The larger-crater population of the lunar highlands is not at saturation density. The ramifications of that little-appreciated fact are tremendous: The ancient history of the highlands remains there to be read; the imprint of the size-frequency distribution of the impacting bodies may be recovered from the observed crater distribution; and the impact histories of different terrains and different planets can be meaningfully compared to that preserved in the ancient lunar highlands. In fact, many recently developed lines of evidence support the hypothesis that on some terrains of all of the heavily cratered bodies thus far studied (Moon, Mercury, Mars, Ganymede and Callisto) the observed large-crater populations (craters >8 km diameter) bear a reasonable likeness to their production functions.

Many new insights into the cratering histories, based on new data sets, new simulations, and new theoretical treatments, show: (1) The lunar highlands are not saturated at crater diameters larger than at least 8 km. (2) The observed size-frequency distribution function for the large craters on the lunar highlands is essentially identical to the production function which generated them. (3) Neither the observed size-density function for the larger craters nor their production functions follow a simple power law relationship. (4) Extrapolating information on saturation conditions obtained from small craters to these larger craters is not valid. (5) Extrapolating the larger-crater curve to much smaller diameters by using a simple power law to represent the highlands populations grossly misrepresents the highlands data and consequently does not provide a meaningful reference line at the small crater diameters.

Obviously if the lunar highlands are not saturated with craters greater than 8 km, then the mare surfaces also are not saturated at comparable crater diameters. Therefore, the post-mare crater population is a production population in this size range. That crater population has a production function which is significantly different from that of the highlands population over the same diameter range (Figure 1).

Mercury: The post-Caloris crater curve is virtually identical in both crater density and slope to that of the lunar post-Orientale curve (Figure 20 in Ref. 1), which, in turn, is the same as the lunar highlands curve. This suggests that the ancient production function as very similar, perhaps identical, for both bodies. Furthermore, the most densely cratered terrains on both bodies have similar total crater densities. (Figure 1). To date, a younger crater population similar to the lunar post-mare population has not been recognized on Mercury (1). Perhaps, either it never reached Mercury in numbers large enough to leave a recognizable signature, or the youngest surfaces on Mercury were formed earlier than the lunar maria, when the objects responsible for heavy bombardment of the highlands still dominated.

Mars: In the southern cratered terrain, if one carefully excludes smooth plains units with few superposed craters and with wrinkle ridges, then the size-density distribution on the truly ancient surfaces is virtually identical (Figure 1) to that of the Moon in both crater density and size-frequency distribution function. The similarity of cratering records between Mars and the Moon extends farther: The northern plains of Mars record an impacting population with a size-frequency distribution function markedly different from that of the ancient terrains, yet almost identical
to that found on the lunar maria.

Synthesis: In summarizing the facts now known about the cratering records of the terrestrial planet, we are first confronted by the great similarities they exhibit. The most ancient, most heavily cratered terrains, of the Moon, Mercury and Mars record a complex-shaped crater curve that differs little from one planet to the next in either density or shape. This may be interpreted, in light of studies suggesting that all three bodies underwent crustal melting at about the same time (2), to imply that the same ancient impacting population reached all three bodies with about the same flux rate. A similar relationship holds for the crater populations of the lunar maria and the martian northern plains. But their size-frequency distribution is different from that of the ancient terrains. These data strongly suggest that two populations of objects have impacted the terrestrial planets; one responsible for the period of heavy bombardment early in the history of Mars, the Moon and Mercury, and probably the Earth and Venus as well, and another primarily responsible for the period of crater formation after mare formation on the Moon and plains formation on Mars.

REFERENCES:


Figure 1. Crater diameter/density distribution of the lunar, mercurian, and martian highlands, and the post-lunar mare and martian sparsely cratered areas. R is the ratio of the observed distribution to the function N=D^{-3}.