

GIANT SPINEL IN LL6 CHONDRITE MILLER RANGE (MIL) 07065.

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Introduction: The LL6 chondrite Miller Range (MIL) 07065 was classified and described in the Fall 2010 Antarctic Meteorite Newsletter [1]. At first glance, it is an unremarkable LL6 chondrite, however, it contains a remarkable chondrule (Figure 1). Within this chondrule, we found a large (1 mm x 500 μ m) spinel grain, reddish-colored in plane polarized light. The grain itself exhibits distinct skeletal, hopper crystal characteristics.

Methods: Electron Dispersive Spectroscopy (EDS) and backscattered electron imaging were conducted on the FEI Nova NanoSEM 600, also at the Smithsonian. Images were processed and compositions were calculated using Noran System Six software.

Results: Initial classification by the authors [as part of 1] determined olivine values for the meteorite of Fa_{30-31} , Pyroxene values of $Fs_{25}Wo_2$, and feldspar values of $An_{10}Or_{4-6}$, consisted with the meteorite being an LL chondrite. EDS analysis of the large isotropic grain (spinel) indicate a composition of ~10 wt.% MgO, 46% Al_2O_3 , 20% Cr_2O_3 , 23% FeO. Compositionally this is a hercynite (var. picotite). Smaller (tens of microns) isotropic grains within the chondrule have composition of 48 wt.% Cr_2O_3 , 31% FeO, 11% Al_2O_3 , 6% TiO_2 and 4% MgO, consistent with chromites. Bulk composition of the chondrule is 41 wt.% SiO_2 , 20% Al_2O_3 , 14% FeO, 5% Cr_2O_3 , ~5% each of Na_2O , MgO, S, and <1% each of Ni, MnO, TiO_2 , and K_2O . EDS maps show an enrichment in Ca within the matrix of the chondrule immediately surrounding the large spinel grain.

Discussion: The bulk composition of this chondrule is Al-rich (>10 wt.% Al [2]), and falls within the range of other Na-Al-Cr rich chondrules in SiO_2 , CaO and Na_2O [3]. The spherical shape of the overall chondrule suggests formation as an independent object within the solar nebula [4]. The texture of the large spinel would indicate that it cooled rapidly as one crystal from one nucleation point, similar to barred olivine chondrules. Indeed, it almost appears as if there are bars present in the spinel structure. The calcium enrichment at the edge of the spinel is consistent with exclusion of Ca during the rapid growth of the spinel. Olivine grains and the micron-sized chromite grains are only seen in the portion of the chondrule away from the large spinel. Chromites likely crystallized after the large spinel.

McCoy et al. [3] report zoning in spinels in Al-rich chondrules in both the Roosevelt County 071 (L4) and 072 (L5) meteorites. Zoning is not seen within the minerals in this chondrule. Smaller, micron sized chromites are also present in the Roosevelt County chondrule, and in a similar fashion are not located near the edges of the large spinel grains. [2] also reported small chromite grains scattered throughout Na-Al-Cr-rich chondrules in Djernaia. In an effort to determine the crystallization sequence of this chondrule, we have compared it to those of Allende CAI crystallization [5] and texturally to chondrules of similar composition in [2]. To our knowledge, no similar large, skeletal spinels have been reported in chondrites. The semi-circular, skeletal (barred?) texture of the large spinel, by analogy with barred olivine chondrules, might suggest rapid cooling from a melt near the liquidus with only a few nuclei. The presence of this chondrule suggests that textures of spinels in Al-rich chondrules might provide additional insights into the thermal histories of these objects, but will likely require additional experimental studies.

References: [1] Satterwhite C. and Righter K. 2010. *Antarctic Meteorite Newsletter* 33,2. [2] Bischoff A. and Keil K. 1983. *UNM Special Publication* 22, 33 p. [3] McCoy T. J., A. Pun, and K. Keil. 1991. *Meteoritics* 26:301–309. [4] Taylor et al. 1983 *Chondrules and Their Origins*, LPI, 262-278.

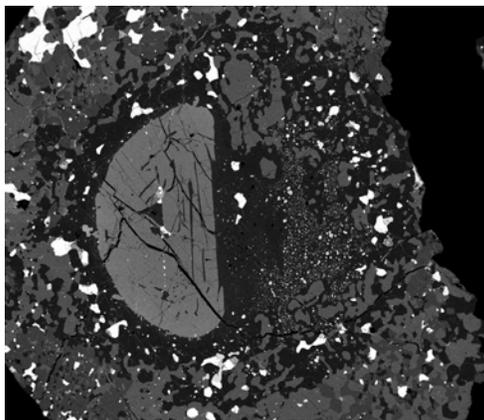


Figure 1 – Backscattered electron image of entire chondrule. FOV 1.5 mm.

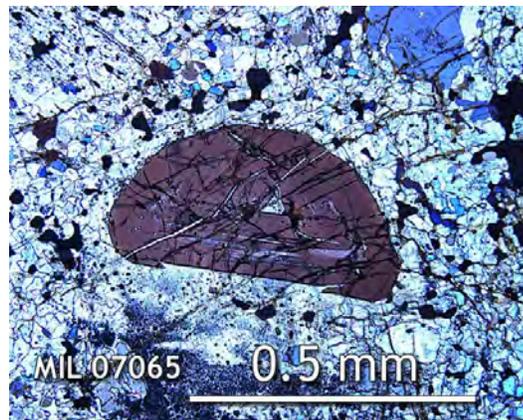


Figure 2 – Plane Polarized light image of large spinel grain from MIL 07065 reported in [1].