THE CRATERING RECORD AT URANUS: IMPLICATIONS FOR SATELLITE EVOLUTION AND THE ORIGIN OF IMPACTING OBJECTS.

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The crater size/frequency distributions on the major Uranian satellites show two distinctly different crater populations of different ages (Smith et al., 1986). Figure 1 is an "R" plot of the size/frequency distributions on Oberon, Titania, Umbriel, Ariel, and the heavily cratered and the resurfaced regions of Miranda. Oberon, Umbriel, and the heavily cratered terrain on Miranda have the same lunar-like size distribution. The crater size/frequency distributions on Titania, Ariel, and the resurfaced areas of Miranda are quite different. They are characterized by an overabundance of small craters and a paucity of large craters relative to Oberon, Umbriel, and the heavily cratered terrain on Miranda. At diameters greater than 30 km, the crater density is significantly less on Titania than Oberon and Umbriel, and progressively decreases from Titania to Ariel to the resurfaced areas of Miranda. Furthermore, the paucity of large craters and a corresponding abundance of small craters becomes more pronounced with decreasing crater density, i.e, with time. This suggests that the objects which caused this younger crater population evolved with time by mutual collision where the collision of large objects produced more and more small ones. If so, they must have been in planetocentric orbits for frequent collisions to have occurred. Since only the young crater population occurs on Titania, the older crater population must have been largely obliterated by a resurfacing event.

Although the young crater population is only recognized on relatively young surfaces, it must also be present on the older heavily cratered surfaces as well. Thus, the old crater population is a mixture of the young population and an original old population that can be recovered by subtracting Titania's young population. This "unmodified" population (curve U1 in Figure 2a) is quite different from other crater populations in the Solar System (see Figure 2a).

Any hypothesis on the origin of the objects responsible for the period of heavy bombardment must account for the occurrence of different crater populations (size/frequency distributions) in different parts of the Solar System. One hypothesis suggests that an early high flux of comets was responsible for the period of heavy bombardment throughout the Solar System (Shoemaker and Wolfe, 1982). To test this hypothesis, a computer simulation using short-period comet impact velocities and a modified Holsapple-Schmidt crater scaling law was used to recover the size distribution of cometary nuclei from the observed cratering record. Figure 2b shows the results of this simulation. It shows that if comets on short-period-like orbits were responsible for the cratering record, they must have had radically different size distributions in different parts of the Solar System. In fact, their diameters would have to have been on average larger in the inner Solar System where comets rapidly lose mass than at Jupiter where their masses are conserved. This is highly unlikely, and suggests that comets were not responsible for the period of heavy bombardment.

The most likely explanation for the cratering record is that the period of heavy bombardment was caused by different families of accretional remnants indigenous to the system in which the different crater populations occur. Since the same crater population is found on all the terrestrial planets but not Jupiter, this family of accretional remnants was indigenous to the inner Solar System and confined to heliocentric orbits with small semi-major axes (< 3 AU). The satellites of Jupiter, Saturn, and Uranus each have different crater populations suggesting that they were the result of accretional remnants in planetocentric orbits around each of these planets.

Since the young crater population at Uranus shows evidence that it was formed by objects that evolved by mutual collisions in planetocentric orbits, it is quite possible that both crater populations resulted from one family of accretional remnants. The old crater population has a paucity of small craters which is what one would expect from the accretional process where large objects are built from smaller ones. If these objects had their relative velocities increased by close encounters with the satellites, then they could collide, resulting in a progressive depletion of large objects and a corresponding increase in small objects as characterizes the younger crater population. In this case, at least the initial orbits would have low eccentricities and the impact rate would be about the same on all major satellites. Therefore, differences in crater density would represent the relative age of surfaces among the satellites and can be used to date the relative time of resurfacing events. Since the crater density on Oberon and Umbriel is significantly lower than on Miranda, it suggests that both Oberon and Umbriel were resurfaced near the end accretion, and that the sequence of resurfacing events from oldest to youngest was, 1) Oberon and Umbriel, 2) Titania, 3) Ariel, and 4) Miranda.

<u>References</u>:

Smith, <u>et al</u>., <u>Science</u>, <u>233</u>, p. 43, 1986.
Shoemaker, E.M. and Wolfe, R.F., <u>Satellites of Jupiter</u>, Univ. of Arizona Press, p. 277, 1982.

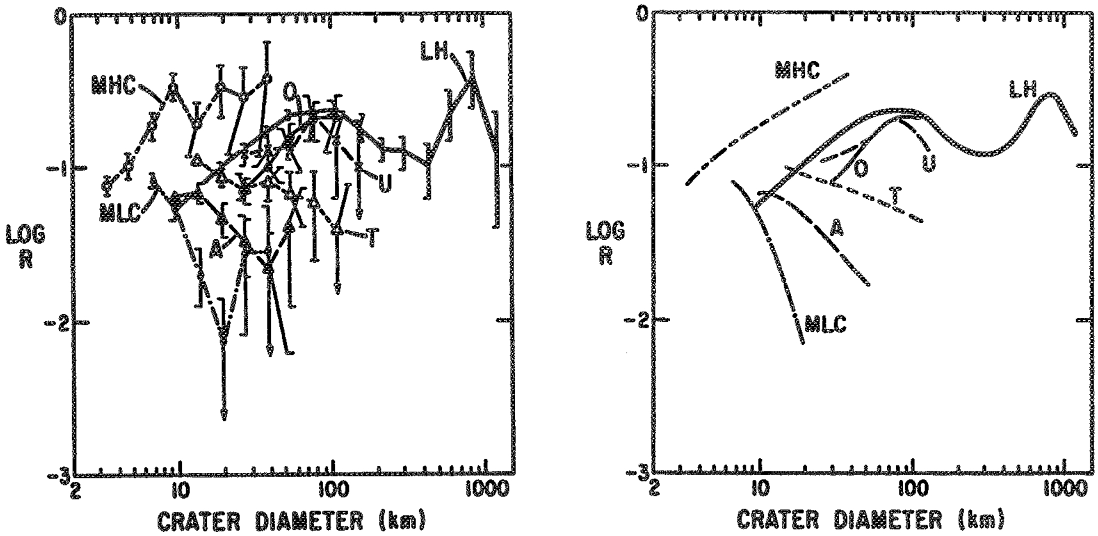

Figure 1. "R" plot of the crater size/frequency distributions on Oberon (O), Umbriel (U), Titania (T), Ariel (A), the heavily cratered terrain (MHC) and resurfaced terrain (MLC) on Miranda, and the lunar highlands (LH).

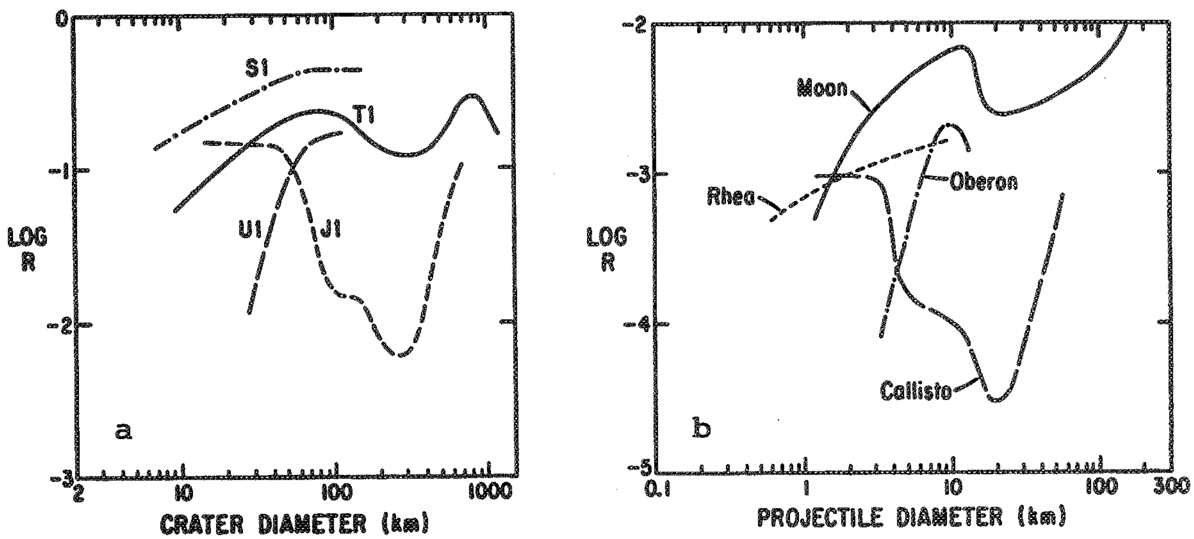

Figure 2. (a) The crater size/frequency distributions representing the period of heavy bombardment on the terrestrial planets (T1), at Jupiter (J1), at Saturn (S1) and at Uranus (U1). (b) The projectile size-frequency distributions for short-period comets recovered from the cratering record.