PALEOGEOLOGIC MAPS OF MERCURY'S SURFACE.

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The three flybys of Mercury by the Mariner 10 spacecraft in 1974 and 1975 provided us with photographic coverage of about 40 percent of the planet's surface with an average resolution of 1 to 2 km [1]. These data were used to prepare a series of nine geologic quadrangle maps at a scale of 1:5 M. Work on a synoptic geologic map of the imaged hemisphere of Mercury at 1:10 M scale (by Spudis) is in progress; this work is summarized in [2]. Through the use of these geologic maps and new geologic analysis [2], we have prepared a series of paleogeologic maps that show the surface geology of the imaged hemisphere of Mercury at six different stages in its history. These new maps facilitate interplanetary comparisons of geologic evolution, particularly with that of the Moon [2].

Mercurian stratigraphic systems. The time-stratigraphic classification developed for the geologic mapping of Mercury [2,3] is patterned after the classification used for lunar mapping [4,5]. Mercurian history is subdivided into five systems; from oldest to youngest, they are (1) pre-Tolstojan, (2) Tolstojan, (3) Calorian, (4) Mansurian, and (5) Kuiperian. The pre-Tolstojan comprises the geologic units emplaced prior to the impact that formed the Tolstoj basin (-16°, 164°; 510 km dia.). The units include materials of ancient craters and multi-ring basins and intercrater plains [6]. Units emplaced after the Tolstoj impact but before the Caloris impact make up the Tolstojan System. This system encompasses mostly crater deposits, although materials of some basins (e.g., Beethoven) and some plains units were emplaced during Tolstojan time. The Calorian System includes materials of the Caloris basin (30°, 195°; 1340 km dia.), widespread smooth plains material, and many large craters and double-ring basins (e.g., Bach). Most Mercurian geologic units are of this age or older [2]. The remaining two systems, the Mansurian (whose base is the base of deposits from the crater Mansur, 48°, 163°; 75 km dia.) and Kuiperian (whose base is the base of deposits from the crater Kuiper, -11°, 31.5°; 60 km dia.), consist only of younger crater deposits; no regional geologic units of these ages are recognized.

Paleogeologic maps and Mercurian geologic evolution. Sometime during the heavy bombardment, the earliest cratering record of Mercury was largely destroyed by the widespread deposition of intercrater plains material [6]. The largest craters of this period (basins), which have been partly preserved [2,7], suggest that Mercury's surface may have resembled the lunar highlands at an earlier stage. The wide, probably global distribution of the intercrater plains suggests that they may be at least partly volcanic in origin [2,8]. The Tolstoj basin impact occurred when the impact flux was beginning to decline but was still high; some plains materials were also emplaced at this time. The Caloris impact formed the largest, best preserved basin on the imaged part of Mercury's surface, and it provides a regionally extensive stratigraphic datum. Some finite but probably short time after this impact, smooth plains material was emplaced over vast regions, probably through eruptions of volcanic flood lavas [2,6,8]. Since this emplacement, a rapidly declining cratering rate has produced minimal changes to Mercury's surface.

Comparisons with lunar stratigraphy. Both on the imaged part of Mercury and on the Moon, almost all geologic activity occurred early in planetary history--during pre-Tolstojan to early Calorian time on Mercury and during pre-Nectarian to early Imbrian time on the Moon [5]. A significant difference between the two bodies is the extended period of mare (smooth plains) deposition on the Moon, which may have extended into Copernican time [9]. Such a wide range in age for Mercurian plains is not evident within the hemisphere imaged by Mariner 10.

To estimate the cratering rates in the early histories of the two bodies, the relative ages of some comparable Mercurian and lunar geologic units can be plotted against crater densities (fig. 1). Although we have absolute ages for only some lunar geologic units (fig. 1b), the general shapes of the two curves are clearly similar. Deposition of the smooth plains material on Mercury was virtually the last global geologic event on that planet; only impact craters have formed since. Crater densities on the Mercurian smooth plains are comparable to the crater density on the lunar Imbrium basin deposits (fig. 1; see also [10]). This suggests that the last major geologic activity occurred on Mercury roughly 3.8 b.y. ago [11], although it is by no means certain that absolute ages may be directly compared between the two bodies [12]. In any event, most Mercurian geologic activity was confined to its early history. Large areas of relatively uncratered units, such as are widespread on Mars [11,13], do not occur on Mercury. It thus appears that in regard to geologic evolution, Mercury has more in common with the Moon than with Mars.

References: [1] Davies, M., et al. (1978) NASA SP-423, 128 pp. [2] Spudis, P.D. and Guest, J.E. (in press), Mercury, U. of Ariz. Press. [3] Spudis, P.D. (1985) NASA TM-87563, 595. [4] Shoemaker, E. and Hackman, R. (1962) in The Moon, Academic Press, N.Y., 289. [5] Wilhelms, D.E. (in press) USGS PP 1348. [6] Trask, N. and Guest, J.E. (1975) JGR 80, 2461. [7] Pike, P.J. and Spudis, P.D. (in press) Earth, Moon, and Planets. [8] Strom, R.G. (1984) NASA SP-469, 12. [9] Schultz, P.H. and Spudis, P.D. (1983) Nature 302, 233. [10] Murray B., et al. (1974) Science 185, 169. [11] Basaltic Volcanism Terrestrial Planets (1981), Pergamon Press, 1286 pp. [12] Chapman, C.R. (1976) Icarus, 28, 523. [13] Scott, D.H., and Carr, M.H. (1978) USGS Map I-1083.

Spudis, P.D. and Guest J.E.

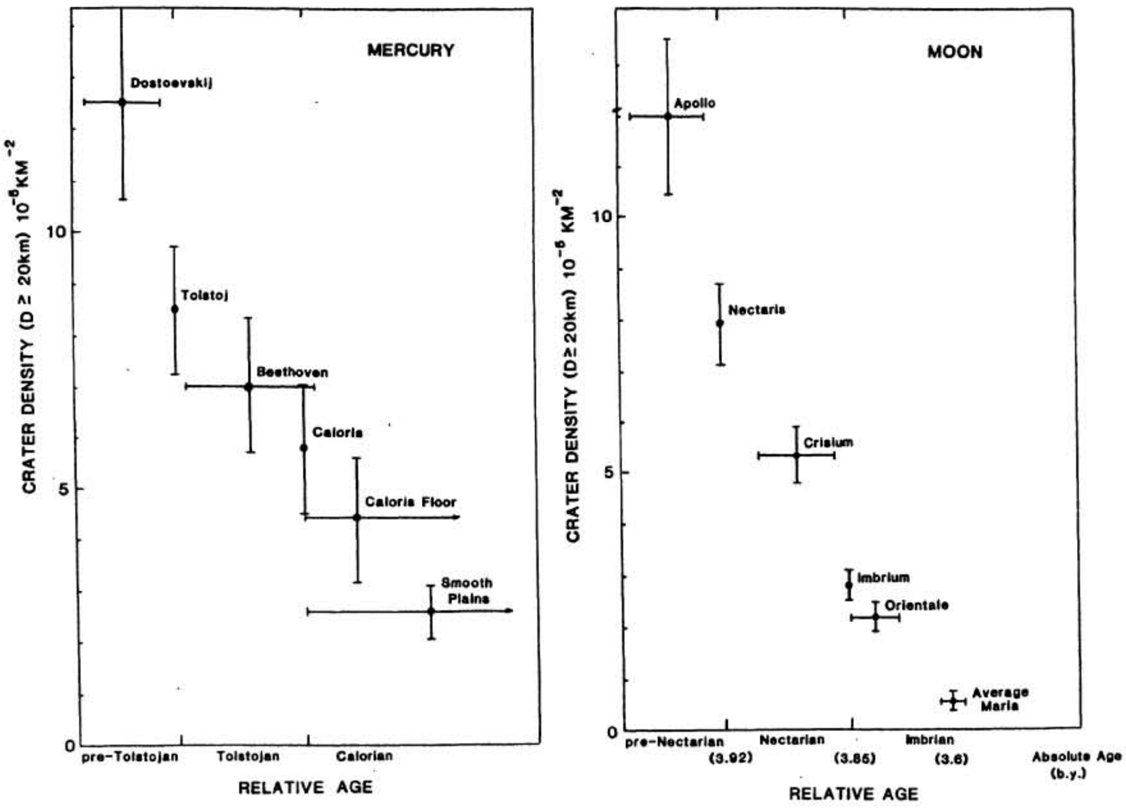

Figure 1. Plots of cumulative density of primary impact craters greater than 20 km in diameter on various geologic units on Mercury and the Moon versus stratigraphically defined relative ages. (a) Mercury. Tolstoj and Caloris basins have no horizontal error bars because they define beginnings of systems. Note that both Caloris basin fill and exterior smooth plains material postdate Caloris basin ejecta. (b) Moon. Nectaris and Imbrium basins have no horizontal error bars because they define beginnings of systems. Crater densities for basins from [5]; data for average maria from [11]. Absolute ages in billion (10^9) years. Note that for comparable stratigraphic positions, lunar units display lower absolute crater densities than Mercurian units.