

THERMAL STABILITY OF THERMOLUMINESCENCE IN CHONDRITES

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New results are presented concerning the decay of thermoluminescence in ordinary chondrites. No evidence is found for the existence of two different decay rates as previously reported and a new interpretation of the earlier data is presented. The relevance to determination of terrestrial ages by thermoluminescence is discussed.

INTRODUCTION

A number of techniques have been proposed to determine terrestrial ages of meteorites including the use of ^{39}Ar , ^{14}C , ^{26}Al , ^{36}Cl (Wasson, 1974), and most recently thermoluminescence (Christodulides *et al.*, 1970; Durrani, 1971; Sears and Mills, 1974a; and Melcher, 1978a). The thermoluminescence (TL) method relies on the knowledge of the rate of decay of the low temperature peak. Evidence has been presented (Sears and Mills, 1974b) for the existence of two groups of chondrites in which the TL decays at different rates. If such is the case, one must determine the rate at which the TL is decaying in a new find before attempting to date that meteorite. However, we present here new results which show that 10 chondrites, including representatives from both of the previously defined groups, all have very similar decay characteristics following identical laboratory irradiations. In addition, we offer a new interpretation of the original "two groups" data that is consistent with our new results.

APPARATUS

The apparatus used for these measurements has been described in detail elsewhere (Hoyt *et al.*, 1970). Approximately 4 mg powdered samples are heated at $1.8^\circ\text{C}/\text{sec}$ on a nichrome plate in an oxygen-free argon atmosphere. The light emitted is detected by an EMI 9635QB bi-alkali photomultiplier with a Corning 5-60 blue filter. The resulting DC signal is amplified and recorded *vs.* temperature on an X - Y recorder, thus producing a glow curve.

Measurements were made on interior samples to avoid heat-altered material near the fusion crusts.

RESULTS

The isothermal decay of the TL of 10 chondrites was measured over a period of 68 hours. Drained samples were given 3000 rad irradiations with a 1 Curie ^{90}Sr beta source and then stored at $120^\circ \pm 1^\circ\text{C}$. The remaining TL was measured after 20 and 68 hours. Table 1 shows the measured TL intensities as fractions of the intensities measured immediately after irradiation. Data are shown for the low temperature peak (LT) and for a glow curve temperature (T^*) of 250°C . The low temperature peak is located at $\sim 175^\circ\text{C}$ immediately following irradiation but shifts to higher temperatures when stored at 120°C . After 20 hours it is located at $\sim 240^\circ\text{C}$, and after 60 hours it is located at $\sim 260^\circ\text{C}$. Since the long-term decay rates are the most important, the ratio of the intensity after 68 hours to the intensity after 20 hours is also given to show the decay rate of each meteorite in this interval. Experimental difficulties resulted in the loss of the initial intensity data for Barwell and Hesse; consequently, only the ratio of the intensity at 68 hours to the intensity at 20 hours is available for these meteorites. The results show no evidence for two different rates of decay of the low temperature TL of these meteorites within experimental error over a period of 68 hours, with the possible exception of Malakal. This meteorite is also anomalous in other respects (Melcher, 1978b, and Cressy and Rancitelli, 1974). Of these chondrites, Barwell and Crumlin had previously been assigned to the low retentivity group, while Saratov and Wold Cottage were thought to be more retentive (Sears and Mills, 1974b). The other meteorites listed had not been classified on the basis of TL decay.

The decay of the TL at a glow curve temperature of 250°C as a function of storage time at 120°C is shown in Figure 1 for the meteorite Fisher, for which more data are available than for the other meteorites listed in Table 1. The decay is not exponential, which indicates that the TL annealing is not characterized by a first order process. The slower-than-exponential decay implies the existence of several overlapping peaks, higher order kinetics, or both.

DISCUSSION

The original evidence for the TL in different meteorites decaying at different rates was based on the decay of the *natural* TL as a function of storage time at 120°C (Sears and Mills, 1974b). The natural TL begins to decay from its orbital equilibrium level at the time of fall since the dose-rate while on earth is negligible. Consequently, old meteorites will have decayed more than young ones. However, since the decay with time is not

Table 1
TL intensities after storage at 120 °C as fractions of initial intensities.
The original TL retentivity class refers to Sears and Mills, 1974b.

Meteorite	Original TL Terres- retentivity class	Age (yrs.)	Fraction of initial intensity after 20 hours		Fraction of initial intensity after 68 hours		Intensity after 68 hours Intensity after 20 hours	
			LT	T* = 250 °C	LT	T* = 250 °C	LT	T* = 250 °C
Wold Cottage	high	183	0.16	0.79	0.08	0.42	0.53	0.52
Saratov	high	60	0.23	0.67	0.13	0.39	0.60	0.46
Crumlin	low	76	0.16	0.35	0.10	0.21	0.62	0.60
Barwell	low	13					0.60	0.60
Fisher	—	84	0.24	0.55	0.14	0.29	0.60	0.53
Farmville	—	44	0.27	0.89	0.13	0.45	0.52	0.51
Innisfree	—	1	0.25	0.79	0.14	0.47	0.60	0.59
Hessle	—	109					0.55	0.56
Ensisheim	—	486	0.20	0.42	0.11	0.23	0.55	0.55
Malakal	—	8	0.48	0.67	0.37	0.42	0.77	0.63

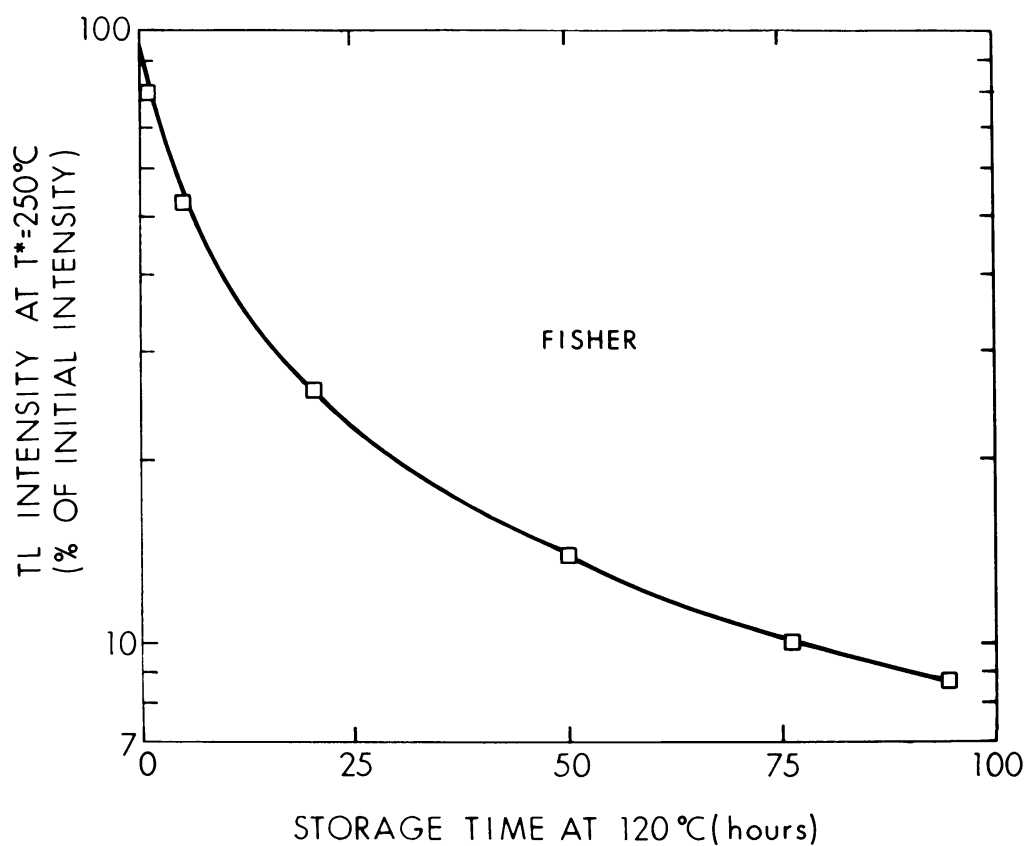


Fig. 1 Decay of the TL induced by a 1200 rad beta dose in the Fisher meteorite as a function of storage time at 120 °C.

exponential, a meteorite may show different rates of decay depending on the part of the decay curve that is observed (see Fig. 1). The natural TL of an old meteorite such as Wold Cottage would be expected to decay slowly in that type of experiment because it has reached the flatter portion of the curve. The natural TL of a young meteorite such as Barwell would be expected to decay somewhat faster in that experiment because it is decaying along the steeper portion of the curve. Therefore, it now appears that the earlier evidence for the existence of two groups could be the result of starting the laboratory decay experiment with the natural TL in samples of both young and old meteorites. This has the effect of starting the decay experiment at different points on a common natural decay curve which is equivalent to starting with different initial doses. In the present work we have started with drained samples and given each of them identical 3000 rad doses, in order to avoid this effect. Starting with identical test doses, we see no evidence for different decay rates in these meteorites with the one exception already noted. This results in a simplification in the use of TL to date meteorite finds by eliminating the need for determining the decay characteristics of each meteorite. Effects related to differences in the initial natural doses warrant further investigation.

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