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Natural thermoluminescence of meteorites and implications for ice movement in the Elephant Moraine region

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The blue ice fields of Antarctica have proved a prolific source for meteorites, over 14,000 meteorite fragments having been collected on them by U.S., Japanese, and European field teams over the last decade. One of the major challenges has been the rapid characterization of these meteorites in order to maximize their utility to researchers. While it is important to identify highly unusual meteorites (e.g., lunar meteorites, Yanai and Kojima 1991) and to do basic comparisons using sample weights and classifications (e.g., Huss 1990), it is also important to collect other scientific data for large numbers of meteorites from individual icefields in order to allow meaningful comparisons of sites. Our laboratory has been measuring natural thermoluminescence (TL) levels of many antarctic meteorites as part of their initial characterization. This paper reports on our ongoing analysis of the meteorite collection from the Elephant Moraine region.

Natural TL levels are a function of the number of electrons in metastable traps in a crystal lattice that, in turn, is determined by the mineralogy of the meteorite, the amount of ionizing radiation to which it has been exposed, and the effective temperature over the recent history of the meteorite (i.e., the last million years in the case of the cold antarctic climate). Most meteorites have natural TL levels of 30,000-100,000 rad, but those with extremely long terrestrial histories may decay to levels less than 30,000 rad. The temperature-dependent decay of TL makes it difficult to use TL to determine exact terrestrial ages of meteorites, especially those with long terrestrial histories. However, it can be highly useful for

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relative comparisons and for "pairing" (i.e., identification of fragments that are actually part of a single meteorite).

We have measured the natural TL levels of more than 800 antarctic meteorites, including approximately 150 from the Elephant Moraine region (76°17' S 157°20' E, see figure 1). We report here on data for ordinary chondrites collected during the 1987-1988 field season, which have been summarized by Score and Lindstrom (1990); data for meteorites collected during the 1990-1991 field season are presently being processed. The Elephant Moraine region (see Faure and Harwood 1990, and references therein for physical description) encompasses at least five meteorite-bearing blue ice fields, including Elephant Moraine proper (EM), Meteorite City (MC), Upper Meteorite City (UMC), Texas Bowl (TB), and the Northern Ice Patch (NIP). While MC, UMC, and TB are physically adjacent to each other, EM and NIP are on opposite sides, and the latter is 40 kilometers separate from the others. We have previously identified numerous pairing groups within our data base without regard to geographic field location. While most pairing groups are found to be restricted to single fields, there are a significant number that span several fields. The howardite group EET87503 covers both TB and EM, and several large L6 groups do likewise or span TB, UMC, and MC. There is also some pairing between UMC and NIP, although the limited number of samples from the latter field makes comparison difficult. This result seems to indicate that, unlike the ice fields in the Allan Hills region (see figure 1; Benoit et al. 1991), the individual ice fields in the Elephant Moraine region are all very similar in terms of their meteorite populations.

Natural TL levels for meteorites from the Elephant Moraine region are generally high (figure 2) with a significant fraction having TL levels greater than 50,000 rad. This would suggest that, in general, these meteorites have relatively small terrestrial ages, probably less than 100,000 years. The cumulative histogram and the data for meteorites from TB show a large number of meteorites with low TL (greater than 30,000 rad), which would suggest these meteorites have longer terrestrial ages than the others. This impression is, however, incorrect because the low TL "hump" in the TB data is caused almost entirely by three large L6 pairing groups that might be paired with each other (i.e., a single meteorite). Thus, the TB data are probably dominated by a single L6 meteorite shower that impacted the Earth prior to most of the other meteorites from this collection.

Natural TL data for the Main and Farwestern blue ice fields at the Allan Hills are also shown in figure 2. The meteorites of the Main ice field are known to have long terrestrial ages, and this is reflected in the large number of samples with low natural TL

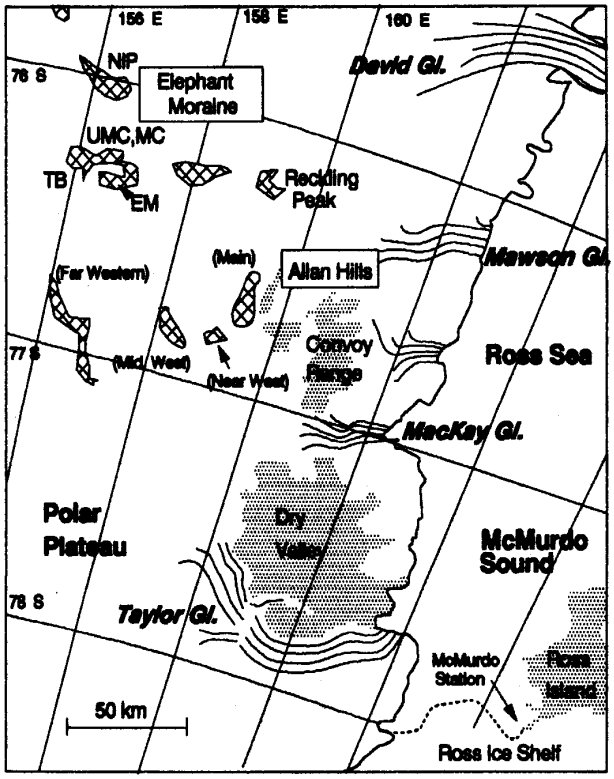

Figure 1. Sketch map showing locations of meteorite-bearing blue icefields associated with the Allan Hills and Elephant Moraine. Names of icefields in the Allan Hills region are given in parentheses. Names of icefields in the Elephant Moraine region are abbreviated: EM = Elephant Moraine proper; UMC = Upper Meteorite City; MC = Meteorite City; TB = Texas Bowl; NIP = Northern Ice Patch.

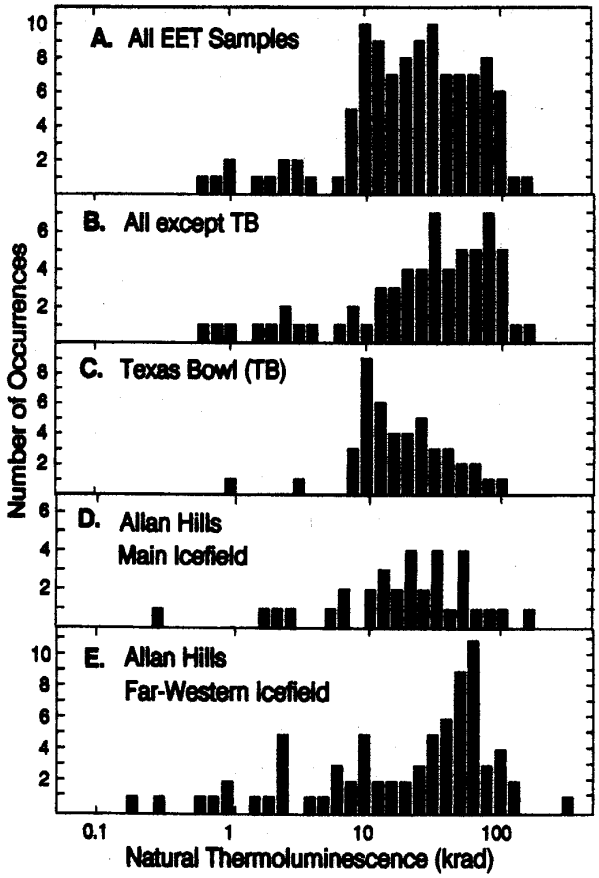

Figure 2. Histograms of natural TL levels in ordinary chondrites from (*A*) all Elephant Moraine sites, (*B*) all sites except Texas Bowl (TB), (*C*) Texas Bowl only, (*D*) Allan Hills Main Icefield, and (*E*) Allan Hills Farwestern Icefield. (krad denotes 1,000 rad.)

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levels. The Farwestern field has a much larger number of meteorites with high TL levels (i.e., short terrestrial ages) and is thus comparable with the Elephant Moraine meteorites. This and field measurements at the Allan Hills Main field indicating strong northerly ice movements (Schultz et al. 1990) might seem to indicate a connection between the Farwestern field at Allan Hills and the Elephant Moraine sites. However, an unusual, highly distinctive group of H5 chondrites that dominates the H-chondrite collection at both the Main and Farwestern fields at Allan Hills (Benoit and Sears 1992) is totally absent at the Elephant Moraine sites. This suggests that the Elephant Moraine and the Allan Hills sites are not linked in terms of their meteorite populations.

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