THE GEOLOGY AND DISTRIBUTION OF IMPACT CRATERS ON VENUS: INITIAL MAGELLAN RESULTS; G.G. Schaber, U.S. Geol. Survey, Flagstaff, AZ 86001; R.E. Grimm, R.R. Herrick, and R.J. Phillips, Dept. of Geol. Sciences, Southern Methodist Univ., Dallas, TX 75275; A.T. Basilevsky, V.I. Vernadsky Instit. of Geochem. and Analy. Chem., Moscow, USSR; J.E. Guest, Univ. of London Observatory, London, England NW72QS; Michael A. Ravine, Altadena Instrument Corp., Pasadena CA 91116; and Paul Schenk, Jet Propulsion Laboratory, Pasadena, CA 91106

Introduction. By the end of 1990, Magellan had imaged 211 impact craters in an area of about $103.2 \times 10^6 km^2$ (22.4% of the planet's surface) between lat 90° N. and 67° S. and long 330° and 82° E., exclusive of a 25° gap in longitude resulting from superior conjunction (112 orbits). The surface of Venus is much less cratered than the post-mare lunar surface, but it has a crater density that is remarkably similar to that of the combined North American and European cratons. The largest crater observed is a multi-ring basin 280 km in diameter. The smallest individual crater is 3 km across; even smaller craters have been found in "crater fields" formed by multiple impacts. There is little evidence of erosion or weathering of craters at Magellan's image resolution of 75m/pixel.

The regional distribution of impact craters appears to be nonrandom, which suggests recent resurfacing of some regions by volcanic or tectonic processes [1,2]. A few good examples of crater burial by volcanic deposits have been found. Cleopatra, a 100-km-diameter crater on the east flank of Maxwell Montes, is unusual in that it appears to be an impact crater that was later the source of major basaltic volcanism.

Crater Density and Average Surface Age. The cumulative frequency distribution and areal densities of craters for the initial 22% of Venus mapped by Magellan are listed in Table 1. The density of craters equal to or larger than 10 km in diameter is 10% higher than that derived from Venera 15/16 data [3] and 33% higher than that derived from Arecibo observations [4].

Based on the latest empirical estimate of the rate of formation on Venus of asteroid-derived craters 20 km in diameter and larger [5], the average age of all surfaces mapped by Magellan in orbits 376 to 676 and 787 to 911 is estimated to be between 155 and 527 m.y. This age range agrees with earlier estimates [6] based on terrestrial cratering rates, but the age is somewhat younger than the 1.0 ± 0.5 b.y. proposed by Basilevsky et al. [3] and Hartmann [7], who extrapolated lunar cratering rates to Venus.

Crater Morphology. The morphology of impact craters on Venus is strongly dependent on crater size, an effect attributed in part to aerodynamic breakup and dispersion of projectiles of different initial mass, density, and strength during their passage through the dense atmosphere. The distribution of morphologic types by size is listed in Table 2, which shows a rather sharp transition between "complex" and "irregular" craters when the crater size exceeds about 13 km. Complex craters on Venus, like those on other solid bodies in the Solar System, are characterized by terraced inner walls; well-developed hummocky and smooth facies of the continuous ejecta; circular rims; and flat floors commonly containing a central peak or peak ring. Irregular craters have noncircular rims, topographically complex floors, and commonly asymmetric ejecta blankets; they are interpreted to form from the nearly simultaneous impacts of multiple, tightly grouped fragments created by aerodynamic breakup of what was probably a single body prior to atmospheric entry. Multiple craters or "crater fields" are thought to have formed from the impacts of more widely dispersed fragments [8]. Simple (bowl-like) craters <15 km in diameter, typically observed on airless bodies like the Moon, are extremely rare on Venus.

The continuous ejecta of most Venusian craters is radar bright, which indicates considerable surface roughness at the scale of a few centimeters to a few meters. Secondary craters generally are confined to the region of the continuous ejecta; exceptions are found at the sites of highly oblique impacts, where the secondaries commonly are concentrated downrange just outside the terminus of the smooth lobate ejecta. Lobate flow fields and radar-dark halos of various sizes associated with many impact craters mapped by Magellan are previously unknown and may be unique to Venus [9].

References: [1] Phillips, R.J. et al., this vol.; [2] Arvidson, R.E., Grimm, R.R., Phillips, R.J., Schaber, G.G., and Shoemaker, E.M., 1990, **Geophy. Res. Lettr.**,17, 1385-1388; [3] Basilevsky, A.T. and 7 others, 1987, **J. Geophy. Res.**, 92, 12869-12901; [4] Campbell, D.B., Stacy, N.J.S., and Hine, A.A., 1990, **Geophy. Res. Lett.**, 17,1389-1392; [5] Shoemaker, E.M., Wolfe, R.F., and Shoemaker, C.S., this vol.; [6] Schaber, G.G., Shoemaker, E.M., and Kozak, R.C., 1987, **Solar System Res.**, 21, 89-94; [7] Hartmann, W.K., 1987, **Izv. Acad. Nauk SSR Ser. Geol.**, 6, 67-74; [8] Melosh, H.J. 1989, Impact Cratering, Oxford Univ. Press., NY, 245 p.; [9] Campbell et al., this vol.

Table 1

Craters equal to or larger than N km in diameter	Number of craters	Percentage of total craters (orbits 376-676, 787-911)	Crater density (craters per 10^6 km^2)
100 km	2	1	0.02
50 km	15	7	0.14
20 km	82	39	0.79
10 km	145	69	1.41
3 km	209	99	2.02

Table 2

Crater morphologic type	Percentage of crater types in diameter ranges		
	<13 km	13 to 50 km	>50 km
Complex crater with peak ring(s)	0	0	75
Complex crater with central peak or peak complex	2	79	25
Complex crater with no central peak or inner ring	6	13	0
Irregular crater	64	2	0
Multiple crater	28	6	0