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Title: Comet Dust: The Diversity of "Primitive" Particles and Implications

Abstract:

Comet dust is primitive and shows significant diversity. Our knowledge of the properties of primitive particles has expanded significantly through microscale investigations of cosmic dust samples (IDPs and AMMs) and of comet dust samples (Stardust and Rosetta's COSIMA), as well as through remote sensing (spectroscopy and imaging) via Spitzer and via spacecraft encounters with 103P/Hartley 2 and 67P/Churyumov-Gerasimenko. Microscale investigations show that comet dust and cosmic dust are particles of unequilibrated materials, including aggregates of materials unequilibrated at submicron scales. We call unequilibrated materials "primitive" and we deduce they were incorporated into ice-rich (H₂O-, CO₂-, and CO-ice) parent bodies that remained cold, i.e., into comets, because of the lack of aqueous or thermal alteration since particle aggregation; yet some Stardust olivines suggest mild thermal metamorphism. Primitive particles exhibit a diverse range of: structure and typology; size and size distribution of constituents; concentration and form of carbonaceous and organic matter; D-, N-, and O- isotopic enhancements over solar; Mg-, Fe-contents of the silicate minerals; the compositions and concentrations of sulfides, and of less abundant mineral species such as chondrules, CAIs and carbonates. The uniformity within a group of samples points to: aerodynamic sorting of particles and/or particle constituents; the inclusion of a limited range of oxygen fugacities; the inclusion or exclusion of chondrules; a selection of organics. The properites of primitive particles imply there were disk processes that resulted in different comets having particular selections of primitive materials. The diversity of primitive particles has implications for the diversity of materials in the protoplanetary disk present at the time and in the region where the comets formed.