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Meteorite studies

Natural thermoluminescence measurements on meteorites collected on the Lewis Cliff blue ice field

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Large numbers of meteorites are found each year on the antarctic blue ice fields, providing a unique opportunity to study both the meteorites themselves (Palme 1986) and the interactions between ice and mountains which caused the meteorites to accumulate (Annexstad, 1986). Our laboratory has been measuring the natural thermoluminescence levels of many of these meteorites as a portion of their initial characterization. This article reports on trends in our data from the meteorites collected on the Lewis Cliff blue ice field and clarifies the trends noted in our previous report, (Sears, Sears, and Myers 1989), which were based on a smaller number of measurements.

Natural thermoluminescence levels in meteorites are a function of the number of electrons in metastable traps in a crystal lattice, which, in turn, is determined by the mineralogy of the meteorite, the amount of ionizing radiation that has passed through the crystal lattice, and the effective temperature over the recent (last few million years) history of the meteorite. Natural thermoluminescence levels are very high in space but decrease with time on Earth because of the higher temperatures and lower cosmic ray exposure. The decay is a second-order process; the decrease is a factor of about 2.5 in 10^6 years

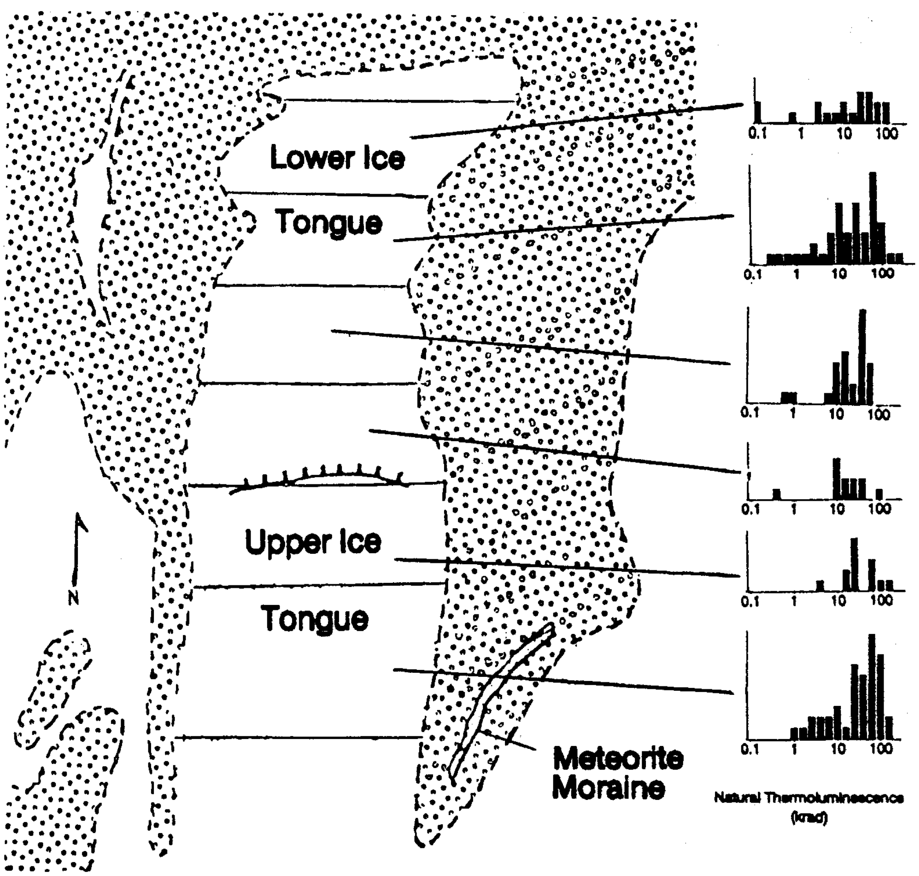

Figure 1. Sketch map showing the Lewis Cliff region and the blue ice field. Regions with circular shading are areas of moraine and snow. Histograms of natural thermoluminescence values of ordinary chondrites from each of the indicated latitude ranges are shown on the right. (krad denotes 1,000 rad.)

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(McKeever 1982; Sears and Hasan 1986; Hasan et al. in press). Most meteorites have natural thermoluminescence levels of 30,000–100,000 rad, depending on how long they have been on Earth. Samples with particularly long terrestrial histories may fall to less than 5,000 rad. Samples with natural thermoluminescence greater than 100,000 rad have not only fallen recently but also they must have been exposed to unusual radiation fields or temperatures. Some meteorites with extremely low natural thermoluminescence levels (less than 5,000 rad) may have been reheated, either by close passage to the Sun or by shock events in space (see McKeever and Sears 1980; Melcher 1981). A very few samples which exhibit low natural thermoluminescence levels may be the result of sampling too close to the heat-altered surface of the meteorite produced during atmospheric passage, though every effort is made to avoid this during sampling.

To date we have measured the natural thermoluminescence of approximately 700 antarctic meteorites, representing the vast majority of samples suitable for this type of analysis. Approximately 220 of these samples are from the Lewis Cliff region (84°16'S 161°25'E), collected during the 1985–1986, 1986–1987, and 1987–1988 austral summers. The data for these samples are listed in the Score and Lindstrom (1990) and Lindstrom (1990). The Lewis Cliff site is a 2.3-kilometer wide, 8-kilometer long, north-south tongue of ice, which is divided into an upper and lower tongue by a step approximately half way along its length (figure 1). A large number of meteorites were also collected from a gully (Meteorite Moraine) to the east of the tongue.

Figure 1 shows histograms of natural thermoluminescence levels of ordinary chondrites collected on various portions of the ice tongue. Histograms of all the Lewis Cliff ordinary chondrites, separated into upper tongue, lower tongue, and meteorite moraine, are shown in figure 2. Since our previous report (Sears et al. 1989), we have found an additional four ordinary chondrites which have natural thermoluminescence levels less than 5,000 rad (LEW87033, LEW87043, LEW87048, and LEW87143) and two with levels greater than 100,000 rad (LEW87041 and LEW87123), all these samples being candidates for unusual histories. The data seem to indicate distinct differences in the natural thermoluminescence levels of the meteorites from the different sampling localities. Considering only those samples with natural thermoluminescence levels between 5,000 and 100,000 rad, the Lower Ice Tongue ordinary chondrites have a lower average natural thermoluminescence level (29,900±2,400 rad) than either the upper tongue or meteorite moraine (41,600±3,800 and 54,600±4,800 rad, respectively). This difference is also observed in the median values of the two ice tongues (24,200 and 38,500 rad for the lower and upper tongues, respectively). The meteorite moraine samples have the smallest range, clustering fairly tightly around 50,000 rad (median value 51,000). This supports the idea (Score and Cassidy personal communication) that many of the meteorite moraine samples are, in fact, fragments of single meteorite.

The differences in natural thermoluminescence levels in the meteorites of the Upper and Lower tongues may also be the result of fragments of a few large falls dominating the data set. It is, however, possible that the differences reflect differences in the concentration mechanism in the two tongues. We intend to investigate these possibilities in greater detail in the immediate future.

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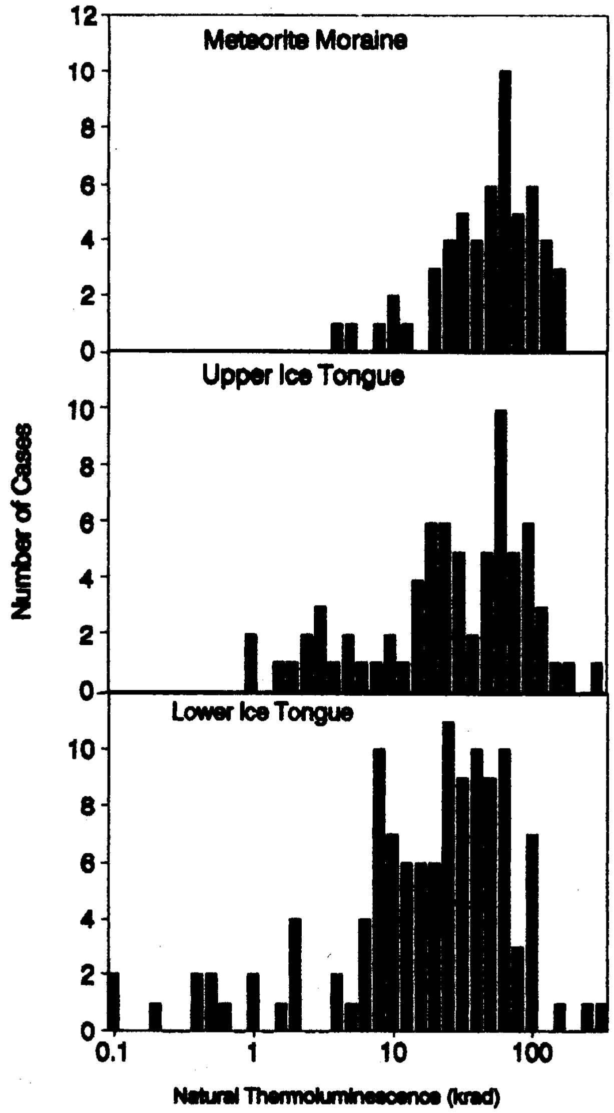

Figure 2. Histograms of natural thermoluminescence values in ordinary chondrites from the Upper Ice Tongue, Lower Ice Tongue, and Meteorite Moraine of the Lewis Cliff region. Samples with natural thermoluminescence levels less than 5,000 and greater than 100,000 rad probably have unusual histories. (krad denotes 1,000 rad.)

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