CATHODOLUMINESCENT PHOSPHORS IN THE MATRICES OF TYPE 3 ORDINARY CHONDRITES. John M. DeHart* Gary E. Lofgren+ and Derek W.G. Sears*. *Cosmochemistry Group, University of Arkansas, Fayetteville, Ar. 72701. +SN2, Johnson Space Center, Houston TX.77058.

Introduction. We have previously shown that the cathodoluminescence (CL) properties of the matrices of type 3ordinary chondrites change rapidly with increasing petrologic type(1). The matrix of Semarkona (type 3.0) is unique because of the abundance of red phosphors, with from 50 to 80 area percent of the matrix areas emitting red light. The matrices of Krymka and Bishunpur (types 3.1) are dominated by nonluminescent phases and have less than 15 area percent of red phosphors in their matrices.In type 3.4 ordinary chondrites (ALHA77214 and Chainpur) the matrices are predominantly nonluminescent phases and completely lack red phosphors, 5 to 15 area percent of their areas emit blue CL. Matrices of type 3s of higher petrologic subtype (e.g. Dhajala 3.8) have similar CL characteristics to the matrices of the intermediate types except for the presence of scattered large red or yellow luminescent grains. As part of a survey of phosphors in the type 3 ordinary chondrites (2) we have conducted an SEM and microprobe study of the phases in the matrices of a metamorphic suite of ordinary chondrites (Semarkona, Krymka, ALHA77214, and Dhajala in order to understand the chemical basis for these changes in CL characteristics. We performed point analyses of matrix grains and clasts > 5 microns in size and broad beam analyses of the fine-grained clastic matrices in Semarkona and Krymka.

Observations. Semarkona- The most frequent luminescent phase analyzed in the matrix was olivine with less than 2 weight % FeO(See Table 1.). Occasional isolated grains and strings of calcite that emit reddish-yellow or red luminescence and have an occurrence and composition similar to that observed and reported by Hutchison et al (3) were also noted. Broad beam analyses of the fine-grained matrix areas produce similar results to those of Hutchison et al and of Huss et al (4). Since FeO is a quencher of luminescence, the high FeO content of these areas despite their large abundance of luminescent phases suggest that these areas are mixtures Fe-poor phases (probably olivines and pyroxenes) and Fe-rich phases. Qualitative EDX analyses of the nonluminescent materials in these areas produced spectra of either FeS, Fe-Ni metal, and an Fe-rich silicate. One area studied had a grain of Fe-rich silicate large enough for microprobe analyses, and the data were consistent with this material being a clay like mineral.

Krymka- The only phosphors noted in the matrix are as analyzed in this meteorite were Forsterite and enstatites with enstatites being the more abundant (See Table 1). Broad-beam analyses of the fine grained clastic matrix areas gave similar results as those of Huss et al for opaque matrix. Microprobe analyses and EDX surveys of the nonluminescent phases indicate these were olivines and pyroxenes with greater than 2 weight percent FeO, FeS and Fe-Ni metal. No clay like minerals were observed. A single blue luminescent area large enough for microprobe analysis was noted, and its composition and occurrence is consistent with it being the mesostasis of a small chondrule fragment.

ALHA77214- The altered nature of this meteorite (weathering class C) is readily apparent in it's matrix. Large grains of hematite associated with a fine-grained material occupy large areas of the matrix. These altered areas end in sharp boundaries and what is interpreted as unaltered matrix consists of grains of olivines and pyroxenes 10-20 microns in diameter embedded in a glassy material that is the source of the blue luminescence.These glassy areas could be the result of phase segregation during metamorphism, or they could be residual glasses of altered chondrule fragments. All olivine grains range in composition from Fa 37 to Fa 49 (Table 1). Olivines with relatively lower FeO content are typically zoned with central areas of the grain being Fa 16 to Fa 22 and the outer areas of the grains Fa 37 in composition, indicating they are products of partial equilibration between these olivines and the Fe-rich matrix phases. The olivines with Fa 49 compositions occur as overgrowths on magnesian pyroxene, indicating that they were formed as an alteration products.

Dhajala- All matrix areas appear are recrystallized and the olivines are equilibrated with a composition of Fa 19. The source of blue luminescence are areas of glasses similar to those seen in ALHA77214, but differ in composition by having higher Na_2O and K_2O content (Table 1). Large yellow luminescent grains are also present. Microprobe and EDX analyses indicate these are grains of Chlor-apatites.Interpretations. It is clear that the loss of red phosphors in the matrix of type 3 ordinary chondrites is due to the partial equilibration of Fe content of the olivines and pyroxenes during thermal metamorphism. Matrix grains are more responsive to metamorphism than the chondrule grains of similar composition because of their smaller grain size and intimate association with Fe-rich phases that are the source of Fe. An associated effect is the appearance of blue luminescent glasses in the matrices of type 3s of intermediate subtype. Whether these glasses are derived from the glassy amorphous interstitial material described by Huss et al (4) or are from chondrule fragments cannot be determined, but their smaller sizes also make these glassy areas more susceptible to thermal effects and thus nucleate phosphors more rapidly than the larger areas of chondrule glasses. Further, the association of calcite and claylike minerals in the matrix of Semarkona indicate these areas have been hydrothermally altered, and the high abundance of red phosphors is possibly due to this alteration. The presence of phosphates in type 3 ordinary chondrites is another characteristic of high petrologic subtype.

Conclusion. The luminescent properties of type 3 matrices are sensitive indicators of thermal metamorphism. This is due to the extremely small average grain size of matrix grains and the intimate mixture of unequilibrated phases in these areas. These properties promote rapid chemical reactions with the onset of thermal metamorphism. In addition, a large abundance of red phosphors in chondrule matrices could be an indicator of hydrothermal alteration.

REFERENCES: (1) DeHart and Sears (1986) LPS XVII, 160-161. (2)DeHart, Lofgren and Sears (1989) GCA submitted. (3) Hutchison,Alexander and Barber (1987) GCA, 51, 1875-1882. (4) Huss, Keil and Taylor (1981) GCA, 45, 33-51.

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Table 1. Listed compositions are representative and not averages. The "red" before olivine designates the color of luminescence and No. represents the number of occurrences analyzed.

Phase	No.	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cr_2O_3	P_2O_5	Total
Semarkona Matrix Phases													
Red Olivine	11	42.31	0.02	0.16	1.38	0.15	55.25	0.22	0.04	0.01	0.31	0.01	99.85
Calcite	4	0.14	0.01	0.00	1.36	0.14	0.39	61.27	0.30	0.02	0.01	0.05	63.70
Fe-rich silicate	1	41.11	0.00	2.24	35.81	0.22	4.40	0.45	0.48	0.40	0.02	0.03	85.16
Clastic Matrix	4	35.93	0.02	4.35	23.55	0.15	11.50	0.82	2.31	0.59	0.25	0.09	79.56
Krymka Matrix Phases.													
Red Olivine	2	42.63	0.05	0.17	0.40	0.02	55.61	0.51	0.02	0.00	0.13	0.00	99.52
Red Pyroxene	8	58.85	0.09	0.68	1.24	0.07	37.82	0.48	0.02	0.01	0.42	0.00	99.69
Blue Glass	1	68.00	0.14	19.49	0.99	0.04	0.90	2.00	5.70	0.06	0.02	0.01	97.36
Clastic Matrix	3	33.74	0.05	4.51	37.60	0.33	11.85	1.27	1.49	0.18	0.37	0.14	91.52
ALHA77214 Matrix Phases.													
Blue Glass	2	66.77	0.51	15.23	4.04	0.10	3.89	4.60	2.80	1.59	0.01	0.87	100.40
Low Fe Ol.core	3	39.39	0.06	0.06	15.95	0.03	45.36	0.42	0.00	0.00	0.09	0.02	101.39
Low Fe Ol.rim	3	35.50	0.04	0.04	33.05	0.35	31.17	0.31	0.00	0.01	0.06	0.01	100.54
High Fe Olivine	7	33.86	0.01	0.00	40.49	0.64	23.32	0.29	0.04	0.01	0.94	0.06	99.66
Dhajala Matrix Phases.													
Olivine	7	39.22	0.01	0.01	18.26	0.42	42.83	0.04	0.01	0.01	0.03	0.01	100.83
Blue Glass	3	63.47	0.52	17.21	1.92	0.10	4.03	2.10	8.27	1.79	0.16	0.75	100.30