ARE H/L CHONDRITES ASSOCIATED WITH THE DISRUPTION OF COMET C/1919 Q2 METCALF?

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Introduction: New evidence suggests that meter-sized meteoroids following high-inclination orbits associated with comets are not necessarily fragile [1]. To compile evidence is a non trivial task because the high velocity associated with these encounter geometries makes meteorite survival only possible in favorable circumstances, but we have identified that the rare H/L ordinary chondrites (hereafter OC) might belong to that kind of source. On July 6, 2007 an H/L OC felt over Cali, Colombia and visual observations of the bolide were compiled [2]. The recovered meteorite was characterized as being a rare H/L chondrite interloper apparently coming from the main belt [2], but other plausible solutions were consistent with a high-inclination orbit. Fortunately, a year later the Spanish Meteor Network recorded a potential meteorite dropping bolide called SPMN110708 "Bejar" on July 11, 2008 with a pre-atmospheric orbit that indicated a plausible association with the debris of disrupted comet C/1919 Q2 Metcalf. The meteoroid was about one meter in diameter suggesting that the disruption of that comet could deliver meteorites periodically to Earth [3]. Events in successive years close to the same time suggested that they should be investigated further, and other orbital solutions for the Cali event are being explored. Obviously visual observations introduce significant observational uncertainties and whether a unique solution can be obtained probably depends on the data set considered. In any case, we realized that another solution coming from the most extremely long trajectory observations was consistent with a Cali apparent radiant consistent with that one estimated for Bejar.

Is it possible that a high-inclination stream of meter-sized meteoroids originating from the disruption of comet C/1919 Q2 Metcalf exists? The answer is probably positive because H/L OC falls occurred on similar dates but separated by several decades each (see Table 1) and roughly matching our forecast [3]. This cannot be casual given the small amount of H/L chondrites falls (4 so far) compared with the number of falls associated with H (366), L (417) or LL (99) group chondrites, usually coming from the MB (Meteoritical Bulletin Database, 2016). The fall of the main chondrite groups of chondrites are scattered all over the year (Grady, 2000), while the H/L chondrites are concentrated between May and July. Interestingly, Tieschitz and probably other H/L OCs (e.g. Cali) exhibit clear signs of aqueous alteration like could have suffered in an ice-rich progenitor [5]. Statistically, to have the 4 H/L chondrites falls occurred in about a 3 months period corresponds to a probability of about a 6% (1/(4x4), for each trimester chance). Moreover, there are only 4 H/L OC falls, compared with 882 OCs belonging to another groups.

Meteorite	Fall date (UTC)	Group & petrological subtype	TKM (kg)
Bremervörde	May 13, 1855	H/L3.9	7.25
Tieschitz	Jul 15, 1878	H/L3.6	28
Cali	July 6, 2007: 21h32m	H/L4	0.478
Famenin	June 27, 2015: 4h30m	H/L3.8-3.9	0.630

Table 1. Compilation of H/L meteorite falls according the Meteoritical Bulletin Database.

Concerning impact hazard, our results suggest that a significant flux of projectiles reaches the Earth from high-inclination orbits, so new strategies to monitor such source should be considered in future NEO surveys. Our disruption scenario supports a heterogeneous nature of comets that can become extinct by aging. The reflectance spectra diversity of the Taurid NEO complex associated with the disruption of comet 2P/Encke can be a good example [6]. The potential danger associated with evolved comets was exemplified with 2015 TB145, a 600 m dormant comet with an encounter velocity of 35 km/s that experienced a closest approach to Earth on Oct. 31st, 2015. Another deep-penetrating superbolide recorded from Spain on July 13, 2012 provided further evidence that meter-sized boulders with high tensile strength are also associated with Damocloids: bodies in Halley type or long-period eccentric orbits named after asteroid 5335 Damocles [7]. Consequently, some comets are probably rubble piles, and formed by low and high-strength heterogeneous materials as also pointed out by Rosetta mission results about comet 67P [8].

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