GEOLOGY, STRUCTURE, AND STATISTICS OF MULTI-RING BASINS ON MARS. *Richard A. Schultz and Herbert V. Frey, NASA Goddard Space Flight Center, Greenbelt, MD 20771.*

Multi-ring basins define the fundamental tectonic framework upon which subsequent geologic and geophysical processes of many planets and satellites are superimposed. For example, most volcanic and tectonic activity on the Moon was localized by pre-existing impact basins [1]. Control of volcanism, tectonics, erosion, and perhaps even volatile dynamics on Mars by multi-ring basins can be discerned in many areas [2] even though endogenic processes were quite vigorous over the planet's history. On the other hand, the family of impacting objects that produced these basins is probably related to planetary accretion [3], and size-frequency characteristics of impactor populations can be estimated given an accurate inventory of impact craters and basins [4]. Thus the record of multi-ring basins on Mars provides a fundamental link between the planet's accretion and its later development.

We have compiled and evaluated available data on martian multi-ring basins [5] using the new 1:15 milion scale geologic maps of Mars [6] and revised global topography [7] as base maps. Published center coordinates and ring diameters of martian basins were plotted by computer and superimposed onto the base maps. In many cases we had to adjust basin centers or ring diameters or both to achieve a better fit to the revised maps. We also found that additional basins can explain subcircular topographic lows as well as map patterns of old Noachian materials, volcanic plains units, and channels in the Tharsis region [8].

Smaller impact basins on Mars such as Ladon (D = 975 km) are comparable dimensionally, morphologically, and structurally to Orientale (D = 930 km) on the Moon. In contrast, Orientale-type morphology can be recognized only for martian basins smaller than Argyre (D = 1850 km). Larger basins such as Isidis, Argyre, and Hellas typically show a rugged, blocky annulus with concentric grabens surrounding a central depression. Still larger structures show either multiple rings reminiscent of Valhalla on Callisto (Chryse) or persistent depressions surrounded by poorly expressed concentric structure (Elysium [9], Utopia [10]). Basin relief relative to diameter becomes progressively shallower with increasing basin diameter. Thus, the morphology and structure of martian multi-ring basins changes significantly as basins increase in size.

The formation of concentric ring structure and post-impact viscous relaxation of basin topography can differ for spherical, rather than planar, targets [11,12]. Diameters of martian multi-ring basins can be significant fractions of Mars' radius. For example, ratios of basin diameter to planetary radius are: Elysium, 1.46; Utopia, 1.39; Chryse, 1.06; Hellas, 0.68; Argyre, 0.55; and Ladon, 0.29. The value for Argyre is comparable to that of Orientale normalized by lunar radius, 0.53, or Caloris on Mercury, 0.53. Because Argyre, Orientale, and Caloris have similar normalized diameters but different morphologies, planetary curvature by itself probably did not control the morphology of these moderate sized basins. Structures larger than Chryse may have been influenced by spherical target geometry.

R-plots of basin diameters (Fig. 1) show that the martian multi-ring basin population dovetails into the smaller crater population [13] near 500 km diameter. The relative abundance of basins >1000 km in diameter is comparable on Mars and the Moon, perhaps suggesting an inner solar system source for the larger impactors [e.g., [4]). R-plots and weighted least squares fit to cumulative frequency data (Fig. 2) both indicate that basins follow a shallow production function. Basins 500 to 1500 km in diameter show the characteristic Orientale morphology and a best-fit slope of $D^{-0.75}$. Basins larger than Argyre define a $D^{-1.7}$ slope. The slope change may in part reflect the size-frequency population of the largest impactors. Formation of large multi-ring basins on early Mars may be more analogous mechanically to impacts on icy satellites (e.g., [14,11]) than to late forming lunar basins. Thus, Orientale morphology may not scale linearly to the largest diameters on Mars.

MULTI-RING BASINS OF MARS

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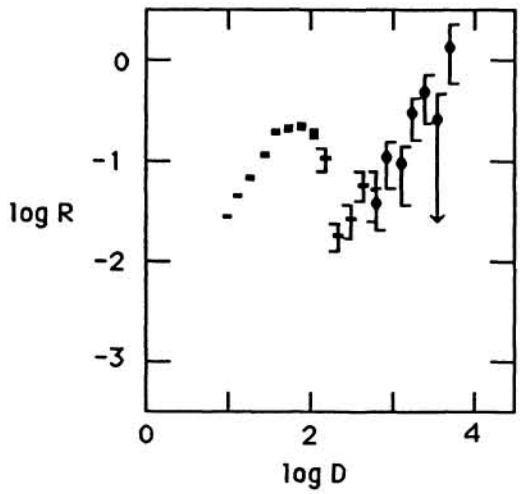

Fig. 1. Relative frequency (R-plot) diagrams of martian craters and basins. Data for basins < 500 km in diameter from Barlow [1988].

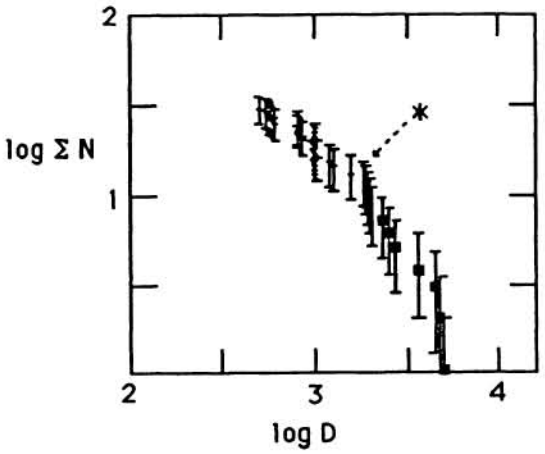

*Fig. 2. Cumulative frequency distribution of martian multi-ring basins > 500 km in diameter (unbinned data). Data normalized by surface area of Mars. Basins > 2300 km in diameter shown by dots; Argyre shown by *.*