A COMPARISON OF THE INDUCED THERMOLUMINESCENCE PROPERTIES OF ANTARCTIC AND NON-ANTARCTIC H CHONDRITES.

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Introduction. Haq et al. (1) recently published induced thermoluminescence data for 74 H chondrites of which 33 were found in the Antarctic. They found differences between the Antarctic and non-Antarctic H chondrites in the TL sensitivity, and in TL peak temperature-peak width relationships. (These three parameters, and induced TL studies of meteorites in general, were recently reviewed in ref. 2). Here we summarize and discuss these data. Differences between Antarctic and non-Antarctic L chondrites may also exist, but the data are meager and the differences less marked.

TL sensitivity data (Fig. 1). The TL sensitivity of both Antarctic and non-Antarctic H chondrites range over a factor of around 30, but the Antarctic chondrites are skewed to lower values by a factor of around 3 (Fig. 1). Among the Antarctic samples, there is little or no correlation between TL sensitivity and weathering category A-C. With two exceptions, the Antarctic samples are all type 5 and 6 and, as in previous studies, show no relationship between TL sensitivity and type. Shock classifications are not available for the Antarctic H chondrites, although the two containing maskelynite have among the lowest TL sensitivities observed among this group. The non-Antarctic samples are observed falls, and presumably little weathered, and also show no obvious differences in TL sensitivity between types 5 and 6; the 10 type 4 chondrites do tend towards lower TL sensitivities, though. Most of the samples are of shock classification a-c; the two class d samples have among the lowest TL sensitivities observed in these data.

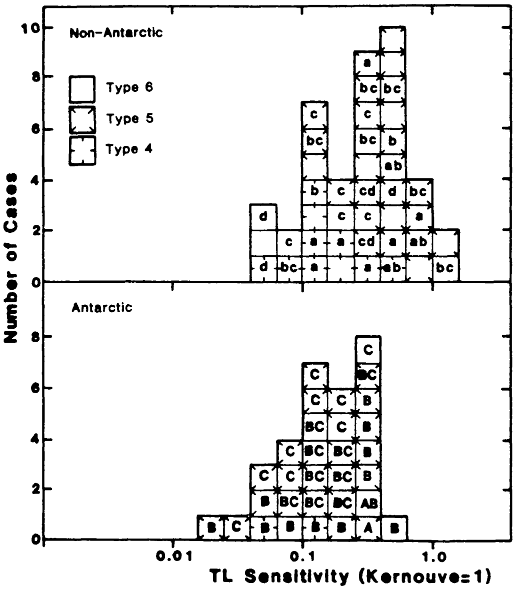

Fig. 1. Histograms of the TL sensitivity of H chondrites. The letters a-f represent shock classifications (least shocked = a) and A-C represent weathering classes based on the appearance of the hand-specimen (least weathered = A). While both Antarctic and non-Antarctic H chondrites show considerable spread in TL sensitivity, the Antarctic H chondrites tend to be skewed to lower values by a factor of about 3.

TL peak temperature and width data (Fig. 2). The non-Antarctic H chondrites plot on a statistically significant trend of increasing peak-temperature with increasing peak-width ($r = 0.90$, $n = 30$, significance 99.9%), with the majority of the data plotting at the lower end of the line. There is no obvious relationship between petrologic type, shock history and position on this line. Antarctic H chondrites do not display such a correlation. Instead, they show a narrower range of peak-width, and do not extend to such low values of peak temperature as the non-Antarctic H chondrites. (According to the t-test, the peak temperatures are different at the 99% level.) There is, therefore, very limited overlap between the non-Antarctic and Antarctic H chondrites in their peak temperature and peak width data.

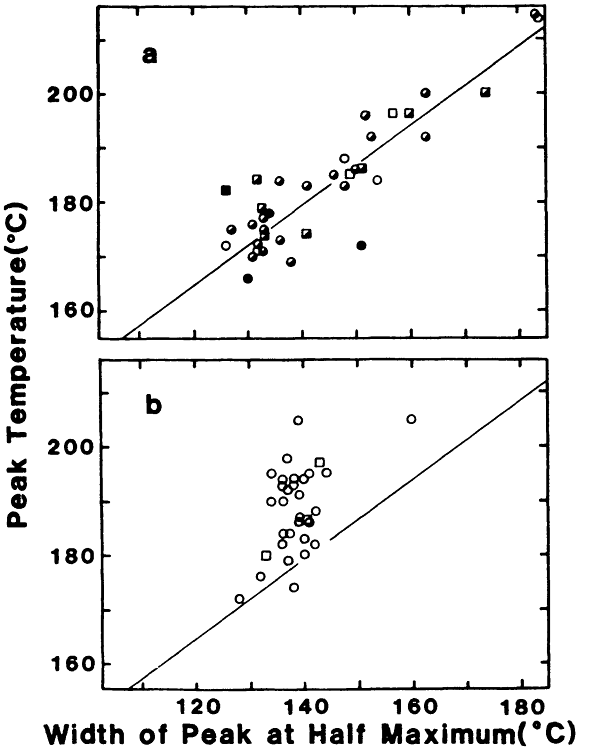

Fig. 2. Plots of the TL peak temperature against peak width for H chondrites. (a) Samples observed to fall world-wide; (b) samples found in the Antarctic. Squares refer to type 4, circles to types 5 and 6, filled symbols represent heavily shocked samples (classes d-f), half-filled symbols represent less heavily shocked samples (a-c), open symbols represent samples for which shock class is unavailable. The diagonal is a regression line through the data for non-Antarctic H chondrites. On this plot, H chondrites from the Antarctic behave differently to those from the rest of the world, and location on the plot does not appear to be related to shock classification.

Discussion. By a series of acid-washing experiments, Sears et al. showed that a factor of 3 decrease in the TL sensitivity of Antarctic meteorites is caused by weathering, the mechanism involving a reduction of albedo (3). Thus the weathering of Antarctic meteorites provides a reasonable explanation for the difference in TL sensitivities between Antarctic and non-Antarctic H chondrites observed here. Against this conclusion is the lack of a correlation between TL sensitivity and weathering category, but it could be that the degree of weathering required to affect TL sensitivity is less than that required to affect the macroscopic appearance of the sample; this is an untested but probably reasonable assumption.

There are no reasonable grounds for attributing the different temperature-width plots for Antarctic and non-Antarctic H chondrites to weathering. Observations on type 3 ordinary chondrites (4,5), data for samples of meteorite heated in the laboratory (4,5), and studies on natural and heat-treated terrestrial feldspars (6,7) show that there are two forms of feldspar producing TL, (these are somehow associated with ordered and disordered structures, but the details are unclear) and that the observed peak shape is determined by the relative proportions of the two forms. Haq et al. also reported data for heating experiments on an H5 chondrite, Kernouve (Fig. 3). As the samples were heated for 10 h at temperatures from 500 to 900 C the TL curves increased in peak temperature and width in a way that paralleled the trend shown by non-Antarctic H chondrites. In another series of experiments in which samples were heated at 1000 C for 1, 2, 10, 20 and 100 h the data moved from the trend line to higher peak temperatures without systematic change in peak width. These changes can also be interpreted in terms of disordering of the feldspar or some process associated with it, but whatever the details the data demonstrate that differences in thermal history are responsible for the distributions of the peak temperature and width data shown by the Antarctic and non-Antarctic H chondrites. Identifying the nature of these thermal histories is more speculative, but shock heating and metamorphism are obvious possibilities. Since there is no relationship between position on the trend line in Fig. 2 and shock classification, one might suspect that the cause of the trend shown by the non-Antarctic H chondrites, and the different behavior of the Antarctic H chondrites, are the result of differences in metamorphic histories, i.e. differences in peak metamorphic temperatures and post-metamorphic cooling rates.

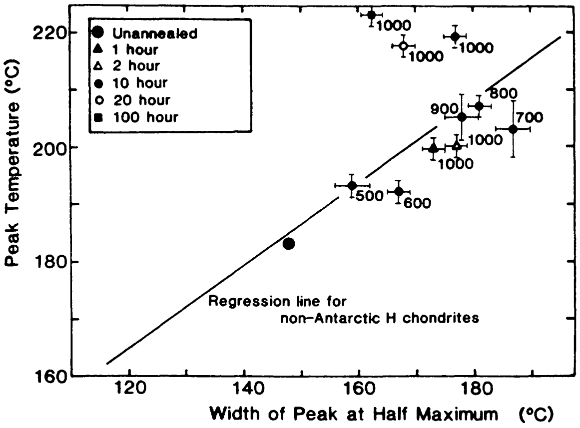

Fig. 3. Plot of TL peak temperature against peak width for samples of the Kernouve H5 chondrite heated in an inert atmosphere at the times and temperatures (C) indicated. Heating at 500-900 C for 100 h causes the data to move along a path close to the regression line in Fig. 2b, while heating at 1000 C for 1-100 h causes the data to move off the line to larger peak temperatures.

1. Haq et al. (1988) GCA 52, 1679. 2. Sears (1988) Nucl. Tracks Radiat. Meas./Int. J. Radiat. Appl. Instrum., D, 14, 5. 3. Sears et al. (1982) GCA 46, 2471. 4. Guimon et al. (1984) Nature 311, 363. 5. Guimon et al. (1985) GCA 49, 1515. 6. Hartmetz and Sears (1987) LPS XVIII 395. 7. Batchelor and Sears (1989) LPS XX 52.
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