

ANNEALING STUDIES OF THE THERMOLUMINESCENCE SENSITIVITY OF CHONDRITES: RELEVANCE TO THE METAMORPHIC AND SHOCK/REHEATING HISTORY OF METEORITES. N. Bakhtiar, W.E. Brandon*, R.K. Guimon, B.D. Keck, K.K. Saebo, K.S. Weeks and D.W.G. Sears. Chemistry Department, University of Arkansas, Fayetteville, AR 72701. *Mechanical Engineering Department.

Chondritic meteorites display a 10^5 -fold range in their TL sensitivity. Most chondrites lie near the top of this range, but two factors are associated with values which are significantly lower: 1) chondrites of petrologic types 3 and 4 have low TL sensitivity values apparently because they have experienced less metamorphism than the most abundant petrologic types 5 and 6 (1,2) and; 2) black chondrites, with low K-Ar ages, have TL sensitivity values which are 0.1-0.01 times those observed for most chondrites - their low values are associated with the severe shock and reheating they have suffered (3,4). Our working hypothesis for these data is that TL sensitivity reflects the amount and nature of the feldspar, which is probably the TL phosphor. Feldspar is absent in unmetamorphosed chondrites but forms by the metamorphism-induced devitrification of glass. Under severe shock reheating, the feldspar converts to maskelynite. In order to explore these ideas further, we have performed systematic time-temperature annealing experiments on a relatively unshocked type 5 H chondrite, Kernouve, and a relatively unshocked and relatively unmetamorphosed meteorite, Allan Hills A77011 (LL3.5).

Several grams of each meteorite were ground and the magnetic portions removed. Aliquots of 20 mg were then placed in high purity quartz vials and sealed in one atmosphere of high purity nitrogen. Since the devitrification of feldspathic glass is catalyzed by water (5,6), 5 μ l of distilled water were added to the Allan Hills vials. We were guided in our choice of annealing conditions by previous work on meteorites (7) and terrestrial feldspars (8,9).

The results are shown in Fig. 1. The data are normalized to the unannealed meteorites and the error bars refer to 1 sigma calculated from three replicates; the errors are greater for the Antarctic meteorite as a result of its much lower TL signal and correction for a white condensate whose TL properties and composition indicated that it was quartz. The effect of annealing on the TL sensitivity of the two meteorites was remarkably similar. After the annealing at 500 C, the TL sensitivity of the Kernouve meteorite showed a 40% decrease. This is probably also the case for the Allan Hills A77011 meteorite, although the errors make it less clear. It is also unclear from the present data whether the drop is gradual or occurs entirely between 500 C and 600 C. At 1100 C the TL of Kernouve drops by a factor of 5 after 1 hour and by more than two orders of magnitude after annealing for 10 and 100 hours. The same steep drop is present in the Allan Hills A77011 data, but requires slightly less severe conditions; there is more than an order of magnitude decrease in the TL sensitivity after annealing at ten hours at 1000 C. This difference in the temperature at which the steep drop occurs for the two meteorites may be associated with the differences in grain size and the petrographic setting for the feldspar, although other factors remain to be considered. There seems also to be a slight time dependence in the TL sensitivity changes.

We conclude that TL sensitivity is more stable to mild annealing than numerous trace elements which are mobilized by very similar annealing

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conditions (7), but that these experiments do not reasonably duplicate metamorphic conditions. This conclusion seems to be consistent with McSween et al.'s observation that silicate phases were not homogenized nor glass devitrified by similar heat treatments of the Krymka chondrite (10). Longer annealing times and higher pressures seem to be called for. The sharp drop in TL sensitivity at 1100 C does seem consistent with feldspar as a TL phosphor, as this is the temperature at which feldspar melts in certain olivine-pyroxene-feldspar assemblages (11). Thus, TL sensitivity can reliably discriminate between meteorites which have experienced shock reheating above this temperature from those which have not.

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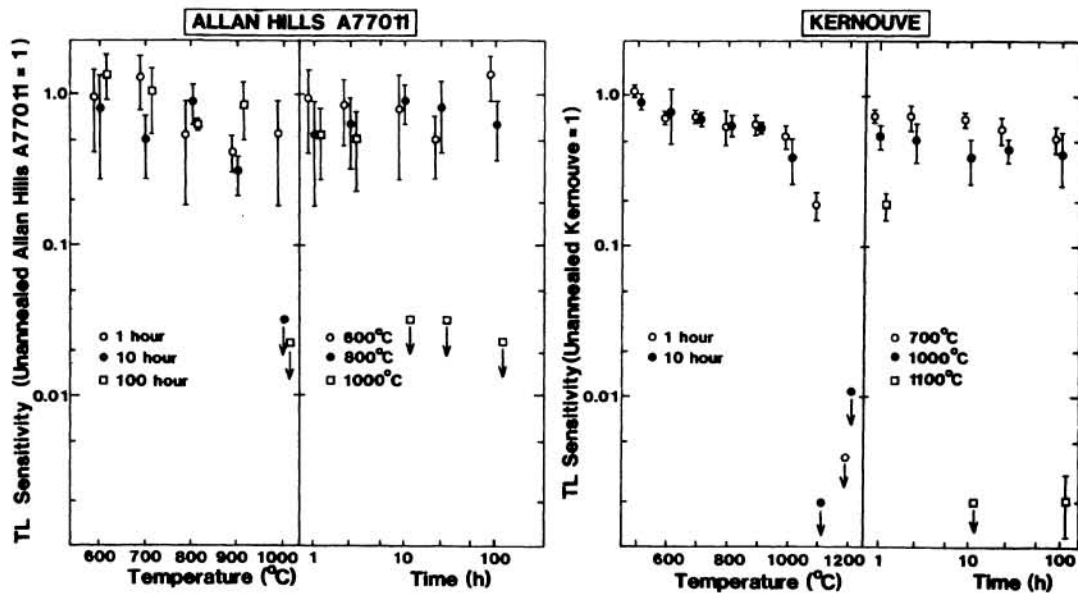


Fig. 1. Effect of annealing on the TL sensitivity of equilibrated (Kernouve) and unequilibrated (Allan Hills A77011) chondrites. Points with arrows are limits. Some of the data points are displaced slightly to one side for the sake of clarity.