# TERRESTRIAL AGES OF ANTARCTIC METEORITES BASED ON THERMOLUMINESCENCE LEVELS IN THEIR FUSION CRUST.

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Terrestrial age of meteoritic finds is an important parameter, which enables us to evaluate the frequency of falls, its time variation, and in turn, the mechanism of their injection into the earth crossing orbit in the interplanetary space. Estimation of terrestrial age is particularly useful for Antarctic meteorites because they can also be used as probes to understand the dynamics of ice as well as the mechanism of their accumulation in a few select localities in Antarctica.

Activity levels of cosmogenic radionuclides, compared to their production rate in space, allows us to estimate the period since their fall, when cosmic ray production ceased. However, these production rates depend on size of the meteoroid, shielding depth of the sample and degree of saturation, which are normally not independently known (1,2). Thermoluminescence (TL) acquired due to cosmic ray exposure in space also decays after the meteorite fall but the extent of its decay has not provided a reliable method of estimating terrestrial ages (3). Ninagawa et. al. (4) instead suggested that TL in the meteorite fusion crust, which gets reset to zero at the time of fall as a result of atmospheric heating, subsequently builds up due to cosmic ray exposure on the earth and the ambient radioactivity, may provide a measure of their terrestrial ages ($T_E$). Thus $T_E$ = TL acquired/(TL dose/a).

We here report results of our study in six Antarctic meteorites collected from Allan Hills, Meteorite Hills and Mount Baldr (Table 1). Surface chips containing the fusion crust were chipped, grinded and polished from all sides, washed in an ultrasonic bath and crushed. Subsequently the samples were treated with 1N HCl to remove any weathered material and grains in the size range 45-110 μm were sieved and deposited on stainless steel discs. Fusion crust samples of Dhajala and Kirin (both fell in 1976) were used as reference. Some of the glow curves obtained at a heating rate of 5°C/sec and the acquired dose (ED) profile are shown in Fig. 1. The ED values were obtained using second glow normalisation.

Two fusion crust samples from Dhajala and ALHA 77231 were studied for anomalous fading at room temperature. These tests did not indicate any appreciable fading (<5%) in the plateau region for a storage period of upto 100 days and shows that long term TL fading may be negligible.

The Antarctic meteorites spend a part of their terrestrial residence time on surface of ice [$T_S$] and a part buried deep in ice [$T_D$] as they travel from the region of fall to the region of recovery (5). Thus $T_E = T_S + T_D$. Dynamical considerations suggest that $T_D \ll T_S$. Hence $T_E \approx T_S$. The dose received by the Antarctic meteorites thus mainly results from irradiation due to the cosmic ray flux on the surface of ice. The dose rate due to the cosmic rays at the Antarctic altitudes of 1500-2000 m and geomagnetic latitude of 70°S is computed to be 0.6-0.8 mGy/a

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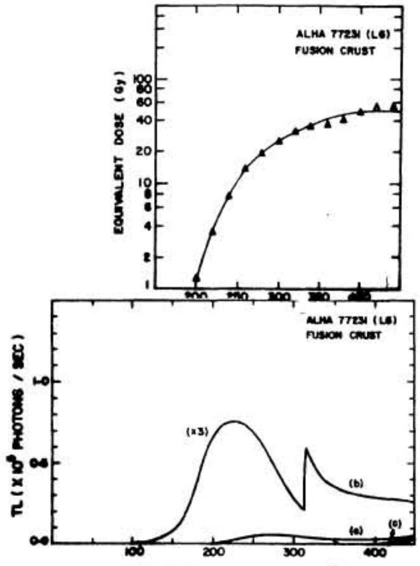

Fig.1. Typical TL glow curves for (a)Natural, (b)β induced TL for a test dose of 500 Gy, (c)Black body and ED profile for ALHA 77231.

Table 1: TL data and the estimated terrestrial ages by the fusion crust method.

| Meteorite | Class | Latitude and Longitude | Altitude (m) | E.D. | | Dose rate (mGy/a) | TL $T_E$ (yrs) | Cosmogenic $T_E$ (yrs) |
|---|---|---|---|---|---|---|---|---|
| | | | | (240-260°C) | (360-380°C) | | | |
| DHAJALA | H3 | 22°22'N,71°25'E | 65 | 0.12 | 0.16 | 1.89[6] | 85 | 11[+] |
| KIRIN | H4 | | 65 | 0.09 | 0.28 | 1.89[6] | 175 | 11[+] |
| ALHA 77256 | DIO | 76°45'S,159°20'E | 2000 | 7 | 42 | 0.80 | $5.2 \times 10^4$ | $1.1 \times 10^4$(7) |
| ALHA 77257 | UREI | 76°45'S,159°20'E | 2000 | 33 | 123 | 0.79 | $1.6 \times 10^5$ | $3.7 \times 10^5$(7) |
| ALHA 77231 | L6 | 76°45',159°20'E | 2000 | 13 | 37 | 0.80 | $4.6 \times 10^4$ | - |
| EETA 79001 | SHER | 76°15'S,156°30'E | 2000 | 7 | 57 | 0.92 | $6.2 \times 10^4$ | $3.2 \times 10^5$(8) |
| MBRA 76001 | L6 | 77°35'S,160°,9'E | 2000 | 6 | 14 | 0.80 | $1.7 \times 10^4$ | $3.2 \times 10^4$(9) |
| META 78028 | L6 | 79°41'S,155°45'E | 1500 | 15 | 67 | 0.63 | $10.6 \times 10^4$ | $3.3 \times 10^4$(9) |

[+] known ages.

(7,8). The contribution of internal radioactivity (U, Th and K) in meteorites and the surrounding ice to dose rate is negligible (<10%) (Table 1). These data lead to the following conclusions (1) The acquired dose for known falls like Dhajala and Kirin with $T_E \sim 11a$ is close to zero. When coupled to an indoor dose rate of 1.6 mGy/a (6) this gives an age of 85a and 175a respectively, well within the experimental uncertainty in detecting the low light levels of 1000 photons/sec. (2) The signal in the fusion crust of Antarctic meteorites is 10-100 times higher than in these recent falls. The ages computed from the ED plateau at T*>300°C exhibits a range of 10-100 Ka for the six Antarctic meteorites studied. The observed trend is generally consistent with the ages based on cosmogenic radionuclides (7,8,9) as shown in Table 1. The present study indicates the feasibility of the TL dating of fusion crust as a rapid and simple method for terrestrial age estimation.

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