Fig. 1 shows a set of typical glow curves. Two peaks are evident in the glow curves of all the samples removed from the meteorite with the exception of the sample from the fusion crust which had no TL. The glow curve peaks have intensity maxima at about 240° C and 375° C. There is a variation in the TL output of the samples with distance from the surface of the stone and this is more clearly shown in Fig. 2 in which the area under the glow curve is plotted as a function of the average depth of each block from the surface of the meteorite. Fig. 2*a* shows the TL measurements performed on the blocks removed from the 13 cm strip of meteorite material (A-A′). The TL output of the meteorite is fairly constant throughout the section, except from about 1.5 cm from the fusion crust to the fusion crust itself, where the TL output is almost zero. Fig. 2*b* shows the change in the TL output with depth for the samples taken along the 9.8 cm strip (B-B′). The TL output along this sampling direction is similar to the output from strip A-A , but there is a superimposed linear decrease from side B to side B′.

These findings can be explained by the effect of atmospheric heating on the TL induced in the specimen by cosmic-ray irradiation. Although the natural TL of the meteorite is induced by both cosmic-ray irradiation and the decay of radioactive impurities, the relative contribution of these sources depends on the diameter of the meteoroid. The average content of U, Th, and ^{40}K in chondrites is 0.014 p.p.m., 0.04 p.p.m., and 0.088% respectively[5], and so the average radiation dose rate due to the decay of radioactive impurities is less than 0.1 rad per year[6]. In contrast, the radiation dose rate due to cosmic-ray irradiation has been calculated[1] to be between 1 and 10 rad per year in the 1 m surface layer of the meteoroid. If the diameter of the meteoroid is not greater than 2 m, the cosmic radiation dose rate in its core could be at least one order of magnitude greater than the radioactive impurity dose rate. The distribution of TL within the mass of the Ucera meteorite may therefore reflect the uniformity of the shielding from cosmic rays as well as revealing the heating effects during its fall.

The effect of the heat wave seems to be restricted to the outer 1.5 cm of the meteorite. The presence of a much reduced 240° C glow curve peak in the material adjacent to the fusion crust indicates that the temperature at 4 mm from the final surface was not greater than 240° C but apparently higher than 120° C in order to bleach partially the centres responsible for the 240° C peak. This conclusion is supported by the determination[7] of the depth of formation of the α_2 structure in the kamacite in the Ucera meteorite. The similarity between the TL output of the four blocks adjacent to the fusion crust at A, A′, B, and B′ shows that the stone was uniformly heated during its fall, a conclusion which is supported by the well rounded shape of the specimen.

The change in the TL buildup measured in the strip B-B′ (Fig. 2*b*) can be interpreted in terms of the non-uniform shielding of the meteorite from cosmic rays. The cosmic radiation dose rate inside a meteoroid depends on the amount of shielding and the TL buildup should therefore change with depth from the surface of the meteoroid. It would seem that the surface B of the meteorite was closer to the exterior of the meteoroid than surface B′. The previously measured ^{14}C activity in this specimen, 34 ± 2 d.p.m. kg^{-1}, is about 50% lower than the average ^{14}C activity recorded for stony meteorites[9], and is also lower than expected from the cross-section for the reaction ^{16}O (p, 3p) ^{14}C as measured at high energy accelerators[10]. This low ^{14}C activity may be a direct consequence of partial shielding of the meteorite in space.

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Interstellar Dust—Reply to Duley's Criticisms

DULEY's second[1] criticism of our hypothesis of graphite–iron–silicate grain mixtures[2,3] contains further errors and misrepresentations of our statements. We wish to refer here to a few crucial facts which seem to have been overlooked by Duley[1,4] and which invalidate his contention that the interstellar extinction curve does not provide additional evidence to support either graphite or silicate grains. The suggestion that a fit to the observed extinction curve on the basis of graphite, iron and silicate grains is confined to the adoption of the special set of values 0.06, 0.02 and 0.15 µm for their respective mean radii is incorrect. In our original paper[2] we stated clearly that $\bar{r}$ (graphite) = 0.045–0.07 µm, $\bar{r}$ (iron) $\leq$ 0.02 µm, and $\bar{r}$ (silicate) = 0.15–0.18 µm are the requirements necessary to obtain good agreement with the observations. A wide range of relative proportions of the three grain species and several different types of size distributions[2,3,5,6] have been shown to provide satisfactory fits to the available astronomical data. It should be stressed that the optical constants of graphite are such that the observed optical extinction curve and the ultraviolet hump at λ2200 Å could be reproduced for a wide range of particle sizes. Iron and silicates in our model play a less important part at optical wavelengths so that constraints on their sizes and proportions relative to graphite are less rigorously specified by the optical extinction data.

As well as matching the extinction data any permissible grain model must satisfy three further restrictions: (1) The postulated grain material should be sufficiently abundant to make up ~1 per cent of the mass of all interstellar matter. (2) It should be sufficiently refractory to persist near hot stars. (3) It should be able to condense with relative ease in astronomically feasible situations, with a replenishment time scale throughout the galaxy of ~10^9 years (ref. 7). These restrictions taken together with the extinction and other optical data severely limit the allowable candidates for grain material. Mixtures of graphite, iron and silicate grains have the attractive property of meeting all these requirements.

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