

Dust in the Solar System – Properties and Origins

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Interplanetary dust pervades the inner Solar System, giving rise to a prominent glow above the horizon at sunrise and sunset known as the zodiacal light. This dust derives from the disintegration of comets as they approach the Sun and from collisions among main-belt asteroids. The Earth accretes roughly 4×10^6 kg/year of 1 – 1,000 μm dust particles as they spiral into the Sun under the influence of Poynting-Robertson drag and solar wind drag [1]. Samples of these grains have been collected from deep sea sediments, Antarctic ice and by high-altitude aircraft and balloon flights [2]. Interplanetary dust particles (IDPs) collected in the stratosphere have been classified by their IR spectra into olivine, pyroxene, and hydrated silicate-dominated classes [3]. Most IDPs have bulk major and minor element abundances that are similar to carbonaceous chondrite meteorites. Hydrated silicate-rich IDPs are thought to derive from asteroids based on their mineralogy and low atmospheric entry velocities estimated from peak temperatures reached during atmospheric entry. Anhydrous IDPs are typically aggregates of 0.1 ~ 1 μm Mg-rich olivine and pyroxene, amorphous silicates (GEMS), Fe, Ni-sulfides and rare spinel and oxides bound together by carbonaceous material. These IDPs are often argued to derive from comets based on compositional similarities and high atmospheric entry velocities that imply high eccentricity orbits. Infrared spectra obtained from anhydrous IDPs closely match remote IR spectra obtained from comets.

The most primitive (anhydrous) IDPs appear to have escaped the parent-body thermal and aqueous alteration that has affected meteorites. These samples thus consist entirely of grains that formed in the ancient solar nebula and pre-solar interstellar and circumstellar environments. Isotopic studies of IDPs have identified silicate stardust grains that formed in the outflows of red giant and asymptotic giant branch stars and supernovae [4]. These stardust grains include both amorphous and crystalline silicates. The organic matter in these samples also exhibits highly anomalous H, C, and N isotopic compositions that are consistent with formation in low temperature environments at the outermost regions of the solar nebula or presolar cold molecular cloud. The scientific frontiers for these samples include working toward a better understanding of the origins of the solar system amorphous and crystalline grains in IDPs and the very challenging task of determining the chemical composition of sub- μm organic grains. Laboratory studies of ancient and present-day dust in the Solar System thus reveal in exquisite detail the chemistry, mineralogy and isotopic properties of materials that derive from a range of astrophysical environments. These studies are an important complement to astronomical observations that help to place the laboratory observations into broader context.

[1] Love SG & Brownlee DE (1993) *Sci* 262, 550 [2] Brownlee DE et al (1985) *Ann Rev Earth Planet Sci* [3] Sandford SA & Walker RM (1985) *ApJ* 291, 838 [4] Messenger S et al. *Sci* 300, 105 [5] Keller LP et al. *GCA* 68, 2577 [6] Messenger (2000) *Nature* 404, 968