Cathodoluminescence Properties of Components in Enstatite Chondrites. John M. DeHart* and Gary E. Lofgren+. *Core Laboratories, 420 W. 1st St., Casper, WY 82601. +Mail Code SN2, Johnson Space Center, Houston, TX. 77058

Introduction. As a group, the enstatite chondrites are notable by the extremely low FeO content of most of their silicates. This property predisposes many of these materials to emit Cathodoluminescence (CL). Since examination of the CL properties of meteoritic components in ordinary and carbonaceous chondrites have proven to be a useful technique (1-3), we have initiated a survey of the enstatite chondrites in order to better characterize the chemical and physical properties of their luminescing phases. Because of the diversity encountered in this study, it is first necessary to describe the number and types of materials observed to emit CL in these meteorites.

Experimental. The meteorites listed in Table 1 were examined in this study. Two CL techniques were used. First, the initial survey work was conducted at low magnification using a Nuclide (now MAAS) Luminoscope mounted to a Wild MP binocular microscope equipped for photomicroscopy. The beam conditions used were 14±1 KeV and 7±1 milliamps, with the beam focussed to the diameter of the field of view of the microscope at 20x (appox. 1.25 cm). Photomosaics were produced for each section using Ecktar 1000 film and an exposure time of 15 to 30 seconds. Second, high magnification (400x) photos were obtained of individual components of interest by mounting a 35mm camera to the optical system of the Cameca Camebax microprobe located at the Johnson Space Center. Beam conditions used were 15 KeV and 600 nA. Ecktar 1000 film was also used, but exposure times of 6 minutes were necessary to produce a useful image.

Observations. The components in E chondrites that produce CL can be divided into four broad categories. These are; 1.) Clasts and aggregates, 2.) Chondrules, 3) matrix components, and 4.) refractory objects. Components in each category are discussed below.

Clasts and aggregates. These objects have an irregular, often elongate outline, and can be divided into metal/sulfide assemblages and silicate assemblages. Most of the metal-sulfide objects are nonluminescent, but several are associated with grains of red luminescing enstatite, whitlockite that emits a bright yellow CL, or blue luminescing enstatite. Those metal/sulfide assemblages associated with blue luminescing pyroxene appear to have a range in the abundance of pyroxene, from containing a few randomly oriented "whiskers" of blue enstatite less than 3 microns in diameter to being predominately composed blue luminescing enstatite with interstitial metal and sulfide., however the second case appears limited in occurance to EL chondrites.

The silicate clasts and aggregates can be divided into two distinct groups. First are pyroxenite clasts. These clasts are composed of; (1) blue luminescing enstatite that is sometimes associated with a red luminescing albite-normative glass, (2) microcrystalline blue luminescing enstatite (grain size <10 microns) set in a red luminescing, pyroxene-normative mesostases, or (3) a red luminescing enstatite that contain 5 to 10 um -sized oval regions of diopside. Second, there are clasts and aggregates of red luminescing pyroxene that often poikalitally enclose a brighter red luminescing olivine. These assemblages are also occasionally associated with overgrowths of blue pyroxene after red pyroxene, an albite-normative glass, or a blue luminescing plagioclase-normative glass.

Chondrules. Although there are a few instances of similar chondrules, the CL properties of most of the chondrules in enstatite chondrites are clearly different compared to the FeO-poor type A chondrules observed in the ordinary and carbonaceous chondrites. Although occasional barred and radial chondrules were observed, porphyritic chondrules are the dominant textural type as in other chondrite groups, The following are the different types of chondrules according to their observed CL.

1. Red grains in a dull red mesostases. This is the dominant type of chondrule observed in most of the enstatite chondrites, especially the EH3 and EH4 classes. The grains are most often En98-99 enstatite occasionally enclosing Fo98-99 olivines. The mesostases has extremely high Na_2O content (4 to 9 weight percent).

2. Similar to the chondrules above, but the red luminscing pyroxene encloses a blue luminescing phase, most often a nearly pure (En99.5 and greater) blue luminescing pyroxene. The different chemistry and unique physical properties of the enclosed blue pyroxene strongly suggest these are relict grains (4). A few instances of blue luminescing olivines enclosed in red luminescing pyroxene were also observed in PCA82518 (EL4).

3. Red luminescing pyroxenes enclosed by a blue luminescing, plagioclase-normative mesostasis. The composition and CL of the phases in these chondrules compare well to the type A3 chondrules in ordinary chondrites (1).

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4. Blue luminescing enstatite (>En99.5) associated with a Na_2O-rich dull-red luminescing mesostasis. This enstatite is clearly different than the relict pyroxene described above, and are found only in chondrites indentified as EL3s.

5. Red luminescing grains associated with a yellow luminscing mesostasis. These chondrules compare well to the type A1 and A2 chondrules observed in the ordinary chondrites.

Matrix Components. The interchondrule matrix in both E3 and E4 chondrites is clastic in nature and composed of smaller clasts (<50 um) of the types described above, smaller, isolated grains or fragments of red and blue luminescing enstatite, small regions (approx. 20 um in diameter) of dull-blue-luminescing SiO_2 and small pockets of a dull-red luminescing albite-normative glass. The proportions of each type of phase appear to vary with chemical group. Blue luminescing phases, principally enstatite, is the predominant matrix componant in the EL3 and EL4 chondrites, and is the only identifiable matrix component in LEW87223 (EL3).

Refractory Objects. Some components in the E3 chondrites are assemblages of refractory minerals. Although CAIs and refractory objects were previously reported as being rare in E chondrites, their unique CL made them easily identifiable in all sections of E3s, and are especially abundant in LEW87223 (EL3). Assemblages identified are;

1 Refractory chondrules with either a.) blue luminescing olivine and/or pyroxene set in a yellow-luminescing, anorthite-normative mesostases, or b.) a red luminescing spinel enclosed by laths of blue-green plagioclase set in a mesostasis of a duller blue-green luminescing, dendritic fassaite and nonluminescent glass.

2. Spherical assemblages of dendritic to subhedral blue luminescing pyroxene set in a yellow-luminescing anorthite-normative mesostasis. These objects differ from the chondrules described above by having many small dull-blue or dull-red luminescing SiO_2-rich ovoid inclusions scattered in them, and is the type of object found in all E3 chondrites.

3. Concentrically layered assemblages of refractory materials (anorthite and enstatite) and/or metal. These objects are found only in LEW87223 (EL3).

Conclusions. The CL properties of the phases in enstatite chondrites highlight subtle, but important differences that are difficult to identify or study by other techniques, such as electron imaging or optical petrographic methods. Because most of the silicate phases emit some type of CL, examining the CL properties of these phases in enstatite chondrites can be an extremely powerful tool in deciphering their petrographic and petrologic relationships.

REFERENCES. (1) DeHart et. al. (1992) *GCA*, Vol. 56, pp. 3701-3807. (2) Steele, I.M. (1989) *GCA*, Vol. 53, pp. 2069-2079. (3) Keck, B. D. and Sears D.W. G. (1987) *GCA*, Vol. 51, pp. 3013-3021. (4) Logren G.E. and DeHart, J.M. (1992) **XXIII Proc. LPSC**, pp. 801-802.

Table 1
Listing of Meteorites used in this study.

Meteorite	Chem. Class.	Weath. Class
Quinzhen	EH3	A
ALH84170	EH3*	B
LEW87223	EL3**	C
MAC88136	EL3	A
Indarch	EH4	A
ALH84206	EH4*	A/B
PCA82518	EL4**	B
ALH85159	EH4*	B/C
EET83254	EH4*	Ce
RKPA80259	EL5	B/C
ALHA81021	E6	A

* Chemical classification tentative, and based on comparison of the CL properties to other E-chondrites of known chemical group.
** Chemical classification based on same as above and the INAA results of Chin and Sears (this volume).