

**LAP 04840: AN AMPHIBOLE-BEARING R-CHONDRITE.**

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**Introduction:** The LaPaz Ice Field 04840 (LAP04840) 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. If the amphibole is hydrous (as it appears), LAP 04840 must come from deep within a water-rich chondritic asteroid.

**Texture:** LAP 04840 contains chondrules, chondrule fragments, and mineral grains in a finely crystalline matrix. Chondrules are up to ~3 mm diam., and include barred olivine, porphyritic olivine, and porphyritic pyroxene varieties. Many are surrounded by rims of finely crystalline material (~20  $\mu\text{m}$  grain size), which lack larger mineral grains. Matrix among the chondrules and fragments is composed of anhedral grains, also ~20  $\mu\text{m}$  diameter, in a granulitic, metamorphic texture. Section ,30 shows no signs of deformation or shock after this metamorphism.

**Mineralogy:** The larger mineral grains (> 50 $\mu\text{m}$ ) in LAP 04840 are olivine, orthopyroxene, plagioclase, amphibole, Cr-magnetite, and sulfides. Olivine occurs in chondrules and as isolated grains. It is compositionally homogeneous ( $\text{Fo}_{61}\text{Fa}_{39}$ ) throughout the meteorite – the same in all analyzed chondrules and mineral grains. The only pyroxene identified is orthopyroxene, which contains abundant inclusions of opaques and other minerals. It has the same composition ( $\text{Wo}_{01}\text{En}_{68}\text{Fs}_{31}$ ), throughout the meteorite. Amphibole is abundant, ~ 15%; it is pleochroic in foxy brown colors, and shows strong cleavage at 120° angles. It is magnesiohornblende [1,2], of nearly constant composition throughout. The amphibole contains little F or Cl, suggesting it is either hydrous or oxy-amphibole. Much of its iron is  $\text{Fe}^{3+}$  (by normalization). LAP contains no metal. Cr-magnetite is scattered throughout the meteorite, but the largest grains occur with the sulfide phases (pyrrhotite and pentlandite) [1]. It is commonly associated with Cl-bearing apatite. Mg-rich biotite (phlogopite), with little F or Cl, occurs rarely with amphibole, Cr-magnetite, and sulfides.

**Metamorphism:** The amphibole in LAP04840 is metamorphic, occurring as anhedral and euhedral scattered through the rock and as replacements of material (glass?) among olivines and pyroxenes in chondrules. By analogy with terrestrial metamorphics, the LAP mineral assemblage (ol-opx-amph) and mineral compositions (e.g., Al in amphibole) suggest upper amphibolite facies conditions: ~600°C < T < 800°C, and  $P(\text{H}_2\text{O}) > 1$  kbar [3,4]. With this temperature range, olivine-orthopyroxene-spinel equilibria yield  $f_{\text{O}_2}$  of QFM+0.6( $\pm 0.5$ ) log units, consistent with the high oxidation states of R chondrites and the absence of Fe metal. Pressure of metamorphism is poorly constrained at present. However, water-pressure must be high to stabilize this Ti-poor hornblende. For LAP 04840, one must infer that it was metamorphosed deep in a chondritic asteroid, under water-rich conditions.

**References:** [1] Satterwhite C. and Righter K. (2006) *Antarctic Meteorite Newsletter*. [2] Leake et al. (1997) *Am. Min.* **82**, 1019-1037. [3] Robinson P. et al. (1982) *Reviews in Mineralogy*, Volume 9B. [4] Spear F. (1993) *Metamorphic Phase Equilibria*. Min. Soc. Amer.