COMETS, ASTEROIDS, METEORITES, AND METEORS: A NEW PARADIGM OF INTERRELATIONS. Charles A. Wood and W. W. Mendell, SN6-NASA Johnson Space Center, Houston, TX 77058

INTRODUCTION. Conventional wisdom has long placed the origin of meteorites in the asteroid belt, with the only other conceivable source — comets — deemed unlikely because of their presumed origin as primitive objects in the outer solar system. Comets and co-orbital meteors thus are believed to be unrelated to meteorites and asteroids, hence generally unsampled. These views have guided decades of research and provide preconceptions for each new observation. Significant evidence now exists to question the validity of this paradigm. We argue that comets, Chiron-like objects, meteorites, and meteors are related, with bodies having comet-like histories being widely sampled. Main belt asteroids may provide a low-level background flux of compositionally constant material to the Earth; while a "cometary" component, which may sample the whole solar system, probably varies with time.

EVIDENCE. Opik (1) and Wetherill (2) have presented convincing dynamical evidence that the vast majority of meteorites do not come from the main asteroid belt (MAB) but rather are fragments of Apollo objects. Dynamically, only ~10% of the Apollos can be derived from the MAB, whereas comets easily can supply the remaining 90% (3). Most meteoriticists ignore or reject these dynamical results, arguing that the petrologically complex meteorites could not have originated in primitive comets.

Derivation of meteorites from the MAB is only partially supported by reflectance spectra of asteroids. The two most common asteroid types are analogous to carbonaceous chondrites or to stony irons (4). Small numbers of asteroids are possible matches to iron meteorites, achondrites, and other infrequent meteorite types. Notably lacking in the MAB is an unambiguous parent for the ordinary chondrites, which comprise ~80% of terrestrial meteorite falls (5). Commonly, this glaring lack of OC parents is minimized; or, conversely, convoluted explanations are offered for their being undetectable.

Recently, Wood (6) has uncovered a clue to the orbit of the parent body of a subset of the H chondrites. Those H's (~50%) with exposure ages near 5 m.y. appear to be in an orbit with a period of 31 years. The data imply a long, elliptical orbit with a perihelion near 1 A.U. and an aphelion of ~19 A.U., near the orbit of Uranus and very close to the aphelion of Chiron. Thus, at least some ordinary chondrites appear to come directly from the outer solar system; they are neither main belt asteroids nor Apollos.

IMPLICATIONS. In addition to possessing a common aphelion value, the orbit of Chiron and the apparent orbit of the young H chondrites are both "chaotic." Chaotic orbits, discovered by Everhart (7), is the name given to a class of unstable solar system orbits, which can take on a variety of forms. Some of the forms achieve long-lived quasi-stability, and an evolutionary path exists from each form to every other form with some statistical probability (8). A Chiron-like orbit can evolve to a long elliptical orbit, or vice versa. The association between the comet-like orbit of the young H chondrites and the unstable orbit of Chiron suggests that each may represent an orbital stage in the evolution of small bodies moving inward in the solar system.

From the above considerations, as well as cosmochemical arguments, we propose that the ordinary chondrite parent bodies formed in the inner solar system, were ejected by Jupiter during the accretionary epoch, have returned to the system via mechanisms operating in the Oort cloud, and have encountered the Earth in cometary or, more generally, chaotic orbits. Although these objects reside in the outer reaches of the solar system, they are not comets in the connotation of a primitive "dirty snowball." Whether they appear...
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cometary upon entering the inner solar system will depend on the probability of accumulation of an icy mantle over the asteroid core and whether such an outer layer has survived the particular orbital history of the object. Thermal metamorphism associated with ordinary chondrite could occur in the planetoid before ejection or even afterwards, if the size of the body and the radioactive abundances permit.

Meteor streams are commonly interpreted as detritus from fragile, primitive, cometary objects. The young H chondrites appear to be the first recognized meteorite stream and thus may be the remains of a more consolidated, evolved, asteroidal object. These phenomena actually may be sequential stages in the erosion and destruction of a single layered object, having an icy mantle and a solid core. Despite the variety of objects appearing in the inner solar system, evidence from the meteorite collections indicates that most of the recent terrestrial falls can be traced to a small number of bodies. Over geologic time, however, Earth and Moon have sampled the entire breadth of creation in the early solar system.

REFERENCES: