The Composition and Luminescence Properties of Chondrule Olivines and Pyroxenes in the Type 3 Ordinary Chondrites. John M. DeHart* Gary E. Lofgren+ and Derek W.G. Sears*. *Cosmochemistry Group, University of Arkansas, Fayetteville, AR. 72701. +SN4, Johnson Space Center, Houston TX. 77058.

Introduction. We have previously shown the cathodoluminescence (CL) properties of the type 3 ordinary chondrites vary systematically with the degree of metamorphism experienced (1). Microprobe analysis of chondrule mesostases in a group of meteorites that are representative of this metamorphic range (Semarkona-3.0, Krymka-3.1, ALHA77214-3.4 and Dhajala-3.8) showed that their luminescent characteristics are highly dependent on the mesostasis bulk composition and the degree of solid state crystallization induced by thermal metamorphism (2). The CL properties of chondrule olivines and pyroxenes also appear to be related to the degree of thermal metamorphism experienced by the meteorite. Red and blue luminescing grains are abundant in the lowest metamorphic types, while their frequency rapidly decreases with increasing metamorphic subtype until all chondrule olivines and pyroxenes are nonluminescent at the 3.6 level of metamorphism. In order to better understand their chemistry, how these phosphors are affected by thermal metamorphism, and if there is any relationship between the occurrence of luminescent grains and chondrule type, we have conducted a microprobe survey of the chondrule olivines and pyroxenes in the four meteorites listed above. The new data were also compared with mesostasis CL properties and composition to further explore the history of chondrites.

Observations. Most luminescent grains in Semarkona and Krymka occur in chondrule types Ia or Ib as described by Scott and Taylor (3), and are located in a mesostases that emits either yellow (in Semarkona) or blue CL. These chondrule types in ALHA77214 have a lower occurrence of luminescing grains and the grains have slightly higher FeO content. All olivines in Mcsween's type II chondrules (4) and other chondrule types are nonluminescent and coexist with mesostases that have variable luminescent character. Olivines and pyroxenes with greater than 2 and 2.5 weight % FeO respectively, do not luminesce.

Most luminescent olivines are compositionally different from those with no CL in more than just FeO content; CaO, Al_2O_3 and TiO_2 are inversely correlated with FeO content and Cr_2O_3, MnO and FeO are positively correlated. The olivines emitting blue light have the highest CaO, Al_2O_3, TiO_2 content and the lowest FeO, MnO and Cr_2O_3 content. CaO and MnO are positively correlated with FeO in most nonluminescent grains.

Three different colors of CL are emitted by grains with pyroxene compositions; blue, red, and yellow. Pyroxenes with blue or red CL are enstatites and usually occur as poikilitic grains enclosing olivine in type Ib chondrules. The grains emitting blue CL have FeO content less than .5 weight and higher content of TiO_2 and Al_2O_3. Fe-poor, Al-rich pyroxenes with compositions comparable to fassaite emit yellow CL and occur as rims surrounding forsterite grains in anorthite normative mesostases.

Interpretations: The strongest control on olivine and pyroxene CL is FeO content. In addition, it is clear that the difference in the conditions of formation of type I and other types of chondrules also promote the production of luminescing phases in these chondrules. We have suggested elsewhere (5), based on mesostases composition and CL properties, that type I chondrules underwent reduction of FeO in their olivine during chondrule formation while the FeO in the olivine grains of type II chondrules was little changed during chondrule formation. The importance of FeO content in controlling CL properties explains why the CL of the olivines and pyroxenes rapidly disappears with increasing petrologic type. FeO equilibration in olivines serves to illustrate this point (Fig. 1). Both Semarkona and Krymka have chondrules whose average FeO content is below the quenching limit of 2 weight %,

CL AND COMPOSITION OF CHONDRULE OLIVINES AND PYROXENES

J.M. DeHart, G.E. Lofgren and D.W.G. Sears

while similar chondrules in ALHA77214 have both higher FeO content and lower CaO content. Most chondrules in Dhajala are equilibrated in both FeO and CaO content.

Conclusions. Type Ia and Ib chondrules are the principle sources of CL in the most primitive of the type 3 ordinary chondrites. Variability in overall CL and thermoluminescence (TL) in the most primitive of type 3 ordinary chondrites could be due to variation in the proportions of these types of chondrules. Fe equilibration during metamorphism is the principle reason for the rapid loss of luminescing olivines and pyroxenes with increasing petrologic subtype.

References: (1)DeHart and Sears (1986) LPSCXVII, 160. (2)DeHart, Lofgren and Sears (1989) LPSCXIX,259. (3)Scott and Taylor,(1983) Proc. XIV LPSC, JGR vol. 88,pp B275-B286. (4) McSween (1977) GCA, 41, 411-418. (5)DeHart, Lofgren and Sears (1989) GCA, submitted.

Research supported by NASA grants NAG 9-81 and NGT-50064.

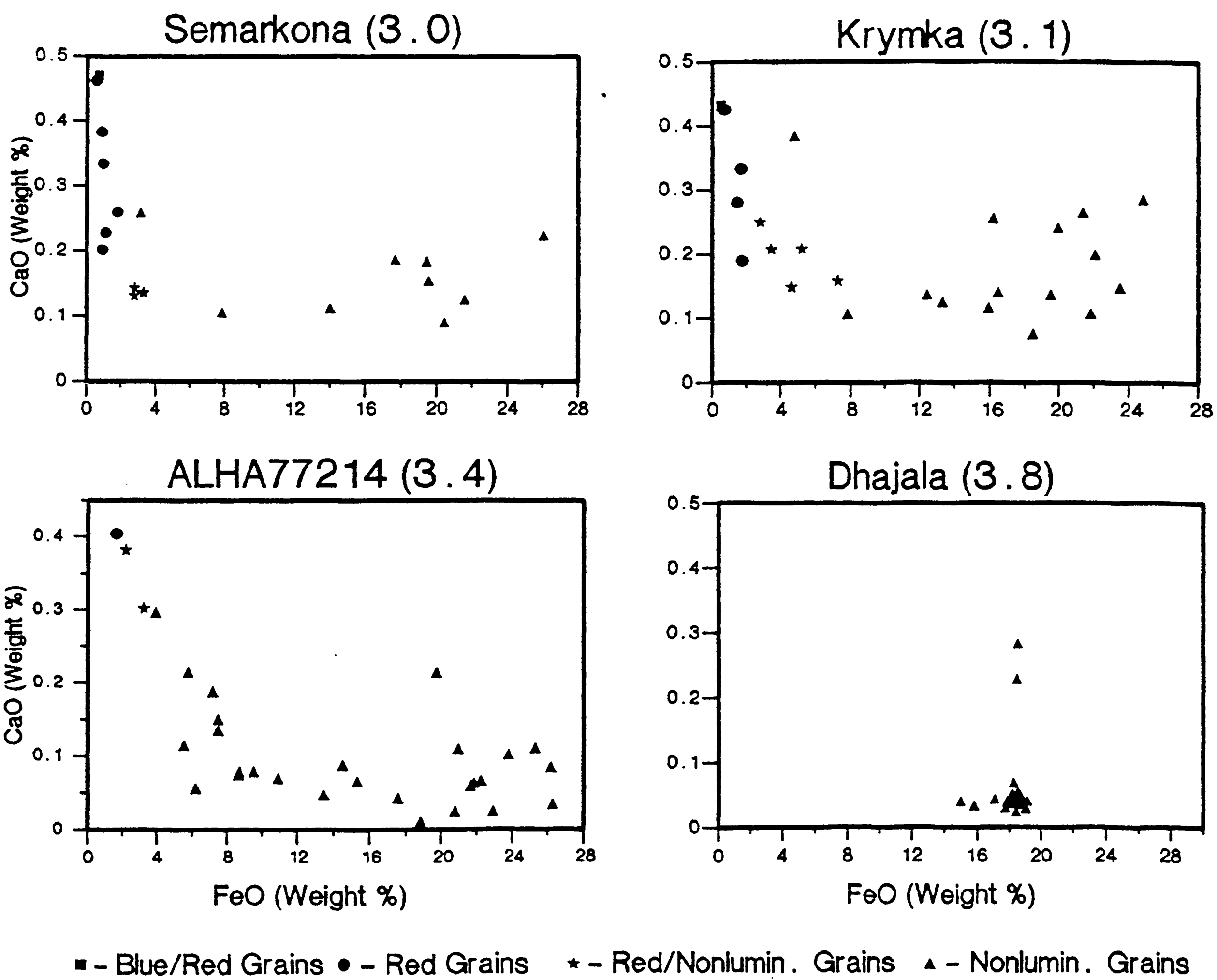

Fig. 1 Average CaO content versus average FeO content of chondrule olivines with the color of the olivine grains indicated.