DO WE NEED A NEW DEFINITION FOR A COMET?

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Introduction: Scott et al. [1] have demonstrated distinct isotopic differences between carbonaceous and ordinary chondrites that are consistent with the formation of the carbonaceous chondrite parent bodies outside of the orbit of Jupiter. Active asteroids in the Main Belt have been observed to form comae and tails near perihelion that are probably driven by subliming water vapor (among other mechanisms). Some B- and C-type asteroids are sources for meteor streams while some B-type asteroids were first discovered as comets, then were later re-discovered as asteroids [2,3] such as Comet Wilson-Harrington. The distinction between comets and asteroids is not always clear.

Order in the Primitive Solar System: In the very early solar system, there are reasons to believe that small bodies formed a roughly continuous sequence from dry asteroids near the Sun, through increasingly water-rich bodies beyond the giant planet region [4]. However, there is evidence that this orderly progression was then thoroughly mixed due to tidal interactions between the giant planets and the nebular disk [5-10] that threw dry bodies into the outer nebula and drove water-rich bodies into the inner solar system. This mixing plays havoc with many distinctions previously used to differentiate between comets and asteroids and, in particular, makes a dynamic definition of a comet problematic. For example, many parent bodies formed in the inner solar system were thrown out to the Kuiper Belt and into the Oort Cloud. If a dry, Eros-like, asteroid were to fall into the inner solar system from the Oort Cloud following a typical cometary trajectory, would this be a comet? If a body of similar composition is captured into a Jupiter Family orbit, is this a JFC? In the same manner, if a small body formed well beyond the orbit of Jupiter but were deflected into the inner solar system, and spent the majority of the last 4.5 billion years in the Main Asteroid Belt, is such a body a comet?

Survival in the Inner Solar System: A simple rule of thumb is that an active comet survives for about one thousand perihelion passages before activity ceases. So for an active, long-period comet such as Halley, its active lifetime is on the order of 100,000 years while for a Jupiter Family comet like Churyumov-Gerasimenko its active lifetime might be as short as 5000 years. On the other hand, a comet is stable in the inner solar system for approximately 200,000 – 500,000 years [11] before it gets thrown out of the solar system or into the Sun. This implies that there are 10 – 100 times more dormant comets than active comets in the solar system. Are such dormant comets now asteroids? If this asteroid class undergoes a major collision that exposes deeply buried volatiles producing a coma or tail, is the asteroid now a comet again? Is there a particular class of asteroid that is most likely a dormant comet?

Type-B Asteroids are Dormant Comets: As a comet evolves from active to dormant by losing volatiles and/or growing an insulating crust over its surface [12], traces of its former activity could remain. Some asteroid class members might be discovered as a barely active comet, lost, then re-discovered as an asteroid [2,3]. Some could be the source of meteor streams [13]. Some class members could still emit particles near perihelion driven by subliming volatiles [14], though there are other mechanisms that could potentially drive such emissions at other locations over the orbit. As a class, B-type asteroids fulfill each of these criterion and we suggest that such asteroids are the first stage of cometary dormancy.

What is a comet? Loss of volatiles over time or through closer approaches to the Sun results in the formation of B- and probably other (C, P, D?) asteroid types. Metamorphism of a comet's surface resulting from relatively rapid passages close to the Sun could result in a similar surface spectrum to a volatile-rich body that slowly metamorphoses while residing in the Main Belt. A dynamical definition (above) of a comet also makes little sense. ***We suggest that any small body that completed its formation outside the Snow Line in the primitive solar nebula should be considered a comet based on its high water/rock ratio regardless of its subsequent dynamic evolution.***

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