**TEM and Cathodoluminescence Spectroscopic Studies of Type A Chondrule Mesostases.** John M. DeHart*, Lindsay Keller*, Walter Prothroe+ and Gary E. Lofgren*. * Mail Code SN2, Johnson Space Center, Houston, TX 77058. +8711 Beau Manoe Houston, TX 77099.

**Introduction:** Although previous studies have shown the Cathodoluminescence (CL) properties of Type A chondrule mesostases are extremely sensitive to low levels of metamorphic reheating (1-3) the phosphor responsible for these CL emissions has yet to be identified. This study was initiated to identify and better characterize the luminescence properties of the phosphor or phosphors responsible for the initial yellow CL observed in unaltered type A chondrule mesostases. By doing so, we hope to better understand the physical and chemical reasons for the change from yellow to white, then finally to blue luminescence that is associated with increased metamorphic reheating.

**Methods of Analysis:** CL spectra were gathered from the mesostases of two type A chondrules in Semarkona (No. 58 and 16 in ref.1) and an experimental type A chondrule analog produced using the methods in (2). This analog has both the same observable crystalline phases present and mesostases CL properties as the Semarkona chondrules. The spectra were gathered using a Cameca CL spectrometer attached to a Cameca Camebax Microprobe. Electron beam conditions were 20 KeV and 300 nA, with the beam defocussed to 10 microns.

An additional type A chondrule analog with similar mineralogical and CL properties to the other samples was ion-thinned and studied using transmission electron microscopy (TEM) and electron diffraction. Two areas, one emitting a bright yellow CL and another that is nonluminescent were studied.

**Results:** CL Spectra. The CL spectra have a broad peak centered at 575 nm while a second peak located at 680 nm is also apparent (Fig. 1). These spectra indicate either a single mineral with two luminescent centers or two different minerals produce the CL that is emitted from these mesostases.

**Electron microcopy.** TEM observations show that the mesostases emitting the bright yellow CL is mostly crystalline and consists of polysynthetically twinned anorthite and minor high-Ca clinopyroxene set in a glassy matrix. The anorthite comprises ~90% of the crystalline material and occurs as fine-grained (<0.5 um in width) laths and dendrites. the clinopyroxene occurs between anorthite laths as stringers or tiny blebs (~50 to 100nm in diameter). Energy dispersive x-ray spectroscopy (EDS) analyses of the anorthite and clinopyroxene show an excess of SiO₂ suggesting that small pockets of SiO₂-rich glass were trapped during anorthite growth.

No crystalline phases were observed in the nonluminescent mesostases and electron diffraction patterns show only diffuse scattering typical for materials with short range order (e.g. silicate glasses).

**Discussion and Conclusions:** These studies indicate that anorthite is the principle phosphor responsible for the yellow luminescence in unaltered type A chondrule mesostases. Previous studies have shown anorthite can produce yellow CL either when trace to minor amounts of Fe²⁺ substitutes for Ca (its CL emission is centered at 590nm) (4), or when Mn²⁺ activated plagioclase is structurally distorted, which shifts the usually observed CL emission from 559 to yellow or longer wavelengths, depending on the degree of structural distortion (5). The second alternative is consistent with the position of the observed 575 nm emission band, especially considering the rapid growth this microcrystalline anorthite experienced. This rapid growth most likely resulted in a distorted crystal structure. The change in CL color that is metamorphism-dependent can then be understood as the ligand field surrounding the Mn²⁺ changing as the distortion is lost during annealing at low temperatures.

The clinopyroxene observed in the TEM study could also contribute to the luminescence of these mesostases, and possibly is the source of the 680 nm emission. Pyroxenes have...
TEM AND CL STUDIES TYPE A CHONDRULE MESOSTASES; DeHart, et.al.
been observed to emit CL at wavelengths ranging from 660 to 680 nm from Mn²⁺ activation (6).


Fig.1 CL spectra acquired from two type A chondrule mesostases in Semarkona, CH16 (lower spectra) and CH58 (upper spectra). Two emission bands are apparent in both spectra (575 and 680 nm, respectively) indicating either a single mineral with two luminescent centers or two minerals are responsible for the CL from these types of mesostases.

Figure 2. High-resolution TEM image of a twinned anorthite in the mesostases with bright yellow CL. Inset is a selected area electron diffraction from the [T10] zone of anorthite.