EXPERIMENTAL PARTIAL MELTING OF THE L6 ORDINARY CHONDRITE, LEEDEY. S. N. Feldstein, R. H. Jones and J. J.Papike, Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131, USA. rsosis@unm.edu

Introduction: The melting behavior of chondrites is critical to our understanding of planetary evolution both for the earth and asteroidal processes. Partial melting experiments on ordinary chondrites are extremely limited [1,2,3]. Furthermore, partial melting experiments regardless of starting composition commonly employ powders of either crushed samples or analogue compositions that permit the definition of equilibrium melt compositions but say little about the melting process itself. The experiments described here differ from most others by using bulk meteorite samples. We are therefore able to investigate the melting process itself in addition to determining equilibrium melt compositions at experimental conditions appropriate for the low pressure reducing environment found in asteroids.

Starting Material: A series of partial melting experiments have been conducted at an oxygen fugacity of IW-1 and at atmospheric pressure on the ordinary chondrite Leedey. Leedey was chosen as the starting material because it is a fall, thereby minimizing terrestrial weathering, and because, as an L6 [4] with low degrees of shock metamorphism (S3; [5]), mineral phases are homogeneous. However, some textural heterogeneity and remnant chondrule textures persist. Average mineral compositions are given in Table 1.

Method: Partial melting experiments were carried out at one bar in a Deltech vertical quenching furnace with an Eurotherm temperature controller. Oxygen fugacity was controlled by H_2/CO_2 gas mixing. Experiments were conducted in Pt baskets which were presaturated in Fe, Ni and Co by running a small piece of Canyon Diablo meteorite in the sample basket for at least 3 days. The iron meteorite was removed from the basket and a 0.4-0.8 gram sample of Leedey was then placed in it.The large sample size was necessitated by the large remnant chondrules present in Leedey, up to 5 mm [this study and 6]. Experimental run durations were varied in order to document the evolution toward equilibrium. Mineral compositions and modal abundances were obtained on a JEOL 733 electron microprobe, the latter using Oxford Instrument's Feature Scan software. Calculated bulk rock major element abundances for Leedey, (Table 2) based on modal abundances and mineral compositions obtained on the microprobe, are similar to those obtained by wet chemistry on bulk samples [5,7,8], although there is significant range in values for Fe° and FeS (±2%) within this literature. This method was also used to calculate a mass balance for each experimental run.

Results: We are reporting the results of a preliminary experiment at 1200 °C with a run duration of 305 hours. This experiment produced 8.2 % melting, considerably less than that obtained in partial melting experiments on CV, CM, LL and H chondrites utilizing powders run at the same temperature [~ 20%; 3,9]. Remnant chondrules are no longer apparent. Melt pockets are up to 100 µm long and 50 µm wide, thereby permitting analysis by both electron microprobe and SIMS. Olivine grains are embayed and corroded, and small olivine remnants are often found jacketed by low Ca-pyroxene. Modal abundances for olivine and low-Ca pyroxene are 37% and 40%, respectively. Feldspar, clinopyroxene, apatite and whitlockite are completely melted, whereas chromite is residual at a more educed fraction than in Leedey (0.5 vs 1.6 wt%, respectively). Troilite melt globules are only rarely observed, indicating pervasive S loss by volatilization as in other partial melting experiments on chondrites [3,9]. Texturally, the metal forms well dispersed though isolated globules and agglomerates, with some coarsening along the edges of the charge.

A calculated bulk composition for the sample charge (Table 2) indicates that nearly all of the Na_2O as well as the S has volatilized; P_2O_5 has also been lost. There is an apparent net gain in iron as Fe°, ~ 20% relative to the amount present in Leedey. This is probably not the result of iron gain by the sample from the presaturated Pt wire, which would result in the stabilization of olivine over pyroxene (the opposite of which is found). Instead, sample heterogeneity in Leedey in terms of Fe° (wt% 6.48-8.37 [5,7,8]; 5.00% value obtained here) and FeS (wt% 5.59-7.60 [5,7,8]; 7.87% value obtained here) is probably responsible for this discrepancy. In fact, the sample may have lost a small amount of Fe to the Pt wire but the extent of Fe loss is difficult to assess. Further experiments are needed in order to fully document this.

Individual melt pockets are homogeneous, as indicated by x-ray mapping and electron microprobe transects, and they are free of quench crystals. Melt compositions are similar regardless of the mineralogy adjacent to each individual melt pocket (within the plane of the thin section), suggesting that melt pockets have formed a connected network throughout the sample. Mixing calculations indicate that melt compositions are consistent (for most major elements) with melting of feldspar, clinopyroxene and apatite in the proportions of Leedey (67%, 26% and 7%, respectively) as well as olivine, with precipitation of low-Ca pyroxene; principal exceptions are Na, K and P. The Mg/Fe exchange coefficient between rims of olivine and adjacent melt are 0.32-0.37, and that between rims of pyroxene and adjacent melt are 0.29-0.34, indicating that a local equilibrium between these phases has been reached [3,9,10,11,12]. Typical values for one melt pocket are given in Table 3. However, olivine grains remain zoned, with cores retaining the Leedey composition. Low-Ca pyroxene grains are also zoned but

with cores distinctly different from that found in Leedey, indicating recrystallization from the melt. Metal compositions vary between the droplets and are intermediate between the kamacite and taenite compositions of Leedey. Thus, in contrast to the silicate melt, metal melt pockets have remained in textural and compositional isolation. The average melt composition in this experiment has a similar CaO/Al_2O_3 ratio (0.66 versus 0.65) with a slightly lower SiO_2/MgO ratio (6.68 versus 6.94) to an equilibrium partial melt of an LL chondrite run at the same temperature and oxygen fugacity [3]. In addition to compositional differences due to chondrite type, this may reflect the lower percent partial melting achieved here in comparison with experiments with powdered starting materials.

Acknowledgements: This research was supported by NASA Grant NAGW-3347 and the Institute of Meteoritics.

References: [1] Kushiro and Mysen 1979 *Mem. Natl. Inst. Polar Res.* **15**165-170; [2] Takahashi 1983 *Mem. Natl. Inst. Polar Res.* **30**: 168-180; [3] Jurewicz et al. 1995 *Geochim Cosmochim Acta* **59**: 391-408; [4] Van Schmus and Wood 1967 *Geochim Cosmochim Acta* **31**: 747-765; [5] McCoy et. al. 1996 *Meteoritics*, in press; [6] Kallemeyn et al. 1989 *Geochim Cosmochim Acta* **53**: 2747-2767; [7] Konig 1964 *Geochim Cosmochim Acta* **28**: 1697-1703; [8] Jarosewich 1967 *Geochim Cosmochim Acta* **31**: 1103-1106; [9] Jurewicz et al. 1993 *Geochim Cosmochim Acta* **57**: 2123-2139; [10] Stolper 1977 *Geochim Cosmochim Acta* **41**: 587-611; [11] Kushiro and Mysen *1979 Mem Natl Inst Polar Res* **Spec. Issue 15**: 165-170; [12] E. Takahashi 1978 *Geochim Cosmochim Acta***42**: 1829-1844.

Table 1 Mineral Compositions in Leedey

olivine	$Fa_{25.4}$
low-Ca pyroxene	$Wo_{1.3}\ Fs_{21.2}En_{77.5}$
clinopyroxene	$Wo_{44.9}Fs_{8.0}En_{47.1}$
feldspar	$Ab_{83.7}An_{10.6}Or_{5.7}$
troilite	$Fe_{61.9}S_{37.0}$
taenite	$Fe_{67.9}Ni_{31.1}Co_{0.42}$
kamacite	$Fe_{92.3}Ni_{6.0}Co_{0.84}$
chromite	$Fe_{0.90}Mg_{0.05}Al_{0.03}Ti_{0.02}Cr_{0.22}O_4$
apatite	$Ca_{4.76}Fe_{0.02}Mn_{0.01}(P_{0.96}O_4)_3$ $F_{0.10}Cl_{0.84}$
whitlockite	$Ca_{3.89}Mg_{0.39}Fe_{0.04}Mn_{0.01}(P_{1.00}O_4)_3$

Table 2 Calculated Bulk Rock Compositions

	Leedey	Run01a
SiO_2	39.59	40.75
TiO_2	0.11	0.09
Al_2O_3	2.13	1.76
Cr_2O_3	1.02	0.60
MgO	25.35	26.47
FeO	14.55	14.09
CaO	1.67	1.44
MnO	0.31	0.32
ZnO	0.01	0.00
Na_2O	0.92	0.06
K_2O	0.09	0.03
P_2O_5	0.44	0.01
Co	0.05	0.08
Fe°	5.00	11.52
Ni	0.59	1.53
FeS	7.87	0.29
	99.70	99.07

Table 3 Compositions for one melt pocket

	melt	olivine	pyroxene
SiO_2	52.48	39.19	55.34
TiO_2	0.50	n.a.	0.12
Al_2O_3	15.93	0.05	2.38
Cr_2O_3	0.21	0.22	0.53
MgO	7.86	42.19	28.91
FeO	10.24	17.59	11.03
CaO	10.21	0.24	1.58
MnO	0.61	0.41	0.39
Na_2O	0.62	n.a.	0.03
K_2O	0.38	n.a.	n.a.
P_2O_5	0.09	n.a.	n.a.
Cl	0.01	n.a.	n.a.
total	99.13	99.88	100.32
		$Fo_{0.810}$	$Wo_{0.031}$ $En_{0.798}$