ELECTRON-MICROPROBE AND CATHODOLUMINESCENT STUDIES OF UNEQUILIBRATED ORDINARY CHONDRITES, II. CHONDRULE MESOSTASES IN ALHA77214 AND DHAJALA.

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Introduction: The unequilibrated ordinary chondrites (UOC), while being little-affected by the metamorphism that has masked the physical record of nebular condensation contained in other meteorites, nevertheless show a wide range in metamorphic levels experienced (1). These have led to particularly large variations in thermoluminescence (TL) and cathodoluminescence (CL) properties, which have enabled the subdivision of this group (3,4). To better understand these variations, we have been studying CL phosphors in UOC by microprobe techniques. We have previously reported data for Semarkona (type 3.0) and Krymka (type 3.1), where aqueous alteration may also have been important (5), and here we report the results of microprobe and CL studies of mesostases in UOC of intermediate (ALHA77214, type 3.4) and high (Dhajala, type 3.8) petrologic subtype.

Observations: The CL colors of the chondrule mesostases and their frequency of occurrence in each meteorite are listed in Table 1. All chondrule mesostases in Dhajala luminesce, producing either blue or purple CL. The mesostases in chondrules from ALHA77214 are also luminescent, but have either blue or red phosphors that can occur separately, as concentric blue rims and red interiors or as mixtures of discrete regions within the same mesostasis. These differences in CL color are clearly related to composition (Table 2); blue and yellow mesostases have higher Al_2O_3 and lower SiO_2 content and thereby higher normative feldspar content. Purple and red luminescing mesostases have lower normative feldspar than the other CL colors, but differ in their K_2O, the purple being much higher. The single yellow phosphor in ALHA77214 is Ca-rich and is similar in composition to other yellow CL phosphors in Semarkona and Krymka. A plot of Na_2O vs. CaO (Fig. 1) demonstrates that a plagioclase-like, inverse correlation between the two oxides exists that involves the blue phosphors. The purple and red phosphors lie well off this line.

Interpretation: Plagioclase or a plagioclase-like mineral is an important phosphor in the chondrule mesostases of intermediate and high type 3 chondrites, just as it is in the lower type 3s. ALHA77214 and Dhajala resemble Krymka in that all mesostases with high normative plagioclase content are blue, but differ from Semarkona in which those mesostases with high normative calcic plagioclase are yellow. This difference is thought to reflect aqueous attack of the calcic mesostases in Semarkona (5). That all plagioclase-normative mesostases have some sort of bright luminescence, regardless of petrologic type of the meteorite, suggests that luminescence is a primary feature in these cases. ALHA77214 and Dhajala differ from the chondrites studied earlier in that in the present case chondrules not lying on the "plagioclase" line in Fig. 1 show purple or red CL, whereas previously they were non-luminescent. Apparently, the greater levels of metamorphism experienced by ALHA77214 and Dhajala were capable of crystallising, to some extent, glasses which were able to resist Semarkona and Krymka levels of metamorphism. The influence of composition on the kinetics of crystallisation was recently explained in terms of the structural features in the glass (6). Such features are inherited by the crystals and could explain the different CL colors of the Na-rich mesostases with blue and red/purple CL. Alternatively, the presence of additional important phosphors in the purple and red mesostases (calcic pyroxene, quartz, etc.) is a real possibility. Chondrules whose mesostases are red in the central regions and blue outside may have experienced the loss of Si, presumably by vapor fractionation during chondrule formation (7).

Conclusions: The CL intensities of chondrule mesostases reflect the degree of crystallisation of glass. Plagioclase-normative mesostases crystallise readily, and may have nucleated some form of feldspar prior to being incorporated in the chondrule. The CL properties of non-plagioclase-normative mesostases appear to reflect level of metamorphism experienced; low - no CL, intermediate - red CL, high - purple CL. More complex compositional factors, which are assumed to be primary (i.e. pre-accretionary), also affect CL color. Unlike the Semarkona case, there are no CL data for ALHA77214 and Dhajala which can be readily interpreted in terms of aqueous alteration.

References: (1) Van Schmus and Wood (1967) GCA, 31, 747-765. (2) Alexander et al. (1986) Meteoritics, 21, 328. (3) Sears et al. (1980) Nature, 287, 791-795. (4) DeHart and Sears (1986) LPS XVII, 160-161. (5) DeHart et al. (1987) LPS XVIII, 225-226. (6) Taylor and Brown (1979) GCA, 43, 61-75. (7) Dodd and Walter (1972) in "Origin of Solar System" (Reeves, Ed.) 293.

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Table 1. Frequency of occurrence (%) of chondrule mesostases CL colors

Meteorite	Number of Chondrules	Blue	Purple	Yellow	Red	Blue/red mix	Blue rim Red int.	Nonlumin.
Semarkona	75	22.7	0	34.7	5.3	0	0	37.3
Krymka	133	59.4	0	3	7.5	0	0	30.1
ALHA77214	128	66.4	0	.8	19.5	9.4	3.9	0
Djahala	62	63	39	0	0	0	0	0

Table 2. Composition and mesostasis CL color.

Analysis	# cases	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cr_2O_3	P_2O_5	Total%	Norms Ab	An	Or	Total Plag.	Qtz
ALHA77214 Blue	26	59.91	0.44	20.00	2.95	0.14	3.42	6.72	5.47	0.64	0.18	0.42	100.28	45.06	24.15	3.80	73.02	7.38
Dhajala Blue	17	60.24	0.42	21.92	1.72	0.15	3.08	7.40	6.59	0.38	0.19	0.08	102.17	53.49	27.79	2.27	83.54	2.48
Dhajala Purple	11	67.67	0.50	14.53	2.96	0.14	5.79	4.11	6.27	1.34	0.20	0.19	103.69	47.34	·5.27	7.92	60.53	13.90
ALHA77214 Red	20	66.49	0.45	15.33	4.21	0.15	4.02	3.85	6.02	0.24	0.13	0.35	101.23	50.95	11.10	1.43	63.47	15.21
ALHA77214 Yellow	1	56.80	0.15	20.75	1.76	0.02	6.13	11.36	2.50	0.10	0.20	0.01	99.77	21.15	45.10	0.59	66.84	9.46

Fig.1 ALHA77214 and Dhajala Mesostases