LABORATORY METAMORPHISM OF A PRIMITIVE METEORITE. R. Kyle Guimon*, Derek W.G. Sears* and Gary E. Lofgren+; *Department of Chemistry, University of Arkansas, Fayetteville, AR 72701. +NASA Johnson Space Center, Houston, TX 77058.

There is considerable evidence that Semarkona is the most primitive ordinary chondrite known (1-5), and it has the lowest measured thermoluminesence (TL) sensitivity and unique cathodoluminescence properties (2,5). It has been suggested that (1) the metamorphism-induced increase in TL reflects the formation of the TL phosphor, feldspar, through the devitrification of primary igneous glass, and (2) the peak width and peak temperature changes are associated with the formation of feldspar in the low-temperature (ordered) form below 600 C and the high-temperature (disordered) form above 600 C. Thus, petrologic types 3.3-3.5 have peak temperatures 149+/-20 C while types 3.6-3.9 and a type 3.4 chondrite annealed above 700 C have peak temperatures of 192+/-20 C and 206+/-12 C, respectively (6,7; Fig. 1). Semarkona is one of a few ordinary chondrites that do not lie on the TL sensitivity/peak temperature/peak width trends, because its TL is due to other phosphors (5). We earlier showed that annealing a type 3.4 chondrite at 850 C, under conditions known to cause the crystallization of glasses, caused the TL sensitivity to increase by a factor of 3-10 and for the peak to move from 140 to 210 C (9). We now report annealing experiments on the Semarkona meteorite under conditions similar to those used in ref. 9, but at a variety of temperatures across the order/disorder transformation.

Aliquants of non-magnetic extracts (30 mg) were sealed, with water (10 w/w%) and sodium disilicate (Nadisi, 2 molal; see Fig.1 for exact amounts), in gold capsules. They were then annealed in 100 C increments between 400 and 900 C, at 1 kbar, in externally heated pressure vessels (10). Except at 900 C, duplicate samples were run at each temperature. The TL was measured using the techniques and apparatus described in ref. 8.

The results are shown in Fig. 1; the error bars are +/-1 sigma on 5 measurements. All samples annealed above 600 C showed major increases in TL sensitivity (factors of 10-100), and there is some indication that the amount of increase is related to the annealing temperature. The samples annealed below 600 C, with one exception, scatter around the unannealed data. This scatter probably reflects heterogeneity in the original powder with the annealing treatment having little or no effect, but it is also possible that relatively subtle changes did occur. The 500 C samples with significantly higher Nadisi than the similarly annealed samples showed an increase in TL sensitivity comparable to that shown by the 800-900 C samples, with chondrules having significantly higher TL than bulk samples. One of the 600 C samples had comparable TL sensitivity to the unannealed sample, while the other is somewhat higher. In general, samples showing >2 sigma increases in TL sensitivity over the unannealed value, had peak temperatures of 200-220 C if annealed above 600 C, and 140 C if annealed below 600 C. One of the 600 C samples had a peak temperature of 145+/-5 C and the other had a value of 206+/-2 C.

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The present experiments have reproduced in the laboratory, using the most primitive meteorite known, the major the TL trends observed in the type 3 ordinary chondrites; namely the increase in TL sensitivity with the peak at 140 or 210 C, depending on temperature. The data are consistent with peak positions being determined by feldspar order/disorder and with the TL sensitivitiy-metamorphism relationship involving the devitrification of glass. Thus the metamorphic equilibration temperature for type 3.5/3.6 chondrites is the order/disorder transformation temperature (roughly 600 C). There is nothing in the present data to preclude a simple closed system metamorphic relationship between type 3 and the higher types (11), although oxygen isotopes (8) and siderophile elements (12,13) make this unlikely.

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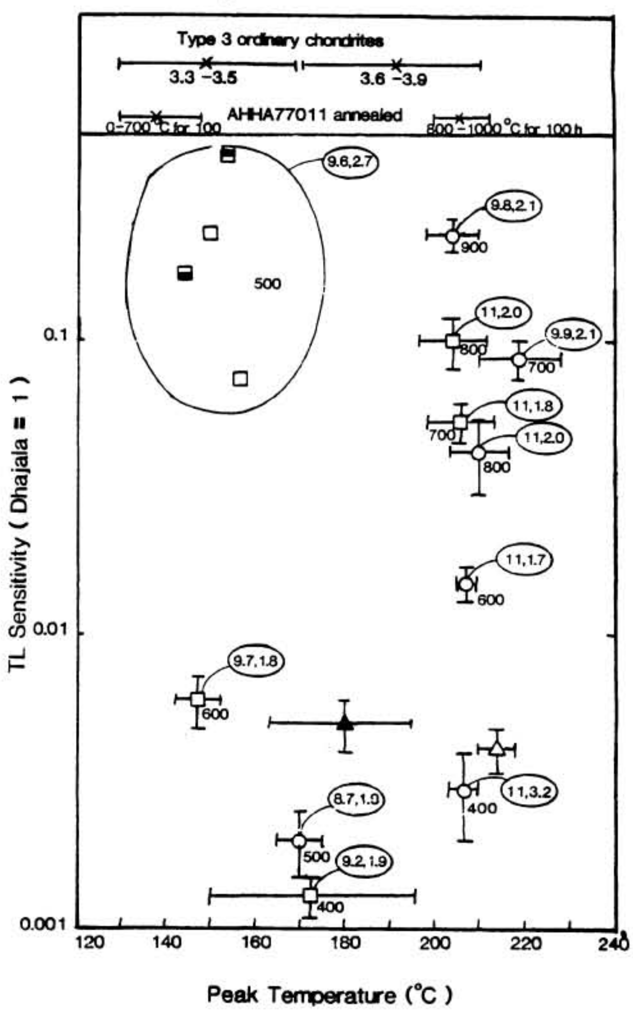

Fig.1 TL sensitivity vs. peak temperature for duplicate Semarkona samples annealed for 1 week (temperatures indicated are in C) with added fluxes (values circled; water w/w%, molal sodium disilicate). Literature data for type 3 ordinary chondrites, ALHA77011 annealed for 100h at 1 atmos., and an unannealed sample (7) are also indicated. Triangles refer to unannealed samples (filled=ref.6), squares and circles refer to the two charges, (upper half-filled =chondrules, lower half-filled= powder remnant after chondrule removal).