ANCIENT LUNAR IMPACT RECORD; Gerhard Neukum, Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR), Forschungszentrum Oberpfaffenhofen, 8031 Wessling, West Germany and Don E. Wilhelms, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025

Lunar Highland rock age data show a strong peak at ∿4 b.y. and a minor peak at ∿4.25 b.y. (1). Those peaks have generally been interpreted as showing the time of resetting the radiometric ages by basin-forming impacts. The clustering af ages around 4 b.y. has led Tera et al. (2) to the interpretation of a "terminal cataclysm" around 4 b.y. ago, i.e. most of the large-scale cratering (basin cratering) at least of the frontside of the Moon would have happened at that time. Different possibilities for the cratering rate dependance are shown in Fig. 1. The cratering rate on the Moon as a function of time is given with the different possibilities of a smooth decay, a hypothetical "cataclysm" at ca. 4 b.y. ago, with a theoretical model from Wetherill (3), and other data (4).

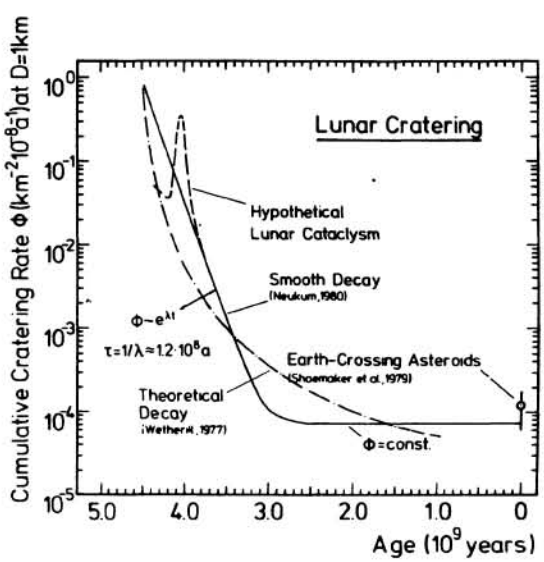

Fig. 1.

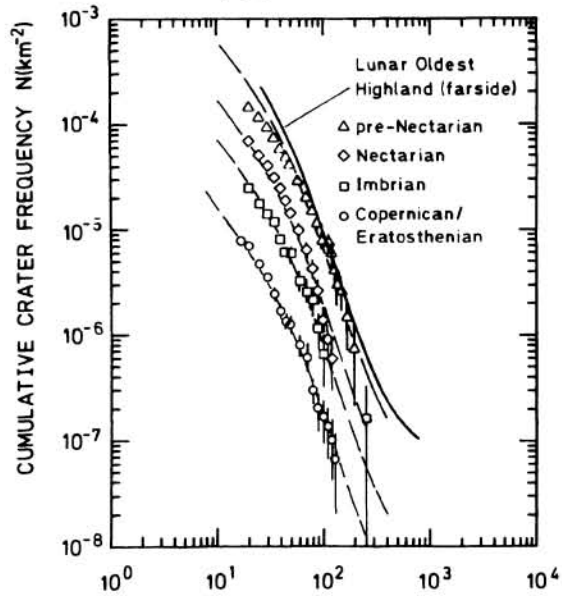

Fig. 2

Wetherill (5) recently discussed the early lunar and solar system wide cratering again. He gave arguments that the interpretation of this cratering record depends heavily on the interpretation of the radiometric ages of lunar highland rocks and on the coupling of age "peaks" in the data with basin-forming events. Especially critical are the ages of the Serenitatis basin and the Nectaris basin, and the interpretation of the Apollo 16 rock ages with groupings around 3.9 and 4.1 b.y., respectively (6). Earlier photogeologic investigations were suggestive that the Serenitatis basin was probably among the oldest on the frontside. This was supported by crater counts (7). It is, however, very difficult to determine the superposition relationships around Serenitatis and also to count post-Serenitatis craters on the Serenitatis rim damaged by the Imbrium and other events. New investigations of the superpositional relationships (8,9,10) strongly suggest that Serenitatis is a basin of Nectarian age but younger than Crisium. It is now a matter of assignment of cratering data to the new age data, especially to the Nectaris basin age to better unravel the early impact history and especially to find out whether there was a "cataclysm" at 4 b.y. ago or not.

We have investigated those questions in more detail. If there was a term-

inal cataclysm, then it must show up in the relative ages of lunar basins and basin production rates as a function of time. In addition, if there was such a singular activity, one might expect a change in the production size frequency distribution of lunar craters. We will give arguments for a smooth decay of the impact rate from crater frequency data superimposed on a number of pre-Nectarian, Nectarian, and Imbrian basins in comparison with the overall large-crater frequency of the oldest parts of the lunar farside. We conclude from the crater counts (Fig.2) that there is one size distribution i.e. one crater production function for the lunar cratering between earliest cratering times recognizable and Copernican times. Fig. 2 shows the large-crater frequencies for Imbrian basins, Nectarian basins, pre-Nectarian basins, and the Lunar Highlands, and Copernican/Eratosthenian craters (sums of counts of craters superimposed on the individual basins). The data demonstrate constancy of the size distributions of large craters over much of the past. The Nectarian crater frequency is a factor of 3 higher than the Imbrian crater frequency. The pre-Nectarian crater frequency is a factor of 3 higher than the Nectarian crater frequency and is slightly below the lunar highland crater frequency. That means that most large craters were produced during pre-Nectarian times and not during Imbrian or Nectarian times. A comparison of the numbers of basins on the moon (pre-N, N, I) gives a similar proportion of production numbers as crater frequency number relations: The total number of basins on the moon (D>265 km) is 44 (including 12 probable or possible ones). There are 30 basins of pre-Nectarian age, 11 of Nectarian age, and 3 of Imbrian age.

The distribution we find (Fig. 2) is not a straight-line function on a log-log plot but a complex function with bends. Our measurements confirm former findings of Neukum (11) and of Strom et al. (e.g., 12) for their highland cratering measurements. We do not agree, however, with Strom et al. with respect to their "post-mare" distributions which they interpret to be different from the "pre-mare" distributions. We cannot find any major difference in our statistically good measurements from the highland distribution or the cratering record for the intermediate times. It is also clear from our data that all the distributions including the highland data are production distributions and <u>not</u> equilibrium or "saturation" distributions. Otherwise we should find distributions with a constant -2 slope.

The majority of craters and in similar proportions the majority of basins was formed during pre-Nectarian times. If Nectaris was formed at 4.1 b.y. ago this means most of the cratering happened at earlier times and not at 4 b.y. ago. In any case it is hard to reconcile our data with a "terminal cataclysm" producing most of the basins and large craters in a narrow time interval at Imbrium to Serenitatis times at about 4 b.y. ago.

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