WHY DO METEORITES COME FROM SUCH A SMALL SET OF ASTEROIDS?.

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Introduction. As shown in the observed fall statistics in Table 1, .86% of meteorites appear to originate on 4 asteroids and 94% on 12 asteroids. This has important implications regarding the locations of the source asteroids. In particular, it would seem to require that these be located near one of the resonances that can deliver meteorites to the Earth. The two resonances are the ν6 and the 3:1 (at 2.50 AU). Because Jupiter ejects meteoroids falling into resonances at greater distances from the Sun, most meteorites originated in the inner belt between 2.15 and 2.55 AU.

How many ordinary chondrite asteroids? It has long been inferred that the three ordinary chondrite (OC) groups are from three asteroids, and that the OC are an incompletely sampled continuum. Evidence of break-up events involving large fractions of the group members are best understood in terms of all members of each group originating in a single asteroid.

Cosmic-ray age clusters show that a large fraction of the H chondrites formed in a breakup event 8 Ma ago (Graf and Marti, 1995); and 35% of the L-group chondrites experienced an outgassing (He loss) event about 0.4 to 0.5 Ma ago (Wasson and Wang, 1991). The hiatus in mafic-mineral compositions between H and L chondrites suggests that no asteroids with intermediate H-L composition experienced a large breakup event. In contrast, the LL chondrites did not experience a major outgassing event; their U,Th-He and K-Ar ages are high.

There is general agreement that HED meteorites formed on the same asteroid (many researchers claim to know which asteroid).

The CM chondrites may be the most common type of meteorite entering the upper atmosphere, but most do not survive as ponderable masses. The atmospheric filter also removes most CI chondrites. These groups thus need to be treated as special cases. The remaining groups appear to be best understood in terms of single parent asteroids.

Why is the spectrum of parent asteroids so small? It is not easy to remove large (R>10 km) asteroids from the interior of the inner belt to one of the resonances. For asteroids having the right combination of properties The Yarkovsky effect can change orbital radii but 0.1 AU in a Ma, but most migrate much more slowly (Bottke et al., 2006). To obtain large numbers of meteoroids from a single breakup event surely requires that the asteroid orbit was close to a resonance before the breakup event occurred. Thus it is probable that each of the OC asteroids was sited near a resonance before the breakup event occurred.

The common view is that OC are the most abundant meteorites in the Inner Belt; this raises the question of whether all three are near the same resonance (in which case that resonance clearly dominates as a source of meteorites) or whether both one asteroid was near one of the resonances and the other asteroids near the other.

The OC evidence suggests that the other common source asteroids were also near resonances. Such an inference implies that the HED meteorites are not from Vesta, which is far from any resonance.

Summary. It appears that meteorites mainly originated from asteroids that, prior to breakup, were sited near the ν6 and the 3:1 resonance. Unless they all are coming out through the same resonance, the ordinary chondrites are by far the most abundant material in the Asteroid Belt. This has implications for the interpretation of asteroid spectral types.

Table 1. Meteorite fall statistics*.

class	falls	fraction	cumulative	asteroids
L	319	0.388	0.388	1
H	276	0.336	0.724	2
LL	66	0.080	0.804	3
HED	50	0.061	0.865	4
CM	15	0.018	0.883	5
Aub	9	0.011	0.894	6
EH	7	0.009	0.903	7
IAB	7	0.009	0.911	8
CV	6	0.007	0.918	9
EL	6	0.007	0.926	10
Mes	6	0.007	0.933	11
IIIAB	6	0.007	0.940	12
CO	5	0.006	0.946	13
CI	5	0.006	0.953	14
IIAB	5	0.006	0.959	15
Ure	4	0.005	0.964	16
IVA	3	0.004	0.967	17
CR	2	0.002	0.970	18
PMG	2	0.002	0.972	19
IID	2	0.002	0.974	20

*Based on a 1995 compilation.

References: W. Bottke et al., (2006) AREPS 34, 157. T. Graf and K. Marti (199%) JGR 100, 21247; J. WassonJ. and S. Wang (1991) Meteoritics 25, 21247.