

# POSSIBLE MISINTERPRETATION OF LUNAR CRATERING RECORD IN VOYAGER TEAM ANALYSES OF OUTER PLANET SATELLITES

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While interpreting outer planetary satellites, the Voyager imaging team repeatedly referred to a lunar frontside highland calibration curve which they say represents "the most ancient, heavily cratered bodies in the solar system" (1). They assume that it is unmodified and not in steady state equilibrium, but rather records all impacts that have occurred. They assume also that it records the size distribution of an early population of impactors, called "Population I" (1), evidence for which they found on various satellites.

This paper reports new evidence that the Voyager team interpretation of this fundamental reference population is wrong, a conclusion that seriously affects the cratering histories reported for outer planet satellites.

The R-plot in Figure 1 (a plot of crater densities relative to the -1.83 index power law found by Hartmann for pure upland populations) shows the situation prior to this work. The heavy horizontal line is a fit to "pure" uplands (defined as uncontaminated by intercrater plains) on several moons and planets. The open circles and S's show data generated for the frontside lunar highlands by Hartmann and Strom, respectively. They are in reasonable agreement, and define a V-shaped curve (thin solid curve in Figure 1). (Strom's counts extended only down to diameters around 8 km; mine extend to smaller sizes, where they turn up due to secondary craters. For clarity, all error bars, based on  $\sqrt{n}$  values, have been dropped; they vary, but are typically  $\pm 30\%$ . The Voyager team interprets this V-shaped curve as a record of a pristine, unique population of ancient impactors, different from more recent populations.

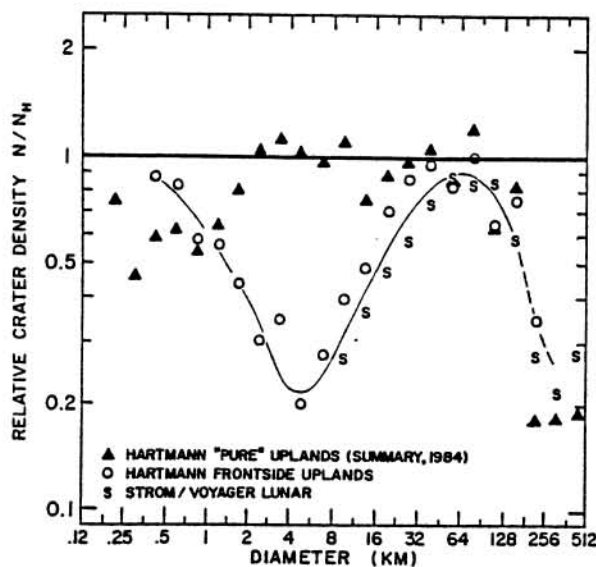


Fig. 1. Old data (through 1984). Left axis shows density relative to that found in most heavily cratered regions. See text for discussion.

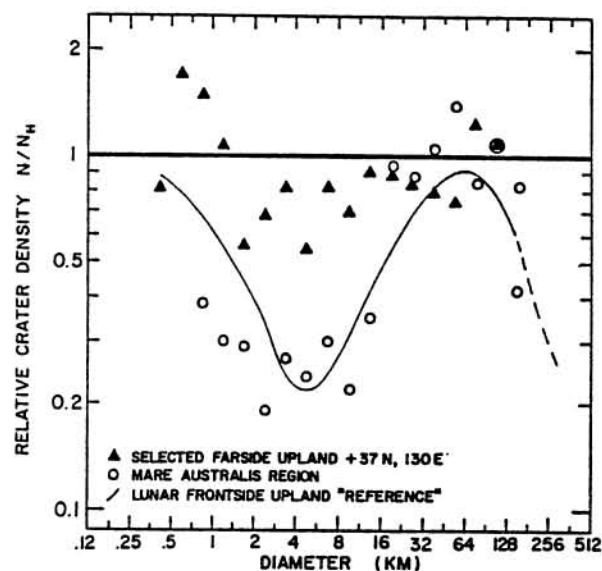


Fig. 2. New data (1990). Mare Australe flooded region matches lunar frontside uplands reference curve (solid curve). A farside test region clusters nearer the "pure" upland heavy horizontal line.

## Lunar Cratering Record; W. K. Hartmann

The Voyager team interpretation goes back to the work of Woronow, Strom, and Gurnis (2), who used the V-shaped lunar frontside upland curve to study Jupiter satellites. They stated that in this curve "the imprint of the size-frequency distribution of the impacting bodies may be recovered...(as) preserved in the ancient lunar uplands." Following this assumption, the Voyager team has identified as many as five different populations of impactors; an independent review (3), while questioning some points, also inclines toward "at least four and perhaps all five" populations.

Hartmann (4), however, argued that the V-shaped population is neither characteristic of pristine lunar uplands, nor a marker of a pristine population of ancient craters. Instead, he found that the upland curve in "pure" uplands on the lunar farside is flat, like that of recent mare populations, and that the V-shape comes from loss of small craters through obliteration by uplands plains. (Craters smaller than about 8 km were obliterated; the left side of the V was quickly restored by post-obliteration secondary craters -- see ref. 3 for details).

To test the two interpretations I have made new counts in the moon's Mare Australis region, and on the lunar farside. "Mare" Australis is a perfect region to test for the effects of flooding on crater populations because it marks recent partial flooding by dark flows. One can clearly see that large craters have been flooded to some depth, leaving the large crater rims visible, but destroying smaller craters. A region on the farside (Lat. 37 N, 130 E, Orbiter V-185 Medium and High Resolution) was also counted. A "nesting frames" technique was used, counting large craters on a medium-resolution view, and smaller craters in successively smaller, but representative, subregions at higher resolution).

Preliminary results are shown in Figure 2. The solid triangles, marking the relatively pure farside upland region, cluster near the heavy solid curve as before, though with more scatter (it being a smaller region with fewer statistics). This behavior should not exist in the uplands, according to the Voyager team interpretation. The thin solid curve is copied from Figure 1 for reference. The Mare Australe points cluster along it, in agreement with an association between this shape and upland flooding.

The preliminary conclusions are that flooding in the Mare Australe region has created almost the same curve that was found in the lunar frontside uplands, and that this signature involves not a primordial "Population 1" of unique impactors, but rather obliteration of small craters, and subsequent re-establishment of the secondary branch by post-mare cratering.

If these conclusions are correct, the Voyager team interpretations of outer planet satellite crater and impactor populations may be fundamentally flawed, as the turn-downs found there (the right branch of the V) may indicate not distinct impactor populations, but ancient obliteration/flooding processes.

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1. Smith, B. A. and 39 others. (1986) *Science*, **233**, 43-64; 2. Woronow, A., R. Strom, and M. Gurnis (1982). In *Satellites of Jupiter*, D. Morrison and M. Matthews, eds. (Tucson: U. Ariz. Press); 3. Chapman, C. and W. McKinnon (1986) in *Satellites*, eds. J. Burns and M. Matthews (Tucson: Univ. of Arizona Press). 4. Hartmann, W. K. (1984) *Icarus*, **60**, 56-74.