Comets as Parent Bodies of CI1 Carbonaceous Meteorites and Possible Habitats of Ice-Microbiota

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ABSTRACT

Recent studies of comets and cometary dust have confirmed the presence of biologically relevant organic molecules along with clay minerals and water ice. It is also now well established by deuterium/hydrogen ratios that the CI1 carbonaceous meteorites contain indigenous extraterrestrial water. The evidence of extensive aqueous alteration of the minerals in these meteorites led to the hypothesis that water-bearing asteroids or comets represent the parent bodies of the CI1 (and perhaps CM2) carbonaceous meteorites. These meteorites have also been shown to possess a diverse array of complex organics and chiral and morphological biomarkers. Stable isotope studies by numerous independent investigators have conclusively established that the complex organics found in these meteorites are both indigenous and extraterrestrial in nature. Although the origin of these organics is still unknown, some researchers have suggested that they originated by unknown abiotic mechanisms and may have played a role in the delivery of chiral biomolecules and the origin of life on Early Earth.

In this paper we review these results and investigate the thermal history of comets. We show that permanent as well as transient domains of liquid water can be maintained on a comet under a plausible set of assumptions. With each perihelion passage of a comet volatiles are preferentially released, and during millions of such passages the comet could shed crustal debris that may survive transit through the Earth's atmosphere as a carbonaceous meteorite. We review the current state of knowledge of comets and carbonaceous meteorites. We also present the results of recent studies on the long-term viability of terrestrial ice-microbiota encased in ancient glacial ice and permafrost. We suggest that the conditions which have been observed to prevail on many comets do not preclude either survivability (or even the active metabolism and growth) of many types of eukaryotic and prokaryotic microbial extremophiles-including algae, cyanobacteria, bacteria and archaea. It is argued that the chemical and morphological biomarkers detected on comets and carbonaceous meteorites can be explained by ancient microbial activity without the need to invoke unknown abiotic production mechanisms.

Keywords: Comets, Meteorites, Chiral Biomolecules, Carbonaceous Meteorites, Ice-Microbiota, Extremophiles

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