CRATERING HISTORY OF UMBRIEL, TITANIA, AND OBERON. J.B. Plescia, U.S.G.S. Flagstaff, AZ 86001.

Crater frequencies have been compiled for Umbriel, Titania, and Oberon, the three outermost satellites of Uranus (Table 1). Only the southern hemisphere of each satellite was observed as a result of the large obliquity of Uranus, and only about 25% of the southern hemisphere of each was observed under conditions suitable for crater counting.

Umbriel exhibits craters having diameters that range from 210 km down to the limit of resolution (5.2 km/pixel) in a relatively uniform distribution of sizes. Most craters are degraded, although a few remain fresh. The cumulative size-frequency distribution for Umbriel has two interesting aspects: (1) distinct breaks in slope at diameters of about 30 and 50 km, the slope being about -2.2 at diameters <30 and >50 km and about -4.0 between those diameters; and (2) at diameters >50 km it appears to be in equilibrium, whereas at smaller diameters it lies well above the distribution for surfaces in an equilibrium condition. Surfaces considered to be in an equilibrium condition include those of the lunar highlands (1) and many of the heavily cratered surfaces on the satellites of the outer planets (2). The surface of Umbriel probably dates to the period of the heavy bombardment and apparently has not experienced significant endogenic resurfacing in a manner similar to the wholesale crustal replacement that has occurred on Miranda and Ariel (3).

Titania's surface is fairly uniformly cratered and, with the exception of the bright, smooth material around the crater Ursula, cannot be divided into different terrains. Recognizable craters range in diameter from about 140 km to the limit of resolution (3.4 km/pixel), but most have diameters <70 km. In addition, there are a well-defined impact basin (Gertrude) 315 km in diameter, a palimpsest about 330 km in diameter, and a feature that may have been a 245-km-diameter basin upon which Gertrude was superposed. The relatively high image resolution allowed the surface to be divided into several counting areas for which meaningful statistics could be compiled. Such areas include the bright smooth plains around Ursula, the interior of Gertrude, the palimpsest, and several areas within the cratered terrain. No significant differences in crater frequency were observed within the cratered terrain, so the data were combined into a single distribution (Table 1). Only the palimpsest and the smooth plains around Ursula have significantly different crater frequencies. The cumulative size-frequency distribution for the cratered terrain, which includes most of the observed surface of Titania, has well-defined breaks in slope at diameters of 20 and 35 km, the slope being about -4 between these diameters and -2 outside that range. The distribution exceeds equilibrium values at diameters <25 km.

Titania has been almost completely resurfaced by endogenic processes since the heavy bombardment ended. Apparently, only the areas around Gertrude and the palimpsest escaped this resurfacing. A second episode of endogenic resurfacing produced the bright, smooth plains around Ursula and the smooth material that was locally deposited along some of the grabens. Graben formation occurred in part after the smooth material around Ursula was deposited, but the stratigraphic relations necessary to constrain the ages of most of the grabens, if present, cannot be observed at this resolution.

Oberon appears to be an ancient, relatively uniformly cratered body whose surface is not divisible into different types of terrain. Craters range in diameter from about 210 km to the limit of resolution (6 km/pixel);

CRATERING OF UMBRIEL, TITANIA, AND OBERON
J.B. PLESCIA

most diameters are <100 km. The cumulative size-frequency distribution for Oberon has distinct breaks in slope at about 45 and 70 km; the slope is about -3 between those diameters and -2 outside that range, and at diameters <70 km the crater frequencies are significantly higher than for an equilibrium distribution. Oberon's surface dates to the heavy bombardment and has not been subjected to wholesale crustal replacement. Endogenic resurfacing appears to have been limited to small deposits of low-albedo material that partly fill the floors of some of the large craters.

The cumulative size-frequency distributions for these three satellites (except the distribution for the bright material around Ursula on Titania) exceed that of an equilibrium distribution at a specific diameter, indicating that these surfaces are out of equilibrium. Each satellite exhibits an overabundance of craters in a specific size range (45 to 70 km on Oberon; 30 to 50 km on Umbriel; 20 to 35 km on Titania) relative to what is expected at diameters outside that range. The nonequilibrium conditions apparently have developed because of this overabundance, in that the number of smaller impacts is insufficient to keep the number of larger craters in equilibrium. Two possible sources for this anomalous population of projectiles are (1) within the Uranian system, the debris was generated by the destruction of small coorbiting satellites, and (2) outside the Uranian system, the debris was either a long- or short-term part of the heliocentric flux. The upper and lower size limits of this debris appear to have decreased with time such that the corresponding size limits of the anomalous craters have decreased with time.

REFERENCES: **(1)** Shoemaker, E.M., et al., 1966, JPL Tech. Rept. 32-800, 249-337; **(2)** Hartmann, W.K., 1984, Icarus, 60, 56-74; **(3)** Smith, B.A., et al., 1986, Science, 233, 43-64.

TABLE 1. CRATER FREQUENCIES

	CUMULATIVE NUMBER OF CRATERS $\geq D/10^6$ KM^2 DIAMETER KM					COUNTING
	10	20	30	40	50	AREA (KM^2)
Umbriel	(1,957±67)	522±35	228±23	104±15	41±10	436,449
Oberon	(1,377±39)	(464±22)	197±14	107±11	60± 8	919,812
Titania:						
Cratered terrain	(1,515±46)	355±22	70±10	25± 6	16± 5	722,016
Gertrude	(2,695±202)	325±70	86±36	53±28	39±24	66,146
Palimpsest	(1,668±152)	520±85	232±57	81±34	22±17	72,088
Plains	(1,066± 96)	120±32	9± 9	<1	<1	115,747

Data in parentheses indicate extrapolations.