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Natural thermoluminescence measurements on meteorites collected on antarctic blue icefields

DEREK W.G. SEARS, HAZEL SEARS, *and* BENJAMIN M. MYERS

Cosmochemistry Group
Department of Chemistry and Biochemistry
University of Arkansas
Fayetteville, Arkansas 72701

The large number of meteorites returned from the antarctic blue icefields each year present special opportunities for research on new meteorites (Palme 1986) and on the interactions between ice and mountains which result in meteorite accumulation (Annexstad 1986). As part of their initial characterization, we have been measuring the natural thermoluminescence levels of the several hundred antarctic meteorites returned each year. Natural thermoluminescence levels are determined by the population of excited electrons in a crystal lattice, which, in turn, is governed by the passage of ionizing radiation through the crystal and its effective temperature over the last million years or so. In the space environment, natural thermoluminescence levels are very high, but once on Earth they decrease by a second-order process, falling a factor of approximately 2.5 in 10^6 years (McKeever 1982; Sears and Hasan 1986; Hasan, Haq, and Sears 1987). In addition, meteorites that have experienced unusually high or low radiation fields, or unusual temperatures, would also be expected to have unusual thermoluminescence levels. In a study of natural thermoluminescence levels in 23 antarctic meteorites, we found that five meteorites with natural thermoluminescence levels of 30,000–80,000 rad had a mean "terrestrial age" (time interval since fall), determined from isotopic studies (Nishiizumi 1986; Evans, Reeves, and Rancitelli 1982), of 150,000 ± 100,000 years. On the other hand, six meteorites with natural thermoluminescence levels of 10,000–30,000 rad had a mean terrestrial age of 400,000 ± 200,000 years (Hasan et al. in press). Also on the basis of our earlier study, we suspect that meteorites with natural thermoluminescence levels below 5,000 rad have had their thermoluminescence levels lowered by reheating (see also Melcher 1981; McKeever and Sears 1980); e.g., by close passage to the Sun, heating by shock events in space or by heating during atmospheric passage (samples too close to the heat-altered surface are avoided but may on occasion be taken accidently).

To date we have measured the natural thermoluminescence for 380 samples, which represent the majority of those collected in the 1985–1986 and 1986–1987 austral summers. Histograms for some of the data are shown in figure 1. The natural thermoluminescence distribution for samples collected at the Allan Hills site, Victoria Land (76°40'S 159°25'E), during the 1985–1986 field season (referred to as ALH85 followed by three digits which identify the individual meteorites), and the histogram for samples collected at the Lewis Cliff region (84°16'S 161°25'E), during the 1986–1987 season (LEW86), are very similar, whereas the samples collected for the Lewis Cliff site during the 1985–1986 field season (LEW85) have a higher proportion of samples in the 5,000–16,000-rad range. There are three meteorites with extremely high natural thermoluminescence suggestive of high radiation doses or low temperatures in space (ALH85003, LEW85448, and LEW86286), and five ALH85 and eleven LEW86 meteorites have natural thermoluminescence levels in excess of 100,000 rad and are good candidates for such a history. The number of meteorites with natural thermoluminescence less than 5,000 rad, and probably reheated, are 13, 18, and 18 for ALH85, LEW85, and LEW86 meteorites, respectively (out of 86, 86, and 163 meteorites, respectively). These meteorites are identified in the paper by Hasan et al. in press).

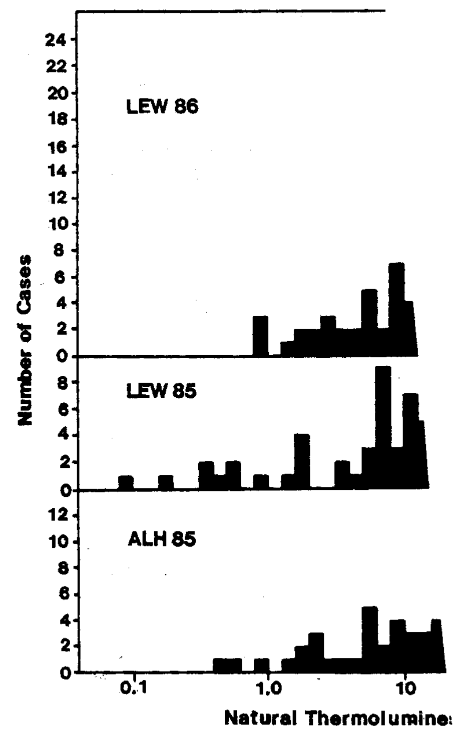

Figure 1. Histogram of natural thermoluminescence values in meteorites collected during the 1985–1986 and 1986–1987 field seasons at the Lewis Cliff (LEW) and Allan Hills regions (ALH).

The cause of the difference in the distribution of thermoluminescence data between the LEW86 and LEW85 collections involves find location (figure 2). The Lewis Cliff site is a 2.3-kilometer-wide, 8-kilometer-long, north-south tongue of ice with a step approximately halfway along its length. The meteorites tend to concentrate along the western edge of the tongue. In addition, many of the LEW86 samples came from a gulley to the east of the tongue (Meteorite Moraine) and show a sharp peak in their natural thermoluminescence histogram at 50,000–63,000 rad; it has been suggested (Score and Cassidy personal communication) that many of the Meteorite Moraine samples are paired (fragments of a single meteorite). The difference in thermoluminescence data between the 1985–1986 and 1986–1987 samples reflects, in part, the presence of the Meteorite Moraine samples in the 1986–1987 collection, but there is also a suggestion that natural thermoluminescence levels may be higher in the lower part of the tongue than in the upper ice tongue. This could also reflect the presence of one or two large showers of fragments from single falls, or it

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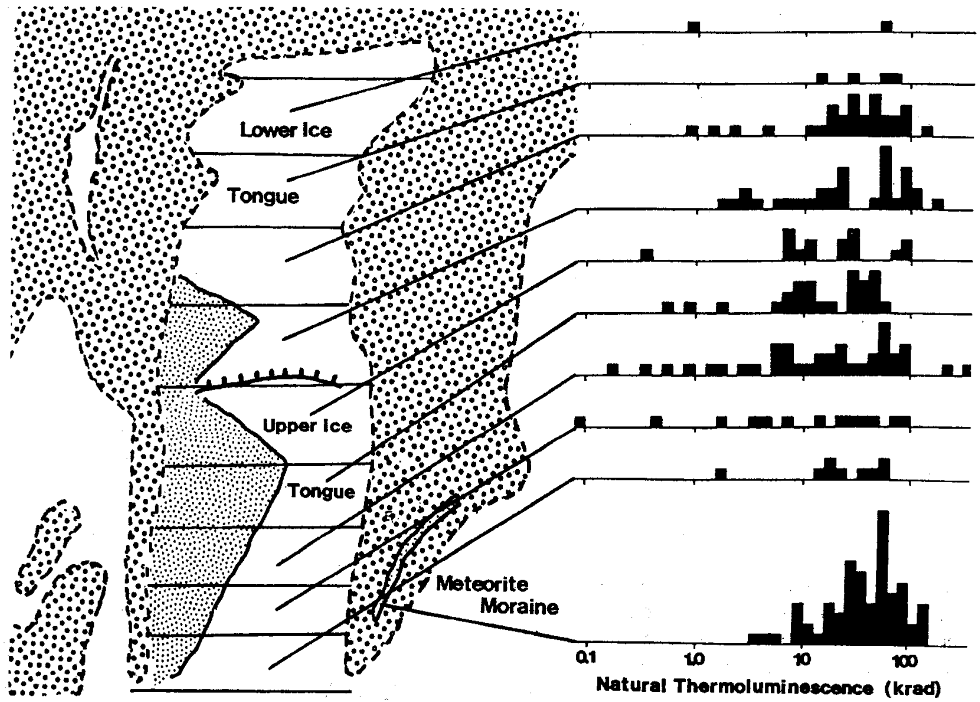

Figure 2. Sketch map showing the Lewis Cliff region and the location of recovered meteorites. Regions of moraine and snow are indicated with circular shading and regions of high meteorite density are indicated with dotted shading. North is to the top, the tongue is about 2.3 kilometers wide and the center of the tongue is located at about 84°16'S 161°25'E. Histograms of natural thermoluminescence values for each of the latitude ranges indicated on the ice tongue (the horizontal lines), and for Meteorite Moraine, are shown on the right.

could reflect the concentration mechanism. It is possible, for instance, that meteorites in the lower ice tongue poured over the moraine from the west, whereas those in the upper ice tongue were carried in from the large icefield to the south (Cassidy personal communication).

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