there is a consensus that pallasites are fragments of the core-mantle boundary of a differentiated asteroid, important questions regarding pallasite formation remain, including the key issue of how the mantle olivine and core metal were mixed (violent injection of metallic liquid into crushed olivine vs. quiescent incomplete separation of coexisting materials). We consider the angular olivine and the wide range of Ir contents in main-group pallasites (PMG) to require metal injection, and have focused our study on better understanding this model. Outstanding questions include the abundance and distribution of trapped liquid, whether liquid flow directions can be discerned, if there was more than one metal/silicate mixing/crushing event, whether the sizes and modal abundances of phases are homogeneously distributed, and the origin of the chromite that is ubiquitous in PMG.

These questions are best addressed by the examination of large pallasite slabs. The largest slab available is that of Esquel (belonging to Haag); the slab is ~90×36 cm (surface area ~2900 cm^2). Olivine is volumetrically the most abundant phase; angular grains range from submillimeter size to 2.5 cm. Approximately 25 vol.% of the olivine occurs in compact subrounded to subangular masses ranging from 3×7 cm to 10×17 cm. The large olivine masses are transected by thin veins of metallic Fe-Ni; these veins presumably formed by the high-pressure injection of low-viscosity metal, probably during an impact event. The large olivine masses are probably fragments of much larger (>>1 m) blocks from the mantle. It seems likely that most of the small olivine fragments were also produced during the original crushing event, but we cannot rule out a role by subsequent events. There are relatively few olivine grains having sizes <1 mm and these tend to occur together in patches; these may record late events because the fine particles produced during the initial crushing event may have been consumed during (very limited) recrystallization. There is no clear-cut evidence of flow of the metallic liquid based on the orientations of the individual olivine grains.

Modal analysis of the Esquel slab was carried out in two stages: metal and olivine abundances were determined using a coarse (1 cm × 1 cm) grid (2874 points); schreibersite, chromite and troilite abundances were determined using a finer (2 mm × 2 mm) grid (74600 points; 1134 hits on minor phases). The listed errors are 1σ counting errors. The combined data indicate that Esquel consists of (in vol.%): 66.0±1.5% olivine, 31.8±1.1% metallic Fe-Ni, 0.76±0.03% schreibersite, 0.46±0.02% troilite and 0.31±0.02% chromite. Schreibersite and most troilite occur at the interface between olivine and metallic Fe-Ni; some troilite is also present as ~200-μm-wide veins within the compact masses of olivine. Chromite is more heterogeneously distributed: 16% occurs within olivine, 7% is surrounded by metallic Fe-Ni, and 77% is adjacent to both olivine and metallic Fe-Ni. It seems likely that the chromite in Esquel was derived from both the mantle and the core.

A small (3×4 cm) triangular region of the slab is particularly rich in minor phases and appears to be a pocket of residual liquid. It consists (in vol.%) of 63% olivine, 21% metallic Fe-Ni, 9% troilite, and 7% schreibersite; no chromite was observed. Although some olivine grains are as large as 5 mm, many are in the range 50-100 µm. Most of the small olivine grains in this region are partially to completely surrounded by troilite and/or schreibersite. One possibility is that these tiny grains became embedded in FeS which prevented them from dissolving and reprecipitating on the surface of large olivine grains. In metallic regions the Si and Mg could have diffused along grain boundaries during the growth of the Widmanstätten structure. Alternatively, these grains and others surrounded by metal may reflect a late, minor impact event.

New chemical data on Esquel metal (Table 1) indicate that it is a typical member of the main-group pallasites. Its Ir content is among the lowest values known. The composition is consistent with the metal having originated by the rapid crystallization of late-stage IIIAB liquid, with at most a minor component having originated as previously crystallized metal. The similarity of the PMG to IIIAB in metal composition is consistent with the similarities between main-group pallasites and IIIAB irons in O-isotopic composition and suggests that both groups were derived from the same asteroid.

The low abundance of troilite in the Esquel slab is inconsistent with an origin for this meteorite as a late-stage liquid. We suggest that, as the metallic Fe-Ni in Esquel was crystallizing, the residual sulfide-rich liquid drained back into the core.

Table 1. Replicate analyses of the metal portion of Esquel determined by instrumental neutron activation. Concentrations in µg/g except Co and Ni, mg/g.

	Cr	Co	Ni*	Cu	Ga*	Ge*	As	W	Ir	Pt	Au
Esquel	648	4.94	103.1	131	22.3		16.8	0.16	0.025	1.5	2.13
Esquel	14	5.45	86.5	107	23.5		19.6	0.39	0.020	1.1	1.98
Esquel mean	**331**	**5.20**	**90±5**	**119**	**22.4**	**55.5**	**18.2**	**0.28**	**0.022**	**1.3**	**2.05**

*mean Ge completely and Ga partly based on RNAA data; Ni partly based on atomic absorption data.