NATURAL THERMOLUMINESCENCE AND ITS RELATION TO THE TERRESTRIAL AGE OF METEORITES.

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Introduction: Thermoluminescence is the phenomenon that occurs when a substance, such as a meteorite, with electrons trapped in defects within its crystalline structure by ionizing radiation gives off photons in response to being heated and releasing electrons from the traps [1]. Natural thermoluminescence (NTL), more specifically, refers to the light given off by a meteorite upon its first reheating after entering Earth's atmosphere.

The level of NTL in a meteorite sample corresponds to the level of radiation received by the meteorite in space and can provide clues into the meteorite's history. Evidence suggests that the level of NTL can be affected by reheating of the meteorite sample and is linked to the terrestrial age of the meteorite. This study aims to provide further support to the correlation between level of NTL present in a meteorite and its terrestrial age.

Methods: This study included a total of 43 samples from 27 different meteorites. The names and locations of these meteorites are given in Table 1, along with their NTL levels, taken from the natural log of the ratio of the low tempertature to high temperature peak, and terrestrial age (T. Age) values. Those meteorites whose falls were observed are marked "Obs. Falls" in the Region column.

Table 1. Sample list with Region, NTL, and Age data

Name	Region	ln(LT/HT)	T. Age (years)
NWA 1974	Sahara	N/A	N/A
WIS 91618,16	Antarctica	1.0855247	Indeterminate
WIS 91618, 17	Antarctica	1.119665698	Indeterminate
GRO 95541.7	Antarctica	N/A	N/A
GRO 95541, 8	Antarctica	N/A	N/A
Dhofar 658	Sahara	N/A	N/A
Cali #1	Obs. Fall	1.223775432	2
Cali #2	Obs. Fall	0.795519684	2
Julesburg	Prairie	1.26294028	3437.5
Bovedy #1	Obs. Fall	No LT Peak	40
Bovedy #2	Obs. Fall	No LT Peak	40
NWA 752	Sahara	N/A	N/A
Matsitama	Sahara	-0.48183808	14000
Kalahari 001	Sahara	-0.53062825	13500
Albareto	Obs. Fall	0.802346473	243
Bo Xian	Obs. Fall	1.56563529	32
GRA 95215, 8	Antarctica	1.062244644	Indeterminate
GRA 95215, 9	Antarctica	1.077558879	Indeterminate
GRA 98013, 10	Antarctica	1.864080131	Indeterminate
GRA 98013, 11	Antarctica	1.791759469	Indeterminate
MAC 02592, 5	Antarctica	N/A	N/A
MAC 02592, 6	Antarctica	N/A	N/A
LAP 0233, 8	Antarctica	-0.12516314	Indeterminate
ALH 85033, 37	Antarctica	2.216642663	50000
ALH 85033, 38	Antarctica	2.005050724	Indeterminate
Bjurbole #1	Obs. Fall	1.336349685	110
Bjurbole #2	Obs. Fall	1.406255104	110
Bremervorde #1	Obs. Fall	0.446287103	154
Bremervorde #2	Obs. Fall	0.770670542	154
Hamlet #1	Obs. Fall	0.706219262	50
Hamlet #2	Obs. Fall	0.693147181	50
Baratta #1	Prairie	1.287087711	3600
Baratta #2	Prairie	1.161132646	4687.5
Cynthiana #1	Obs. Fall	0.871222446	132
Cynthiana #2	Obs. Fall	0.8936909	132
Hedjaz #1	Obs. Fall	N/A	99
Hedjaz #2	Obs. Fall	N/A	99
Thuathe #1	Obs. Fall	1.637830987	7
Thuathe #2	Obs. Fall	1.487390478	7
Tiffa 002 #1	Sahara	-0.35139788	14000
Tiffa 002 #2	Sahara	-0.30368241	14000
Y-81075, 97	Antarctica	1.045502463	Indeterminate
Y-74002, 98	Antarctica	0.540121993	Indeterminate

Approximately 4 mg of the samples were placed in a small copper pan and heated at a linear rate up to 500°C in the TL apparatus. The low temperature (LT) and high temperature (HT) peaks were then measured (in counts/second) and the natural log of the ratio [2] used as a measure of NTL for this study.

Since the terrestrial age is known exactly for observed falls, those meteorites can be easily plotted on a graph of NTL vs. Terrestrial Age. In the case of non-observed falls, terrestrial ages were found by using graphs taken from Benoit et al. [3] illustrating how quickly NTL decays with increasing terrestrial age at different average temperatures. The 0°C, 20°C, and 30°C curves correspond to the Antarctic, Prairie State, and Saharan environments where the meteorites were located. A value for NTL was obtained using the formula: $\log(NTL) = (1.2903 \times LT/HT) + 1.089$ was marked on the y-axis and an age determined by extrapolating the NTL value out to the appropriate decay curve for the region containing the sample and reading the age value for that point on the curve from the x-axis.

Results: Two graphs were created using the applicable data from Table 1. Figure 3 is a plot of NTL, measured as ln(LT/HT), for all meteorites with measurable NTL and terrestrial age.

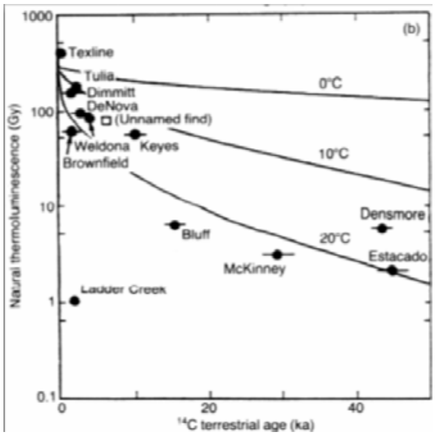

Figure 1. NTL decay curves for Antarctic (O°C) and Prairie State (20°C) environments.

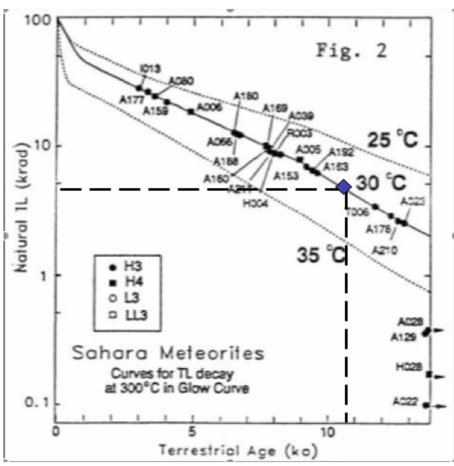

Figure 2. NTL decay curve for Saharan environment, with terrestrial age extrapolation method illustrated.

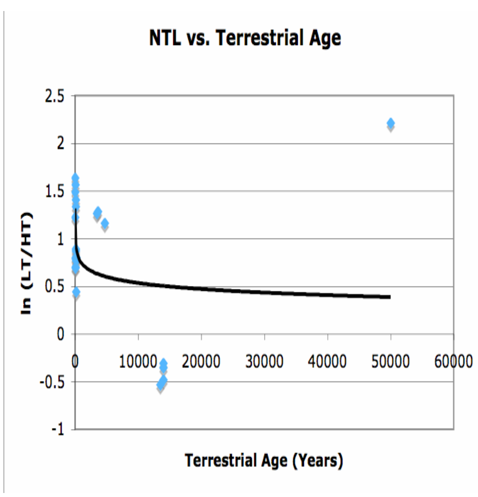

Figure 3. NTL vs. Terrestrial Age for all samples with measurable TL and age.

In order to better show the distribution of terrestrial ages for the observed falls, the observed falls were plotted separately on a similar graph, shown in Figure 4.

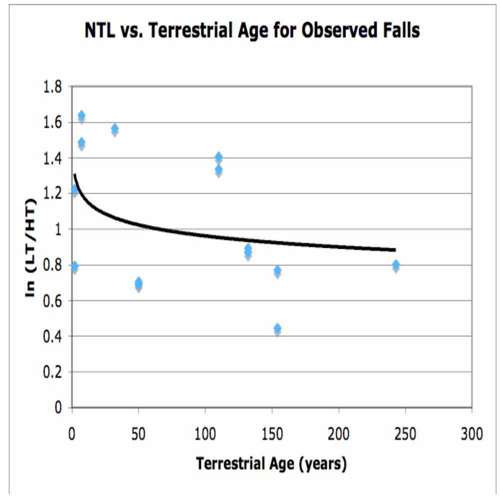

Figure 4. NTL vs. Terrestrial Age for Observed Falls

Some samples were unable to be plotted on these graphs due to the lack of a low temperature peak in the data obtained from the TL apparatus. Terrestrial ages for certain samples of meteorites from the Antarctic were impossible to estimate using the graph in Figure 1 due to the very gradual decay curve for the Antarctic environment.

Discussion: The results shown in Figures 5 and 6 support the evidence that lower levels of NTL correlate to a higher terrestrial age. One exception is the Antarctic meteorite sample ALH 85033, 37, which has a high value of NTL for its estimated terrestrial age. As shown in Figure 1, however, storage temperature at an average of 0°C causes the NTL of a meteorite to decay slowly, so this could account for the NTL value remaining high after a long period in this sample.

The observed falls, with terrestrial ages generally much lower than the other meteorites, have a higher average value of NTL. Their distribution, shown in Figure 6, illustrates a bit more clearly the general trend of decreasing levels of NTL with increasing terrestrial age.

Conclusion: The results of this study appear to further support the link between decreasing levels of NTL and increasing terrestrial age, as illustrated in Figures 5 and 6. The level of NTL present in a sample along with the knowledge of the rate of NTL decay for certain average storage temperatures can provide information on the parent meteorite's history such as the meteorite's terrestrial age and possible reheating events.

References: [1] Sears, D. W. G. and Hasan, F. A. (1986) *Thermoluminescence and Antarctic Meteorites*, Lunar and Planetary Inst. International Workshop on Antarctic Meteorites, 83-100. [2] Hasan, F. A. et al. (1987) *Natural thermoluminescence levels in meteorites, I: 23 meteorites of known Al-26 content*, Proc. 17th Lunar and Planet. Sci. Conf., Part 2, J. Geophys. Res., 92, E703-E709. [3] Benoit et al. (1992) *LPSC XXIII, 89-90*.