THE NATURAL THERMOLUMINESCENCE PROPERTIES OF BASALTIC AND LUNAR METEORITES. Derek W.G. Sears, Paul H. Benoit, H. Sears, J. David Batchelor and Steve Symes. Cosmochemistry Group, Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701.

Lunar meteorites have unusually low natural TL levels which Sutton has ascribed partly to 'anomalous fading' of the TL (1,2) and partly to a recent heating event such as a small perihelion orbit or shock-heating at the time of lunar ejection followed by a short earth-moon transit time (3-5). We have found that MAC88104 and MAC88105 have similar natural TL properties to the earlier lunar meteorites (6). The basaltic meteorites (howardites, eucrites, diogenites and mesosiderites) are similar to the lunar samples in their chemical and physical properties (7), and they appear to have suffered similar igneous and regolith histories, although the igneous phase was simpler for the meteorites (7,8). We have obtained natural TL data for 65 basaltic meteorites to see if they have suffered similar unusual histories, and whether their properties shed further light on the history of the lunar meteorites.

We have found that, like the lunar meteorites, the basaltic meteorites have low natural TL levels compared to chondrites (5-20 krad, c.f. 30-80 krad for chondrites, when measured at 250°C in the glow curve, Fig. 1, and 15-40 krad, c.f. 40-65 krad for chondrites, when the TL is measured at 400°C in the glow curve). Antarctic basaltic meteorites have slightly lower natural TL than their non-Antarctic equivalents at both glow curve temperatures. We also measured the anomalous fading of the two MAC lunar meteorites, four basaltic meteorites and, as a control, the Bruderheim L5 chondrite. We found that all the lunar and basaltic meteorites displayed anomalous fading, but, in keeping with earlier results (2,9), that Bruderheim did not. As for many volcanic feldspars, the anomalous fading followed a power-law and when extrapolated to 10^5-10^6 years is capable of reproducing the low natural TL of most of the basaltic meteorites. The systematically lower natural TL values for basaltic meteorites compared to chondrites is most readily understood in terms of anomalous fading, but, as is the case for chondrites, some samples appear to have suffered additional thermal draining.

Orbital theory and cosmic ray exposure ages are also inconsistent with the low natural TL of the basaltic meteorites as a whole being due to small perihelia orbits. Perihelia small enough to drain the natural TL are either Venus approaching or Venus-crossing (0.7AU, ref. 10), and such orbits are stable only on a 10^5 year timescale (11). Cosmic ray exposure ages for the basaltic meteorite classes are 4-75 Ma, frequently 5-40 Ma (calculated from the data in ref. 12 using the equations in ref. 13), which probably represent the time at which the meteorites were placed on their earth-bound orbits. Similarly, the $^3He/^{21}Ne$ values for basaltic meteorites are remarkably constant at 5+-2 (12), inconsistent with the loss of He expected at such solar distances (c.f. 14.)

The plot of natural TL against terrestrial age for Antarctic and non-Antarctic basaltic meteorites (16) is rather similar to the equivalent plots for chondrites (17), albeit skewed to lower natural TL values because of anomalous fading (Fig. 2). For the chondrites, Antarctic meteorites with the largest terrestrial ages have natural TL values of around 5 krad (@ 250°C), and values <5 krad are due to recent reheating. The analogous 'cut-off' for basaltic meteorites also appears to be around 5 krad, and we suggest that Pasamonte, Moore County, Bununu, Lowicz, three diogenites (ALHA77256, ALHA84001, EETA79002) and the lunar meteorites Y791197, ALHA81005 and MAC88104/5 have been reheated within the last 1 Ma or so, either by small perihelia or moderate shock-heating. If we assume, after Sutton (3-5), that it was the force of ejection from the Moon that drained the natural TL of the lunar meteorites, that the dose rate following ejection was 10 rad/year, and decay constants from the present work, then MAC88104 and 88105 have Earth-Moon transit times of about 21,000 and 18,500 years, respectively.

The TL data confirm the pairing of the howardite samples EET87503, 87509, 87510, 87513, 87518, 87531 (although, unlike ref. 15, we would exclude 87512 and include 87528 in the pairing group), the eucrites LEW85303, 88005, the mesosiderites EET87500, 87501 and the lunar meteorites MAC88104, 88105, but not the howardites LEW85313 and 85441.

(1) Wintle (1977) J. Lumin. *15*, 385. (2) Hasan et al. (1986) J. Lumin. *34*, 327. (3) Sutton & Crozaz (1983) GRL *10*, 809. (4) Sutton (1986) Meteor. *21*, 520. (5) Sutton (1986) Proc. 10th Symp. Antarct. Meteor. 133. (6) Sears et al. (1990) LPS. XXI 1121. (7) Basaltic Volcanism Study Project (1981) chap. 1.2.8. (8) McSween (1989) Ann. Rev. Earth Planet. Sci. *17*, 119. (9) McKeever & Durrani (1980) Mod. Geol. *7*, 180. (10) Sears & Hasan (1986) LPI Tech. Rpt. 86-01, 83. (11) Wetherill (1985) Meteor. *20*, 1. (12) Schultz & Kruse (1989) Meteor. *24*, 155. (13) Schultz et al. (1991) GCA *53* (in press). (14) Anders (1978) NASA Spec. Publ. 2053, 57. (15) Mason (1988) In Antarct. Meteor. Newslett. *11* #2. (16) Nishiizumi et al (1989) EPSL. *93*, 299. (17) Hasan et al. (1987) Proc. 17LPSC *92*, E703.

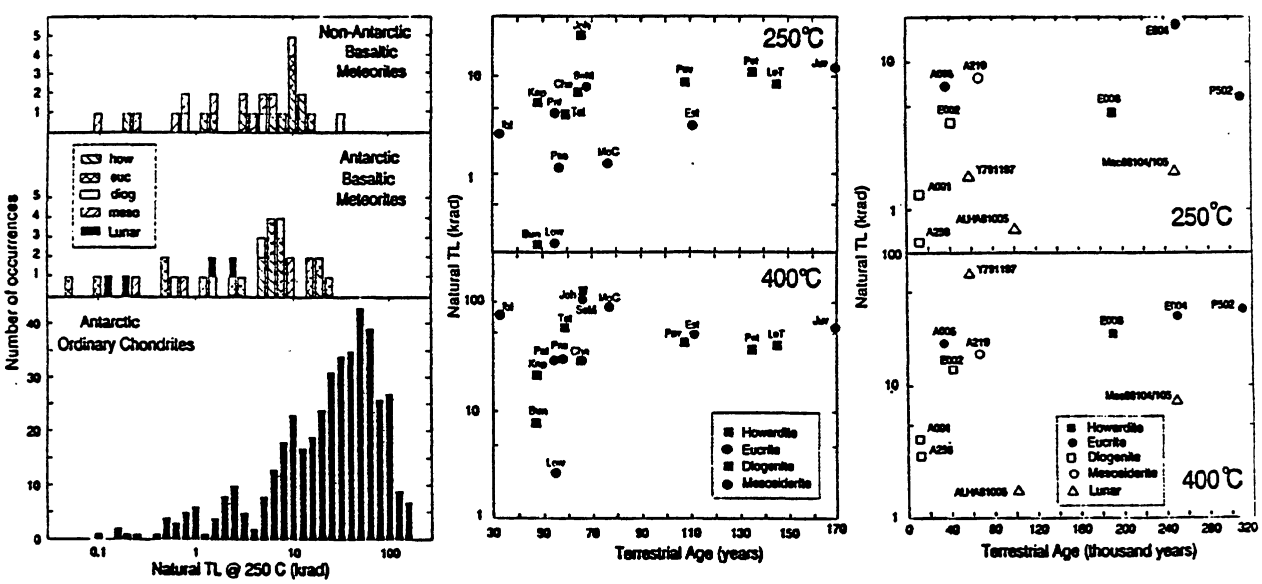

Fig. 1. (Left) Histograms of natural TL for basaltic and lunar meteorites. Except for the two MAC lunar meteorites, data for paired meteorites have been averaged.
Fig. 2. (Center and right) Natural TL vs. terrestrial age determined from cosmogenic isotopes (16). Meteorites with the largest terrestrial ages tend to have natural TL values around 5 krad @ 250°C (30 krad @ 400°C), suggesting that samples with natural TL below these values have been reheated.