

Remnants of Rock and Ice (Chapter 12)

Asteroids (small rocky bodies) and comets (small icy bodies) are leftover planetesimals. Their compositions and orbits reveal a lot about solar system formation. The largest asteroid, Ceres, is around 1000 km in diameter, one-third the diameter of the Moon. The asteroids would only form an object 2000 km in diameter if combined together. The few largest asteroids may be spherical and differentiated into a mantle and a core, but most are rugged, undifferentiated lumps. Most asteroids orbit in the Asteroid Belt between Mars and Jupiter. Orbital resonances with Jupiter have ejected any asteroids with periods that are simple fractions of Jupiter's period. Jupiter is responsible for the objects in the Asteroid Belt not accreting into a planet and for the total mass in the Asteroid Belt being so low. Asteroids from the outer edge of the Belt have different compositions (more carbon-rich, with minerals that only condense at low temperatures) than those from the inner edge (more rocky or stony)

Meteorites are pieces of rock that have collided with Earth. They come from asteroids. Primitive meteorites come from asteroids that have never differentiated. Stony primitive meteorites come from stony asteroids near the inner edge of the Belt, whereas carbon-rich primitive meteorites come from carbon-rich asteroids near the outer edge of the Belt. Processed meteorites come from asteroids that have differentiated. Metal-rich processed meteorites come from exposed asteroid cores, whereas rocky processed meteorites come from asteroid mantles or crusts.

Comets are dirty snowballs less than 20 km across with very elliptical orbits. When they approach the Sun, their heated surfaces release gas that blows dust out into space as well. This forms a spherical coma 100,000 km wide. Some gas from the coma is ionized by solar UV and stretched out into a long tail by the solar wind. Some dust from the coma is stretched outwards into a separate tail. Comets from the Oort Cloud have long periods and any inclination. Comets from the Kuiper Belt have short periods and small inclinations. Some icy planetesimals that formed between Jupiter and Neptune were flung far away in all directions by the jovian planets' gravity, forming the vast Oort Cloud. By contrast, icy planetesimals that formed beyond Neptune remain in their original disk-like orbits today, forming the Kuiper Belt. When gravitational tugs change the orbit of an icy body in the Kuiper Belt or Oort Cloud so that it approaches the Sun, it becomes a comet.

Pluto is not a rocky terrestrial planet, nor a hydrogen-rich jovian planet. It looks like an ice-rock jovian moon that formed without a parent planet. It is only 1200 km in radius, has a very inclined and elliptical orbit, a thin N₂ atmosphere, and a surface temperature of 40 K. Pluto is a very large Kuiper Belt object. Pluto has a large moon, Charon. Pluto's day, Charon's day, and Charon's orbital period are identical due to strong tides. The Kuiper Belt contains comet-sized objects, medium-sized objects, and Pluto-sized objects. Comets from the Kuiper Belt are small because a given gravitational tug alters the orbit of a small object more than that of a heavy object.

Asteroids and comets occasionally crash into planets. These impacts can have tremendous effects on the planet, including mass extinctions on Earth.