THE H5 PARENT COLLISION 7 MA AGO.

Th. Graf and K. Marti, Dept. of Chemistry, University of California, San Diego, La Jolla, CA92093-0317.

Much indirect evidence has been assembled for a general meteorite-asteroid link such as orbital information, injection mechanisms into Earth-crossing orbits, compositional information, evidence for collisions in the records of radiogenic gases (^{4}He, ^{40}Ar), ^{39}Ar-^{40}Ar ages, and exposure age clusters. We have previously reported (1,2) that a well known broad cluster of exposure ages (T_e) for H-chondrites can be resolved into two peaks at 6-8 Ma and 3-4 Ma, respectively. The 3-4 Ma peak is pronounced for H5-chondrites, but absent for types H4. On the other hand, the 6-8 Ma peak is pronounced for types H4 and H5, but only marginally visible for types H3 and H6. Furthermore, chondrites on the 6-8 Ma peak experienced only minor losses of radiogenic ^{40}Ar ($>4 \times 10^{-5}$ cm^3 STP g^{-1}) and only small or moderate losses of radiogenic ^{4}He ($>5 \times 10^{-6}$ cm^3 STP g^{-1}). In contrast, a substantial fraction of H-chondrites belonging to the 3-4 Ma peak experienced significant losses of radiogenic gases ($^{40}Ar < 4 \times 10^{-5}$ cm^3 STP g^{-1}, $^{4}He < 5 \times 10^{-6}$ cm^3 STP g^{-1}). H3, H4, and H6-chondrites also show an exposure age cluster at 30-35 Ma, while for H5-chondrites this peak is marginal. Considering that the collisional half-life of meteoroid sized fragments is < 15 Ma (3), the 30-35 Ma event can be pictured at least as big as the 6-8 Ma event.

It appeared puzzling that exposure age distributions of H3 and H6-chondrites are similar to each other, but in marked contrast to the distributions of intermediate types H4 and H5. We report here collisional evidence based on dynamical data: Observed distributions of fall-times of H-chondrites are listed in Table 1. As usual, only falls between 6 AM and 6 PM are considered and fall-times are from (4). It is well known, that the AM/PM ratio of Earth impacts relates to the orbital elements of the impactors (3): About 70% of all H3, H4, H6, L, and LL chondrites are afternoon falls, indicating clusterings of their orbits at semi-major axes a $\simeq$2.5 AU and perihelia q$\simeq$1 AU. On the other hand, less than 50% of all H5-chondrites (the largest subgroup of H-chondrites) are afternoon falls. The confidence level for this difference is ~99.5%, based on counting statistics. Similar systematics are obtained if only chondrites with known exposure age (T_e) are considered (Table 1), indicating no serious sampling bias for the latter. Obviously, H5-chondrites have a different distribution of their orbital elements. Consequently, H-chondrites originate from at least two different parents (not necessarily grand-parents). Samples from one are predominantly of petrographic type 5, whereas all petrographic sub-types may be represented in the other parent. Fig. 1 shows the exposure age distributions of H3,4,6 and H5 chondrites separately for AM falls and PM falls. We observe the following systematics:

Table 1. Fall statistics of H-chondrites. Numbers of meteorites are given in parentheses.

Type	PM-Fraction All	PM-Fraction T_e known
H	0.62 (139)	0.63 (86)
H6	0.67 (42)	0.73 (30)
H4	0.70 (30)	0.78 (18)
H3,4,6	0.69 (74)	0.76 (50)
H5	0.47 (53)	0.42 (33)
H5 (6-8Ma)		0.31 (13)

1) The difference in the distributions of fall-times is striking: Pronounced 6-8 Ma exposure age clusters are restricted to the distributions of the H5 AM falls and the H3,4,6 PM falls.

2) The positions of these two age peaks differ by about 0.5 Ma: The center of the H5 peak is at 6.7 Ma, whereas the center of the H3,4,6 peak is at 7.2 Ma. It is possible that the 6-8 Ma cluster is due to two independent collisions. Alternatively, a collision between two H-parents may be invoked. In the latter case, the offset between the two peaks could be an artifact of incorrect use of equal spallation production rates, although modulation variations due to different average heliocentric distances of the respective fragments may be involved. This option can be tested by a calibration of the respective production rates using radionuclides (e.g. ^{53}Mn).

3) The 7.2 Ma age peak is pronounced only for H4-chondrites. In this group, major losses of radiogenic gases are rare. We also note that types H3, H4, and H6 are all represented in the 30-35 Ma age cluster, and ~30% of this group suffered significant losses of radiogenic ^{4}He and ^{40}Ar. In one scenario different parents may be invoked for the 30-35 Ma and the 7.2 Ma collisions. Alternatively, the same parent-body might have been involved in both collisions. Since the 30-35 Ma collision was probably large, it may have sampled a larger variety of collisional fragments.

4) H5-chondrites in the T_e=6.7 Ma cluster have a PM-fraction of only ~30% (Fig. 1). It appears that a majority of these meteorites originated on the parent-body of predominantly H5 composition. Therefore, the characteristic signature of this parent is predominantly AM fall-times. This would be expected, for example, if its orbit was inside the Earth's.

5) While our results clearly show, that a H5 parent was involved in the 6.7 Ma collision, they also raise some questions regarding orbital dynamics. If the AM/PM distinction for H5-chondrites is due to a parent orbit well inside the belt asteroids ($a \ll 2.5$ AU), the collisional probability of such objects is expected to be small. Moreover, the small time difference between the exposure age clusters at 6.7 and 7.2 Ma would be a coincidence. Alternatively, the aphelia of the fragments may initially have been in the asteroid belt and the orbital elements may have evolved over the 6.7 Ma period. However, within the context of orbital-dynamical models, meteor streams appear to survive as recognizable groups only over time-scales of $< 10^6$ a (3,5). On the other hand, some evidence for the existence of meteor streams was recently reported (6).

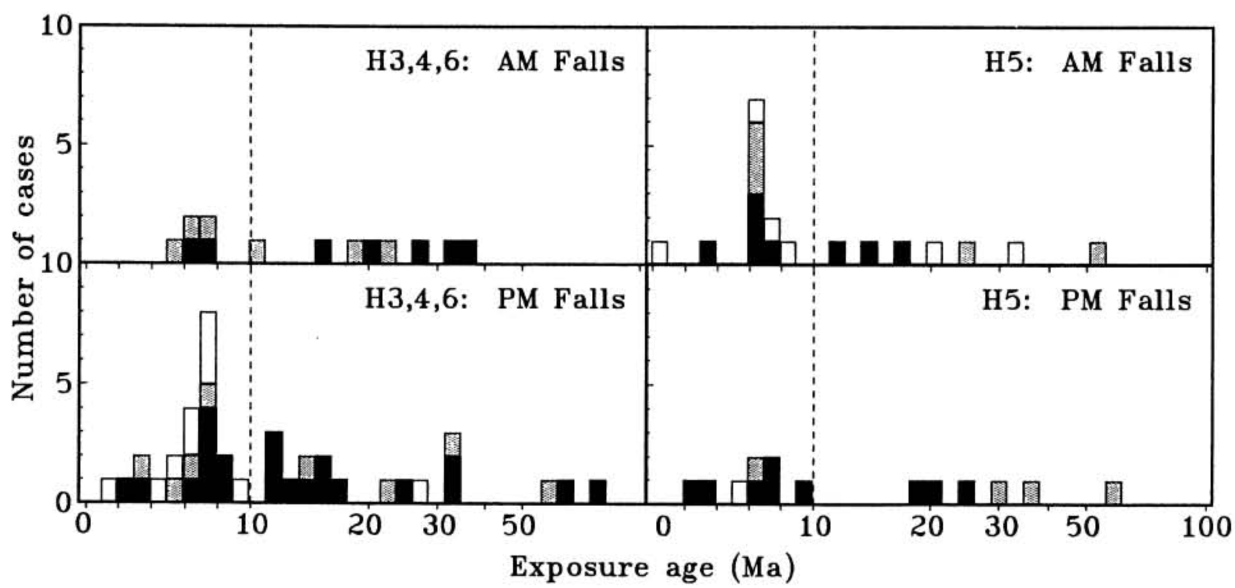

Fig. 1. Exposure age distributions of H3,4,6 (left panel) and H5 (right) are shown separately for AM falls (top) and PM falls (bottom). Data quality is grouped in classes: high (black), intermediate (grey), and poor (white). Note scale change: linear between 0-10 Ma (resolution 1 Ma), logarithmic scale above 10 Ma (resolution 10% of the age).

References: **(1)** Graf Th., and Marti K., (1989) Meteoritics 24, 271-272. **(2)** Graf Th., and Marti K. (1990) Abstr., 53rd Meteoritical Society Meeting. **(3)** Wetherill G.W. (1985) Meteoritics 20, 1-22. **(4)** Graham A.L., Bevan A.W.R., and Hutchison R. (1985) Catalogue of Meteorites. **(5)** Wetherill G.W. (1988) Icarus 76, 1-18. **(6)** Halliday I., Blackwell T., and Griffin A.A. (1990) Meteoritics 25, 93-99.