MINERALOGY AND PETROGRAPHY OF THE AMPHIBOLE-BEARING R-CHONDRITE LAP 04840.
M. C. McCanta[1,2], A. H. Treiman[2], C. M. O'D. Alexander[3] and M. D. Dyar[4]. [1]Pomona College, Geology Department, 185 E. Sixth St, Claremont, CA 91711 (molly.mccanta@pomona.edu). [2]Lunar and Planetary Institute, Houston, TX 77058. [3]DTM, Carnegie Institution of Washington, Washington D.C. [4]Dept. of Astronomy, Mount Holyoke College, South Hadley, MA 01075.

Introduction: The LaPaz Ice Field 04840 (LAP 04840) meteorite is an R chondrite of petrographic grade 6 [1]. It is unique among meteorites in containing abundant amphibole, and has the second meteoritic occurrence of biotite. LAP 04840 contains chondrules, chondrule fragments, and mineral grains in a finely crystalline matrix. Chondrules are up to ~3 mm diameter, and include barred olivine, porphyritic olivine, and porphyritic pyroxene varieties. Many are surrounded by rims of finely crystalline material (~20 µm grain size), which lack larger mineral grains. The matrix material among the chondrules and fragments is composed of anhedral grains, also ~20 µm diameter, in a granulitic, metamorphic texture. Section 04840,30 shows no signs of deformation or shock after this metamorphism.

LAP 04840 is similar to other R-chondrite meteorites in several ways. Most obvious is its high oxidation state (see [2]). LAP 04840 contains no metal phase and Ni-bearing olivine, both indicative of relatively high oxidation conditions. Additionally, like other R-chondrites LAP 04840 also has a low chondrule/matrix ratio [3-7]. Finally, the major phenocryst compositions (i.e., olivine, pyroxene, plagioclase) and the oxygen isotopes are similar to other R-chondrites [1,3-6]. However LAP 04840 contains only one pyroxene, orthopyroxene, unlike the two pyroxenes found in other members of the R-chondrite class.

Methods: LAP 04840 was studied by optical petrography and BSE imagery. Mineral chemical compositions and maps are by electron microprobe (SX-100 at JSC), using natural mineral standards. SIMS analyses are described in [8].

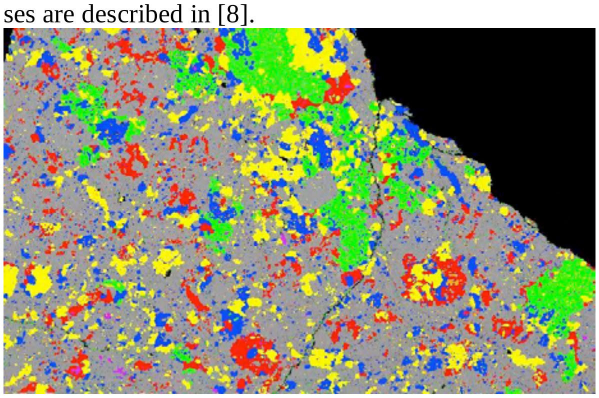

Figure 1. EMP element map portion of section of LAP 04840,30. Grey=olivine; green=orthopyroxene; red=plagioclase; yellow=amphibole; blue=opaques; orange=Ca-phosphate; purple=biotite.

Mineralogy: The modal abundance of mineral phases in LAP 04840 is: olivine 58%, orthopyroxene 13.2%, amphibole 11.6%, plagioclase 7.3%, opaques 5.4%, Ca-phosphate, and biotite 0.1% (Figure 1). Detailed analysis of the phases follows.

Olivine. The olivine in LAP 04840 is found both as isolated grains and in chondrules. It is compositionally homogeneous among different chondrules and between chondrules and isolated grains. Its composition is $Fo_{61}Fa_{39}$ (Table 1).

Pyroxene. Only one pyroxene, orthopyroxene, has been found in LAP 04840 (Table 1). It is compositionally homogeneous throughout the meteorite ($Wo_{01}En_{68}Fs_{31}$).

Plagioclase. The plagioclase grains in LAP 04840 are true feldspars with little evidence of shock deformation. They exhibit birefringence and twinning and are albitic in composition ($An_8Ab_{88}Or_4$) (Table 1).

Amphibole. The amphiboles in LAP 04840 are tan to brown in color, exhibit 120° cleavage, and are strongly pleochroic (Figure 2). The grains, which are fairly homogeneous in composition throughout the sample, are classified as magnesiohornblendes $[(Na_{0.38}K_{0.05})(Ca_{1.54}Na_{0.46})(Cr_{0.09}Ti_{0.05}Mg_{3.52}Fe_{1.32}Mn_{0.02})(Si_{6.86}Al_{1.10}Fe_{0.04})O_{22}(F_{0.01}Cl_{0.01}OH_{1.98})]$ (Table 1). SIMS analyses of the amphiboles show that they are hydrous with average volatile contents of 2.0 wt.% H_2O, 250 ppm F, and 400 ppm Cl. FTIR analysis indicates a second phase is present in the amphibole. A comparison of FTIR peak positions suggests this phase is a serpentine, potentially lizardite. Further TEM study is needed to confirm the presence of this phase.

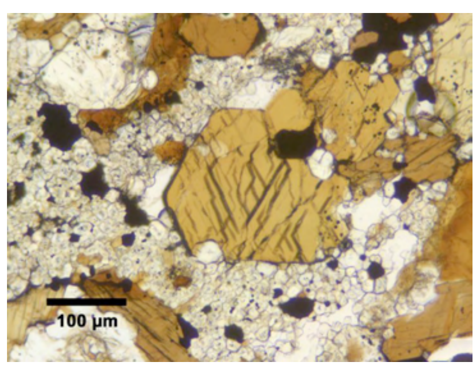

Figure 2. Photomicrograph of amphibole grain in LAP04840.

Biotite. The biotite in LAP is ferri-phlogopite $[(K_{0.72}Na_{0.23})(Fe_{0.74}Mg_{2.06}Al_{0.09}Cr_{0.05}Ti_{0.06})(Al_{1.11}Si_{2.89})O_{10}(OH_{1.97}Cl_{0.01}F_{0.02})]$. The average biotite volatile content as determined by SIMS is 4.25 wt.% H_2O, 400 ppm F, 800 ppm Cl.

Opaques. Opaque minerals are found throughout this meteorite and consist of Cr-rich magnetite ($Mt_{63}Chr_{28}Sp_{05}Usp_{04}$) (Table 1)and two Fe-Ni sulfides, commonly intermingled (Figure 3). The Fe-Ni sulfides are pyrrhotite $(Fe_{0.87}Ni_{0.13})S$ and pentlandite $(Fe_{4.26}Ni_{4.74})S_8$. The high Ni content of the pyrrhotite may be due to small pentlandite inclusions. Inclusions of Ca-phosphate in the magnetite are common.

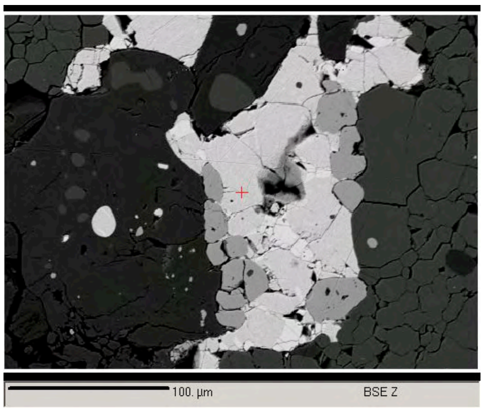

Figure 3. The center region in this BSE image shows the different intermingled opaque minerals in LAP 04840. Brightest is pentlandite, next is pyrrhotite, the grey region is magnetite, and the black and dark grey minerals are silicates.

Groundmass. The groundmass is composed of anhedral grains of olivine, 10-30 µm in diameter, which are compositionally identical to the olivines found in the chondrules and as isolated grains. The granulitic nature of the groundmass suggests an approach to textural equilibrium as evidenced in the 120° triple junctions seen in Figure 4.

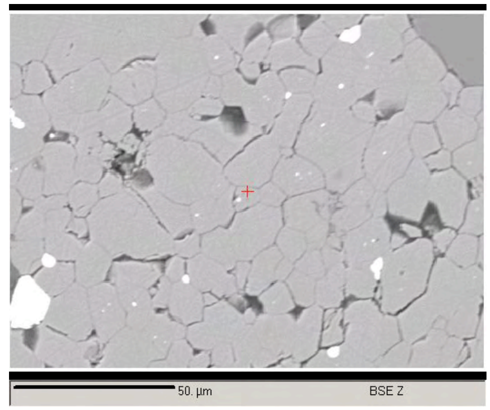

Figure 4. BSE image of LAP 04840 groundmass. Mineral grains are olivine (grey) and sulfide (white).

Petrography: The presence of amphibole and biotite in LAP 04840 makes it unique among R-chondrites. These hydrous phases appear to represent growth during a metamorphic episode whose conditions can be constrained via standard metamorphic facies analysis [8]. The amphibole is distributed throughout the chondrule interiors and the groundmass. The lack of clinopyroxene in LAP 04840 as opposed to the other R-chondrites may suggest that during metamorphism, amphibole formed at the expense of clinopyroxene.

References: [1] Satterwhite C. and Righter K. (2006) *Antarctic Meteorite Newsletter*. [2] Dyar M. et al. (2007) *This volume*. [3] Kallemeyn G., Rubin A., and Wasson (1996) *GCA., 60,* 2243-2256. [4] Schulze H. et al. (1994) *Meteoritics, 29,* 275-286. [5] Bischoff A. et al. (1994) *Meteoritics, 29,* 264-274. [6] Rubin A. and Kallemeyn G. (1994) *Meteoritics, 29,* 255-264. [7] Bischoff A. (2000) *Met.Planet.Sci., 35,* 699-706. [8] Treiman A. et al. (2007) *This volume*.

Table 1.

	Olivine		Pyroxene		Plagioclase		Amphibole		Biotite		Magnetite	
SiO_2	36.02	(0.14)	53.96	(0.29)	65.94	(0.16)	47.61	(0.89)	39.23	(0.39)	0.05	(0.04)
TiO_2	0.02	(0.02)	0.02	(0.02)	ND		0.47	(0.09)	0.95	(0.10)	1.26	(0.06)
Al_2O_3	0.02	(0.02)	0.14	(0.02)	20.83	(0.15)	6.46	(0.46)	13.83	(0.19)	2.28	(0.05)
Cr_2O_3	0.02	(0.02)	0.05	(0.02)	ND		0.75	(0.11)	0.85	(0.01)	19.07	(0.33)
FeO^a	32.98	(0.30)	19.40	(0.20)	0.62	(0.05)	11.09	(0.32)	11.96	(0.07)	70.19	(0.73)
NiO	0.36	(0.03)	0.13	(0.02)	ND		ND		0.42	(0.05)	0.33	(0.08)
MnO	0.43	(0.03)	0.42	(0.02)	ND		0.13	(0.02)	0.06	(0.02)	0.25	(0.03)
MgO	29.56	(0.17)	24.72	(0.08)	ND		16.55	(0.39)	18.53	(0.48)	1.62	(0.06)
CaO	0.04	(0.02)	0.48	(0.04)	1.56	(0.05)	9.95	(0.12)	0.03	(0.01)	0.27	(0.39)
Na_2O	0.01	(0.01)	0.02	(0.01)	8.69	(0.03)	3.03	(0.14)	1.45	(0.09)	ND	
K_2O	ND^b		ND		0.41	(0.01)	0.25	(0.02)	7.53	(0.18)	ND	
F	NM^c		NM		NM		0.03		0.04		NM	
Cl	NM		NM		NM		0.04		0.08		NM	
H_2O	NM		NM		NM		2.00		4.25		NM	
	99.45		99.33		98.05		98.37		99.20		95.31	

Major element totals are recorded as oxide weight percent. Numbers in parentheses indicate the standard deviation among sample analyses.

[a]All Fe as FeO; [b]Not detected; [c]Not measured