**THE ABUNDANCE OF LARGE, COPERNICAN-AGE CRATERS ON THE MOON**; Jeffrey M. Moore[1] and Alfred S. McEwen[2], [1]NASA-Ames Research Center; MS 245-3; Moffett Field, CA 94035, [2]U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001.

Overview. Recent studies [1,2] have brought into question the size-frequency distribution of Copernican-age lunar craters. In particular, several large near-side craters that have been mapped as Copernican in the compilation of Wilhelms [3] are probably older, on the basis of the size-frequency distribution of superposed craters. The craters were mapped as Copernican at least in part because of the presence of bright rays. However, the rays are only apparent over dark mare terrains, and are probably due to highlands materials excavated and deposited over the maria rather than being due to immature soils [4]. The geologically-mapped population of large Copernican craters has also been suspect due to the apparent deficiency of these craters on the far side when compared with the near side [3]. The far side contains very little maria, and provides a more uniform canvas to record bright-rayed craters. With the recent receipt of high-resolution and high-sun multispectral images of the far side by *Clementine*, it is now possible to re-evaluate the size-frequency distribution of far-side rayed craters, which are of likely Copernican age. We find a systematically lower density of far-side Copernican craters than the previous whole-Moon counts [3], especially at the larger sizes. We find that several large craters were previously misidentified as having bright rays due to the superposition of smaller rayed craters. These results have implications for the age of Venus' surface and the frequency and severity of impact-induced extinctions and climate changes on the Earth.

Images collected during the December 1990 flyby of the Earth-Moon system by *Galileo* afforded a first opportunity to re-examine the age-color relations of far-side Copernican craters. McEwen *et al.* [2] correlated colors and albedos of craters (away from impact-melt veneers) with their geologic emplacement ages as determined from counts of superposed craters. They used these age-color relations to estimate the emplacement age (time since impact event) for other Copernican-age craters. They reported that the age-color relations indicated a probable Copernican age for 27 far-side or western limb craters larger than 10 km in diameter that were not previously mapped as Copernican. Their data showed no disparity in Copernican crater distributions between the near and far sides of the Moon. They also concluded that soil-maturity trends, as they affect color and albedo, represent longer geologic time periods in regions with thinner regoliths (such as the maria), giving some craters on those surfaces a false appearance of relative youth. With the availablity of high-resolution multispectral data from *Clementine*, the color/albedo properties of small craters sampled by *Apollo* can be used to improve the absolute calibration of the age-color trends [5].

In this study we inspect the lunar far side (90° to 270°W) imaged by *Clementine* at 0.75 μm, mosaicked and sampled at 1 km/pixel [6]. The regions poleward of 60° were ignored to avoid the problems of low illumination. We searched for craters ≥20 km diameter that exhibited ejecta rays with a higher albedo (to the limit of discrimination) than the surroundings. We limited our search to the far side to avoid the problems found with ejecta rays on maria. Table 1 lists the 31 craters that meet our criteria. Note that we did not recognize any qualifying craters on the small maria deposits of the far side. We tentatively classify these far-side rayed craters as Copernican (≤ Copernicus, about $1.0 \pm 0.2\ 10^9$ yrs) based on the observation that the rays of Copernicus are just barely discernable over highland terrains. Wilhelms [3] summarized the identification and distribution of Copernican-age craters ≥30 km diameter as mapped prior to 1987. He reported 44 such craters over the whole Moon. Figure 1 shows the normalized-area, size-frequency distribution of both the "Wilhelms" population and those we identified and list in Table 1. Our data shows a systematically lower density, especially at the larger sizes. There are two major reasons for our lower density: (1) we excluded near-side rayed craters whose rays are due to compositional contrasts rather than immature soils; and (2) some farside craters previously identified as Copernican because of bright rays were found to be the consequence of a small very bright crater superposed on the larger crater. In low-resolution albedo data it was often not possible to resolve the small parent, and so the location of the signature was matched to a co-residing larger crater.

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Examples of this mis-identification in the "Wilhelms" data set are Perrine-E and Hartmann. Similarly, McEwen *et al.* [2] mis-attributed Copernican-age ejecta from small impacts to the larger craters: Engelhardt and Golitsyn. If indeed the craters we have identified represent the Copernican age population of impactors in the inner solar system, our lower-than-canonical crater density has implications for other solar-system studies, such as the age of Venus' surface and the frequency and severity of impact-induced extinctions and climate changes on the Earth.

[1] Neukum, G., and B. Konig, 1976, PLPSC 7th, 2867. [2] McEwen, A.S., *et al.*, 1993, JGR 98, 17207. [3] Wilhelms, D.E., 1987, USGS Prof. Pap. 1348, 302 pp. [4] Pieters, C.M., *et al.*, 1985, JGR 90, 12393. [5] Lucey, P.G., *et al.*, 1995, Bull. AAS 27, 54. [6] McEwen, A.S., *et al.*, 1995, LPSC 26, 931.

**TABLE 1**

| NAME | dia in km | NAME | dia in km |
|---|---|---|---|
| Jackson | 71 | Zhukovsky Z | 30 |
| part of Von Neumann F | 30 | Ohm | 64 |
| King | 77 | Hartmann M | 40 |
| Coriolis Y | 31 | Saha E | 30 |
| Vavilov | 99 | Coriolis G | 22 |
| Necho | 31 | Dufay B | 23 |
| Crookes | 49 | 0.5°N, 158.5°W | 20 |
| Das | 39 | Ventris M | 20 |
| Milne N | 37 | Plante | 38 |
| Guthnick | 36 | Galois F | 22 |
| Glordano Bruno | 22 | 23.5°S, 116°W | 20 |
| Stefan L | 25 | Focas | 22 |
| Moore F | 24 | Golitsyn J | 20 |
| Klute W | 31 | 34°S, 130°W | 20 |
| Dante Q | 20 | Gerasimovich D | 26 |
| Virtanen | 43 | | |

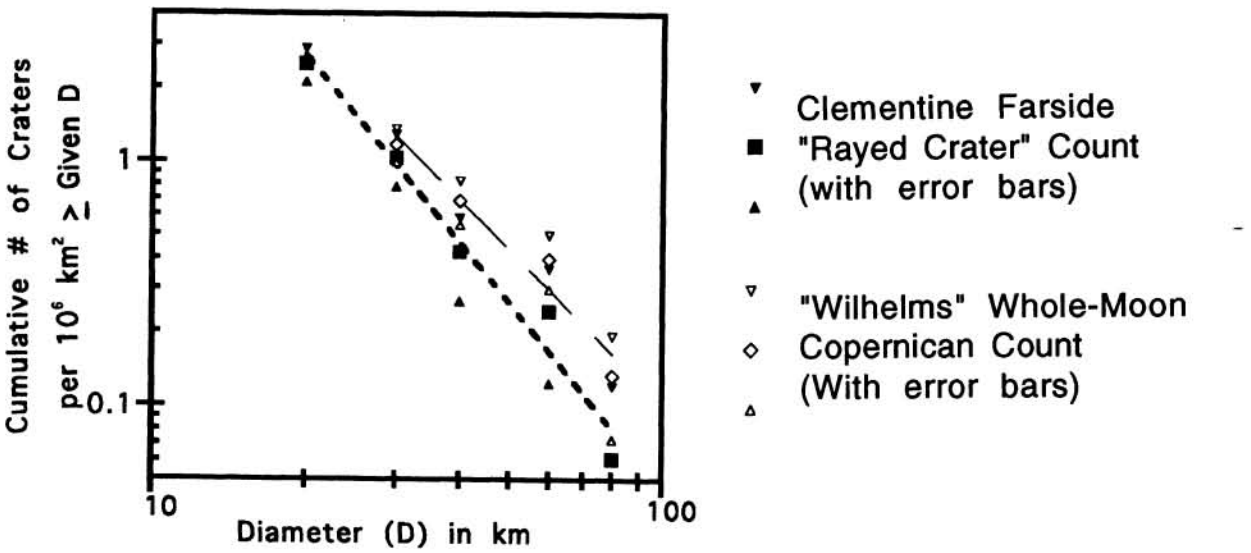


**Figure 1.** A plot of Copernican-age, far-side craters we identified using *Cementine* data, and those reported in Wilhelms [3] for the whole Moon. Lines are power-fits to the two sets.