ON THE DELIVERY OF METEORITES AND NEAR-EARTH ASTEROIDS.
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Observational constraints on the delivery of meteoroids, the smallest of the near-earth asteroids (NEA's) can be obtained from cosmic-ray-exposure age ($T_e$) systematics in addition to orbital information, and compositional data. We have recently discussed the $T_e$ histograms of H-, L-, and LL-chondrites (1-3). None of these histograms is consistent with a continuous supply of asteroidal material to the Earth, as the observed $T_e$ histograms disagree with expected exponential distributions. In order to infer a continuously produced "background" of meteoroid populations and their characteristic lifetimes, it is necessary to first remove those portions from $T_e$ histograms that can be assigned to discrete events (e.g. H-chondrites: 7 Ma and 33 Ma events; L-chondrites: 28 Ma and 40 Ma events; LL-chondrites: 15 Ma event). The lifetimes of meteoroid sized bodies are presumably determined chiefly by collisional destruction since the calculated dynamical lifetimes ($\sim 10^8$ a) are larger than observed exposure ages (4).

We fitted exponential functions to selected intervals of the $T_e$ histograms of H-, L-, and LL-chondrites, chosen such as to minimize the influence of discrete collisional events. Table 1 shows mean lifetimes ($T_m$) of H-, L-, and LL-chondrites as well as the $T_e$ intervals that were used for the fitting. Figure 1 shows the $T_e$ histograms and the calculated "background" contributions. The good agreement of the lifetimes of the 3 chondrite classes suggests that a time scale of $\sim 17$ Ma is characteristic for ordinary chondrites. Nevertheless, there are several mechanisms that could bias our estimate:

1) Unresolved minor collisional peaks may still be present.
2) The $T_e$ distributions of H- and L-chondrites include collisional peaks close to the upper end of the age scale. These events not only have produced meteoroid sized fragments but also a population of larger objects which subsequently will undergo further collisions on a characteristic timescale $T_1$. If a considerable fraction of the H- and L-chondrites derived from these objects, the effective lifetime calculated from $T_e$ histograms ($T_{eff}$) is larger than the collisional lifetime of meteoroid sized fragments ($T_m$) according to the equation $1/T_{eff} = 1/T_m - 1/T_1$. However, LL-chondrites do not show a peak at the upper end of the age scale and nevertheless exhibit the largest $T_m$. Therefore, this effect is probably not very important.
3) During orbital evolution of meteoroids some aphelia fall inside the asteroid belt and their collisional lifetimes increase. This could result in a significant tailing of the $T_e$ histograms towards longer exposure ages. Orbital maturity in the inner solar system is documented by the a.m./p.m. fall statistics among observed meteorite falls (5,6). The significance of this ratio is that meteoroids that become Earth-crossing by chaotic effects in the 3:1 resonance zone will predominantly be p.m. falls. Subsequent orbital evolution on a $10^7-10^8$ Ma timescale will erode...
a p.m. excess. Therefore, if an orbitally evolved population of meteorites causes a tail in the $T_e$ histograms, the ratio of p.m./a.m. falls should be lower for meteorites with large $T_e$. No indications for such an effect are found for any of the chondrite classes studied here.

4) Based on Monte Carlo calculations Wetherill (7) suggested that $>20\%$ of all meteoroids experienced multiple exposures to cosmic-rays. Therefore, the exposure ages may generally be larger than the actual collisional lifetime. On the other hand, we note, that $>50\%$ of all H, L, and LL-chondrites can be assigned to discrete collisional events and that therefore the exposure ages of at least these meteorites are not significantly affected by complex exposure histories.

Using our estimate of $T_m$, it is possible to compare the relative magnitude of the resolved collisional events: The 40 Ma event of the L-chondrites is about twice as large as the 7 Ma or the 33 Ma event of the H-chondrites, the latter two being of comparable magnitude. On the other hand, the 15 Ma event of the LL-chondrites is about 4 times smaller than the 7 Ma event of the H-chondrites. Note, that if $T_m$ would only be $\sim 5$ Ma as suggested in (4), the 40 Ma event of the L-chondrites would be $\sim 30$ times as large as the 7 Ma event of the H-chondrites.

The $T_e$ histograms of H- and LL- chondrites are well reproduced by a superposition of the "background" and peaks at 7 Ma, 33 Ma, and 15 Ma, respectively. An excess population of L-chondrites with $12<T_e<22$ is observed. This could indicate the presence of additional unresolved peaks in this age interval. If the excesses were due to only one event, the question is as to why it cannot be resolved. One might postulate that a large fraction of meteoroids originating from such a hypothetical event experienced complex exposure histories (possibly because the immediate parent object itself was already a relatively small collisional product of an earlier event). However, the shielding sensitive $^{22}\text{Ne}/^{21}\text{Ne}$ ratios of this chondrite population are close to average.