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TERRESTRIAL AGES OF ANTARCTIC METEORITES MEASURED BY THERMOLUMINESCENCE OF THE FUSION CRUST

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Abstract: The acquired doses of 14 Antarctic meteorites were measured using the thermoluminescent (TL) intensity of the fusion crust. It was found that there is a good correlation between the acquired TL doses and the terrestrial ages, which were previously measured by the cosmogenic radionuclide abundance.

1. Introduction

Measurement of the terrestrial ages of Antarctic meteorites is important for studying the influx rate, its variation over time, and the history of movement of the ice sheets. Terrestrial age is usually estimated by measuring the abundance of cosmogenic radionuclides by means of accelerator mass spectrometry or non-destructive gamma ray spectrometry. There are certain advantages, however, of using a thermoluminescence (TL) technique, as it is easier than other methods for treating a large number of meteorites in a short time.

Typical terrestrial ages obtained by using a TL technique have been derived from the ratio of the peak TL intensity at low temperature to that at high temperature in the glow curve for the interior of a meteorite (HASAN *et al.*, 1987). This method is based on the natural fading of the TL intensity of a meteorite irradiated in space after it fell to the earth. But the rate of fading strongly depends on the storage temperature of the meteorites, which can vary widely. Therefore it is difficult to accurately estimate the rate of fading. A new method using the fusion crust to estimate terrestrial age was previously proposed by one of the authors (NINAGAWA *et al.*, 1983), and we recently developed a sample preparation process and TL measurement apparatus. The principle behind this method is that the TL intensity of the fusion crust is reset to zero due to heating during its atmospheric passage, and subsequently increases with time due to cosmic ray irradiation. The terrestrial age thus can be derived from the acquired dose of the fusion crust divided by the annual dose.

2. Sample Preparation and Measurement

Meteorite samples were filed out of the fusion crust using a diamond grinder sheet in water and the magnetic components were removed. After drying, 5-mg each sample was measured using a TL analyser (KUJIRAI *et al.*, 1989). Employing this method, the TL intensity of the fusion crust can be measured without sample loss. All procedures were carried out under dim light.

The sample to be measured was spread on a 1.0 cm in diameter platinum disc and heated from room temperature to 400°C at a heating rate of 5.2°C/s in a nitrogen gas atmosphere. A blue glass filter (Corning 5–60) was placed between the ceramic heater and the photomultiplier tube to reduce black body radiation. An additional dose (30 Gy from a ^{60}Co gamma ray source) was given to some of the samples of each meteorite in order to estimate the acquired dose.

3. Results and Discussion

The natural TL intensity profile from the fusion crust is shown in Fig. 1. The TL intensity decreases from the interior to the fusion crust. From this result, the TL intensity within 1 mm of the fusion crust was considered to have been reset to zero when the meteorite fell to the earth, and subsequently increased due to irradiation by cosmic rays. The acquired dose of this 1-mm portion was then estimated from the ratio of natural TL intensity to natural + artificial TL intensity in the plateau region of 180–260°C. The results are shown in Table 1.

The terrestrial ages of 11 of 14 meteorites are known as obtained by measuring the abundance of cosmogenic radionuclides (NISHIIZUMI *et al.*, 1989). A plot of the acquired dose against the terrestrial ages is shown in Fig. 2. The terrestrial ages were found to correlate well with the acquired doses, but a difference was found between Yamato meteorites and non-Yamato meteorites. This may be due to the different history of terrestrial residence. From the results of 7 Yamato meteorites, preliminary, the relation between terrestrial age T and acquired dose D was obtained as follows:

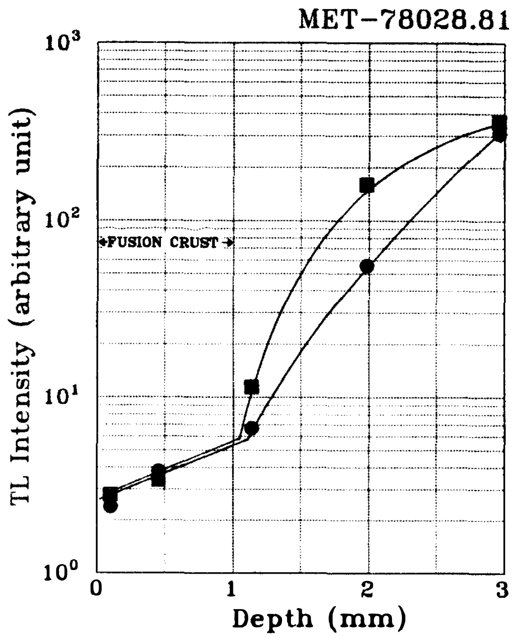

Fig. 1. Natural thermoluminescence intensity profile from fusion crust. Circles and squares indicate TL intensities at 200 and 250°C respectively.

Table 1. Terrestrial ages and acquired doses of Antarctic meteorites.

Meteorite	Class	Terrestrial age ($\times 10^3$ yr)	Acquired dose (Gy)
Y-74014,100	H6	11	2.8
Y-74191,110	L3	17	7.5
Y-74647,70	H5	4	13.0
Y-75102,75	L6	3	1.7
Y-75271,88	L5	2	0.6
Y-791500,86	H3	28	20.7
Y-791630,64	L4	1	2.1
Y-74190,96	L6		36.6
Y-74362,89	L6		47.2
Y-81124,93	H5		7.8
ALH-77297,81	L6	80	27
ALH-78043,81	L6	500	36
ALH-78076,81	H6	130	34
MET-78028,81	L6	70	16

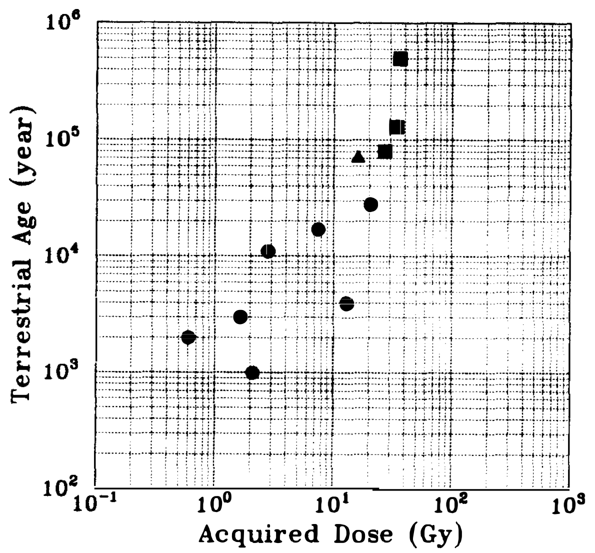

Fig. 2. A plot of terrestrial ages against acquired doses. Circles: Yamato meteorites. Squares: Allan Hills meteorites. Triangle: Meteorite Hills meteorite.

$$T\,(\text{year}) \simeq 10^3 D\ (\text{Gy})$$

From this relation, the terrestrial ages of 3 Yamato meteorites, Y-74190, Y-74362 and Y-81124, were estimated as 37000, 47000, and 8000 years respectively.

In order to estimate the terrestrial age more accurately, several sections of the fusion crust of each meteorite should be tried. The area of fusion crust facing upward when the meteorite was found in Antarctica was most probably exposed to the sun for a long time. The TL intensity of that area of fusion crust was thus no doubt reduced due to optical bleaching, with the result that a younger value was obtained for the terrestrial age.

As further improvements and refinements such as that described above are made in dating method, routine measurement of the terrestrial age of meteorites by use of the fusion crust will provide a truly viable prospect.

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