NATURAL THERMOLUMINESCENCE AND TERRESTRIAL AGES OF METEORITES: AGE CLUSTERING IN THE THE SAHARAN COLLECTION.

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Over the last four years approximately 400 meteorites have been recovered at various locations in the Sahara desert. Approximately half of these meteorites have been classified [1-4]. As part of the initial characterization of the unequilibrated meteorites from this collection, we have collected natural and induced thermoluminescence (TL) data for 26 of the Saharan meteorites. The TL sensitivity data are given in [4]. We report here on the natural TL data.

Natural TL data is useful in a variety of contexts, including pairing of meteorite finds and identification of reheated meteorites [5-6]. Perhaps the most potentially useful application of natural TL, however, is the determination of terrestrial ages for meteorite finds. Because the decay rate of natural TL is dependent on storage temperature, TL can be applied to both very old (up to 1 Ma) Antarctic meteorites and to finds in more temperate climes (generally <40,000 years). We have recently demonstrated strong correlations, in accord with theoretical TL decay curves, between TL and AMS-determined C-14 ages for meteorites from both the Prairie States of the U.S. (Fig. 1a) and Roosevelt County (Fig. 1b) [7] and have previously discussed correlation between natural TL and terrestrial age by the much less precise ^{36}Cl determination (Fig. 1c) [8].

In Fig. 2 we show the natural TL values at 300 ^{o}C in the glow curve for the samples we examined in the present study. It was necessary to use a higher glow curve temperature for this study than is usual in most natural TL studies (typically 250 ^{o}C) because virtually all these meteorites have lost much or all of their natural TL at 250 ^{o}C. None of these meteorites have yet been studied by AMS ^{14}C. The data have been plotted on a theoretical curve which was calculated using the TL parameters for TL decay at an effective storage temperature of 30 ^{o}C [9]. Using this curve as a first approximation, the derived ages are in the same general range as ^{14}C terrestrial ages of a group of equilibrated meteorites from the same vicinity measured by Jull *et al.* [10]. The 30 ^{o}C storage temperature is, in this case, based on the mean summer temperatures experienced by the meteorites in the Sahara. Such an approximation is valid, again pending ^{14}C calibration, considering the approximation to mean summer temperatures (of ~20 ^{o}C) observed in the TL of meteorites from Roosevelt County and the Prairie States of the United States (Fig. 1a,b). The theoretical decay curves for storage temperatures of 25 oC and 35 oC are also given in Fig. 2 as a guide to the effects of slightly lower and higher storage temperatures.

The data in Fig. 2 suggest 4 groups, three of which are clusters on the theoretical line at ages of <15 ka and one of which is at very low natural TL levels (<1 krad at 300^{o}C in the glow curve). The first three clusters, with approximate terrestrial ages of 2500, 7500, and 12000 years are at least partly caused by pairing but differences in induced TL data, classes, and collection sites [4] indicate that pairing is not the sole cause of these clusters. Jull et al. [11] observed clustering in ^{14}C terrestrial ages of an independent group of equilibrated ordinary chondrites from this region, with distinct peaks in the histograms at 4000 and 8000 years. They did not observe any cluster at ~12000 years, but this may be because of the small number of samples in their study. A relatively old group of meteorites would, barring unusual circumstances, be much reduced in numbers compared to younger groups through normal weathering processes and this group is the smallest of the groups with TL > 1 krad. One interpretation of these temporal clusters is that collection/preservation efficiency at the Saharan sites was variable over time, possibly as a result of climate changes [10]. A similar tendency for periods of high and low collection efficiency was observed by both TL [7] and ^{14}C [11] in the Roosevelt County collection. The variable collection efficiency of these sites must be considered in using these collections to estimate paleo-terrestrial meteorite fluxes.

The very low natural TL group (<1 krad at 300 ^{o}C) could represent meteorites with very large terrestrial ages (>20 ka). However, it is more likely that this group is the equivalent of the low TL group observed in the Antarctic collection [12,13] and in observed falls [6]. In this case, it is possible that at least some of the meteorites of this group have very short cosmic ray exposure ages (which are extremely rare), or may have been intensely shocked (which is not supported by the petrographic data [4]), or may have been reheated by close solar passages prior to Earth impact. In connection with the latter suggestion, we note that the size of this group (~15% of the dataset) is very similar to the proportion of meteroid bodies known to have low perihelia orbits, based on the radiants of observed falls [14] and fireball observations [15].

These data, in conjunction with our previous results for meteorites from Roosevelt County, the Prairie States, and the Antarctic, demonstrate the utility of natural TL measurements for meteorite finds. The growing data base for natural TL values from finds from a variety of climates suggests that critical use of theoretical TL decay curves and reasonable approximations of effective storage temperatures permit quantitative terrestrial age determinations. In the case of meteorites from the Sahara, such first approximations give clusters of terrestrial ages which seem to correspond to clusters identified by ^{14}C measurements and which are probably the result of a changing collection efficiency over time. (NASA grant NAG 9-81).

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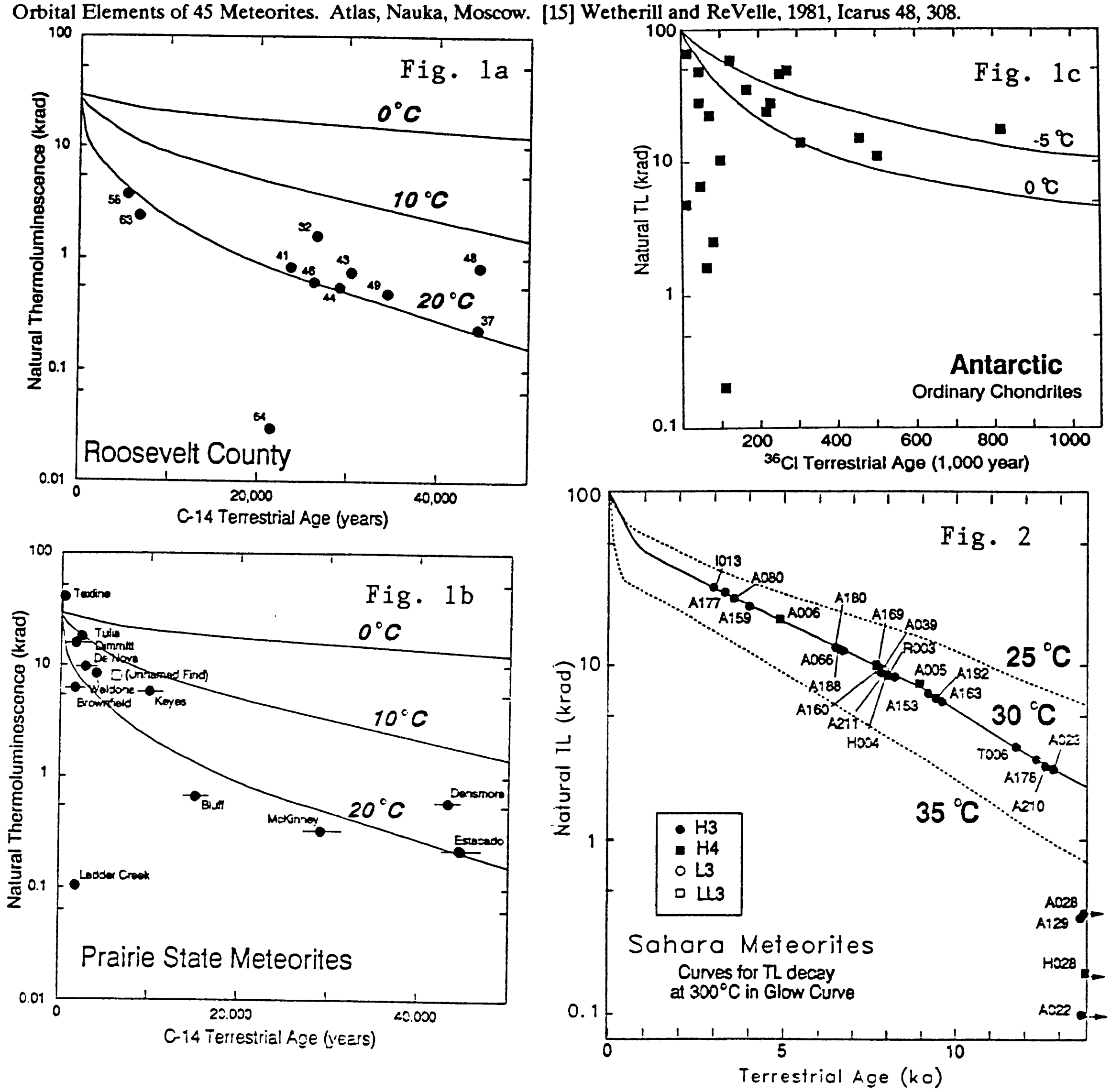

Fig. 1. Natural TL data at 250 °C in the glow curve verses terrestrial age derived from ^{14}C (a,b) or ^{36}Cl (c) for various collection sites. **Fig. 2.** Natural TL data at 300 °C in the glow curve for Saharan meteorites plotted on the theoretical TL decay curve for an effective storage temperature of 30 °C.