The Solar System Cratering Record: Voyager 2 Results at Uranus and Implications for the Origin of Impacting Objects; R. G. Strom, Dept. of Planetary Sciences, University of Arizona, Tucson, AZ 85721

The cratering record at Uranus shows two different crater populations of different ages. The old crater population occurs on the heavily cratered surfaces of Oberon, Umbriel, and Miranda, while the younger one is found on Titania, Ariel, and the resurfaced areas of Miranda (figure 1). Since only the young population occurs on Titania, this satellite must have experienced a global resurfacing event which obliterated the older population prior to the impact of objects causing the younger one. The old crater population is characterized by an abundance of large craters and a relative paucity of small ones. The young crater population, however, has an abundance of small craters and a paucity of large ones relative to the old population. Furthermore, the abundance of small craters and the paucity of large craters increases with decreasing crater density (figure 1). This change in the size distribution is consistent with a population of impactors that evolved with time by mutual collision, and therefore was probably in planetocentric orbits. In fact, both crater populations may be the result of accretional remnants in planetocentric orbits that evolved with time by mutual collisions. If so, then the higher crater density on Miranda compared to Oberon and Umbriel suggests that both Oberon and Umbriel were also resurfaced early in their histories.

A comparison of the Solar System cratering record from Mercury to Uranus (19 AU) shows different crater populations at different locations in the Solar System (figure 2a). Computer simulations using a modified Holsapple-Schmidt crater scaling law and short-period comet impact velocities to recover the projectile diameters from the cratering record, produce different projectile populations in different parts of the Solar System (figure 2b). Furthermore, adjusting the Jovian crater curve to match that in the inner Solar System requires differences in the impact velocities that are unrealistic for objects in heliocentric orbits. These results suggest that the Solar System cratering record cannot be explained by a single family of objects in heliocentric orbits, e.g. comets. One possible explanation is that the cratering record is the result of different families of objects (possibly accretional remnants) indigenous to that region of the Solar System in which the different crater populations are found.

In the inner Solar System the shapes of the crater curves for the heavily cratered terrains on the Moon, Mercury, and Mars are the same, but they are laterally shifted with respect to each other in such a way that higher impact velocities are required at Mercury and lower ones at Mars compared to the Moon. Solving for the impact velocity for a given projectile diameter in the Holsapple/Schmidt crater scaling equations to account for this shift produces a Mercury/Moon impact velocity ratio of about 2.17 and a Mars/Moon impact velocity ratio of about 0.57. This requires that the average orbital elements of the projectiles had a semimajor axis of about 0.8 AU and an eccentricity of about 0.9 which means that their orbits were confined to the inner Solar System interior to the asteroid belt. This explains why the crater population resulting from the period of heavy bombardment on the terrestrial planets is not found elsewhere in the Solar System. In the outer Solar System, the objects responsible for the period of heavy bombardment may have been in planetocentric orbits around each of the Jovian planets.
Crater size/frequency distribution on Oberon (O), Umbriel (U), Titania (T), Ariel (A), the heavily cratered terrain on Miranda (MHC), the lightly cratered terrain on Miranda (MLC), and in the lunar highlands (LH).

(Left) Crater size/frequency distributions for the heavily cratered surface on the terrestrial planets (T1), at Jupiter (J1), at Saturn (S1) and at Uranus (U1). (Right) The size distribution of projectiles recovered from the cratering records using short-period comet impact velocity distributions.