ANCIENT CRATERING RECORDS OF THE TERRESTRIAL-TYPE PLANETS; Gerhard Neukum, Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR), Forschungszentrum Oberpfaffenhofen, 8031 Wessling, West Germany.

The crater size-frequency distributions on the terrestrial-type planets can be examined for irregularities such as different target response to cratering due to factors like different lithologies, contrasting strength of the target substrate for craters of different sizes, water content, layering, etc., as discussed especially for the lunar and/or Martian case in the literature (References 1-6). Neukum and Hiller (Ref. 7) discussed the effects for the Martian case. Neukum and Wise (Ref. 8) also in general discussed the effects of different impact conditions on a size-frequency distribution curve whose slope (on a log-log diagram) is different at different crater sizes. The different effects are shown in Fig. 1. Age effects - that is, similar ratios of exposure times of the surfaces to cratering - will result in similar ratios of crater frequencies at any diameter (Δlog N = constant for the right half of Fig. 1). The same is true for different cross-section effects, in which slower meteorites are more easily deflected by a planet's gravity.This is equivalent to a difference in flux. These effects do not change the shape of the curve - that is, the crater frequency at some diameter in the steep part of the curve relative to the value at some diameter in the flat part of the curve. In other words, age differences and cross-section effects are such that the curves can be shifted vertically and should coincide. The shape of the curve, in terms of the diameter at which the inflection point occurs in Fig. 1 does not remain constant if the impact velocity is different on different planets, or if target properties have an effect on the sizes of the craters produced. Thus, even with the same meteoroid mass distribution different (average) impact velocities on different planets or different target properties will result in different crater sizes for the same projectile mass, and the shapes or inflection points of the curves for the different planets will differ. The ratios of crater frequencies at two fixed diameter values in the steep and flat part of the curve will be different, as seen in the left half of Fig. 1 (Δlog N1 $\neq$ Δlog N2 for a diameter shift by a constant factor).

Thus, different crater distributions measured on different planets do not necessarily mean different mass distributions of the impactors as put forward by some workers (e.g. 9). The impactors could still have the same mass spectrum. We have reinvestigated a number of production size distributions as shown in Figs. 2 and 3. The crater frequencies on the oldest parts of all those terrestrial-type planets look very much alike with respect to the shape of the distributions and with respect to the absolute crater densities. With the assumption of reasonable impact velocity differences at the different planets which would affect the distributions by diameter shifts with respect to the lunar curve taken as a basis, the distributions for Mars and Mercury would fall right on the lunar curve. This suggests, that the mass spectrum of the impactors was the same throughout the inner solar system which would probably mean the same family of bodies.

The similarity of the shapes of the distributions can more impressingly be shown in a plot of relative crater frequencies which enhances the details of variations of the distribution index. The data for the oldest part of the mercurian highlands, and the oldest part of Ganymede (Galileo Regio) are shown in Fig. 4 in comparison with the distribution on the oldest parts of the lunar highlands. In this presentation there is more scatter in the individual data points than in cummulative plots because of poorer statistical validity of the individual data points. However, it is obvious that the majority of the Ganymede data points lies left of the lunar curve, and the majority of the Mercury

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data points lies slightly right of the lunar curve; whereas the shapes of the curves are very similar with relative frequency maxima at about 40 km (Ganymede), about 80 km (moon) and about 120 km (Mercury). The simplest explanation of those systematic differences is that the impactors had the same mass spectrum but different average impact velocities. The differences in impact velocity would be (compared the moon and for the same target response) about a factor of 2 - 3 lower at Ganymede, and a factor of 2 - 3 higher at Mercury. Accounting for the target properties of Ganymede's icy crust probably resulting in larger craters than on silicate targets we would deduce impact velocities of the bodies responsible for the ancient cratering record on Ganymede of the order of a few km/s. This would exclude bodies in heliocentric orbits because the impact velocity from Jupiter's attraction at Ganymede's orbit would be in excess of 15 km/s.

In summary we come to the following conclusions:

1) All crater size-distributions measured by us on the most ancient surface parts of the terrestrial-type planets show great similarities.
2) The distributions can easily be explained by the same or similar mass spectrum of the impactors and by plausible velocity differences (and to some extent by different target response).
3) It appears that if we had the same mass spectrum of bodies in the inner solar system and in the Javian system, then the ancient cratering record there was produced by bodies in jovicentric orbits.

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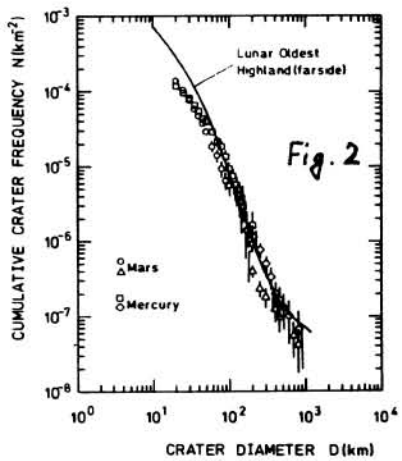

Fig. 2

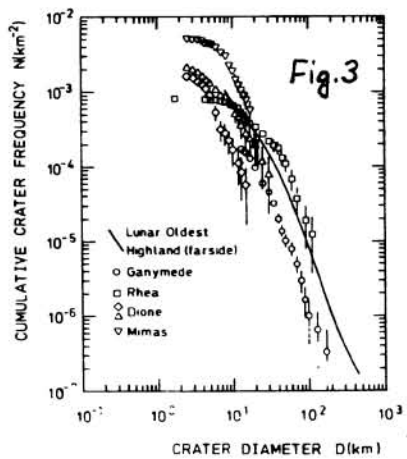

Fig. 3

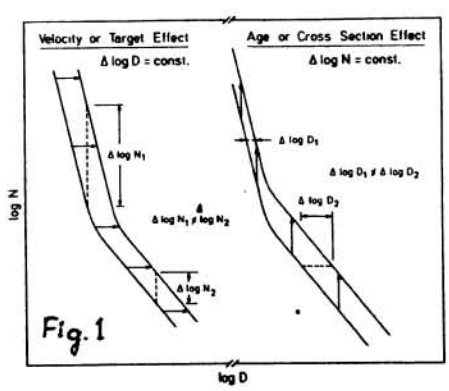

Fig. 1

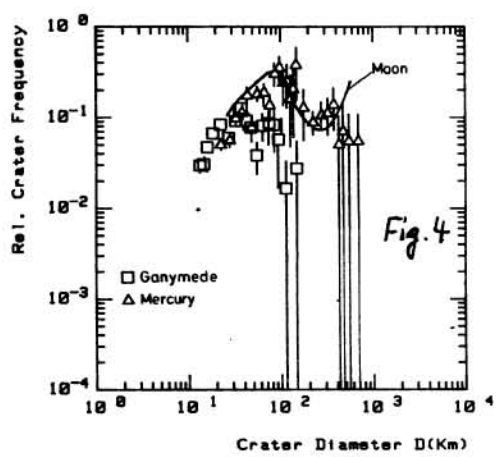

Fig. 4