11. The Observed Martian Crater Production Function

Every interpretation and sequence of events are valid independently of any revision of the applied chronology model, because the crater frequencies are directly related to relative ages. The validity of the cratering chronology model has been discussed above. The applied crater scaling laws are tested as they were utilized to transfer the lunar crater production function to Mars.

In this work, the crater size–frequency distributions, in many geological units for variously aged surfaces, and over the entire crater diameter range (given by the available imagery), are measured. To normalize (following Neukum, 1983) the crater size–frequency distributions to a randomly chosen age t_{norm} using the equation (compare equation 8.10)

$$N_{cum}\left(D, t_x\right) \star \frac{F\left(t_{norm}\right)}{F\left(t_x\right)} = N_{cum}\left(D, t_{norm}\right) \tag{11.1}$$

the measured crater size–frequency distributions on differently aged surfaces are combined to a representative set of measurements to achieve the unified crater production function. For this purpose, we selected crater size–frequency distributions measured on Viking, HRSC, SRC, THEMIS and MOC imagery to cover the entire diameter range, limited just by the image resolution and/or the image sizes. The very large size range (global basin distribution, diameters ≥ 250 km) is supplemented by a size–frequency distribution derived from basin diameters listed by Barlow (1988a). The given frequency of large basins present in the highland areas yields a global maximum highland surface age of about 4.2 Ga on average.

In Figure 11.1(A), selected crater size–frequency distributions and a set of isochrons are plotted. The isochrons are calculated by applying the cratering chronology model of Hartmann and Neukum (2001) and the crater production function described by Ivanov (2001). The analytical expression for the chronology model is

$$\begin{aligned} N(1\text{km}) &= 2.68 \cdot 10^{-14}[\exp(6.93\text{T}) - 1] \\ &\quad + 4.13 \cdot 10^{-4} T \end{aligned} \tag{11.2}$$

given by Ivanov (2001). The larger–diameter range of the crater size–frequency distribution is mostly represented by measurements on old surfaces, whereas in the smaller–size range either the image resolution prohibits measurements in that range ($<$ 15 km, Viking) or resurfacing occurred (1–10 km, e.g. THEMIS, HRSC). The smaller size–range is represented mostly by measurements on younger surfaces ($<$ 3.5 Ga). Due to the strong geologic activity over the entire history of Mars, many surface units formed or have been resurfaced by erosion subsequent to the planet's formation. Intentionally, all diameter ranges are represented by several measurements to improve the statistics. Nevertheless, these measurements are based on different image resolution, assuring only a limited range of accuracy. A largest possible overlap of the individual measurements was considered to avoid gaps and minimize statistical uncertainties.

Figure 11.1(B) shows the resulting distribution when all measurements are normalized to a surface age of 3.25 Ga, represented by the measurement "UTOPIA15mA+B". This measurement was performed on a photo mosaic compiled from Viking high–resolution (15 m/pxl) observations taken from the center of Utopia Planitia (see Chap. 14.3). This region was selected because it covers a medium crater–size range and formed at an intermediate time. The assemblage of normalized crater size–frequency distributions is plotted together with an isochron representing a 3.25–Ga age, calculated by applying the Hartmann and Neukum (2001) cratering chronology model and the lunar crater production function transferred

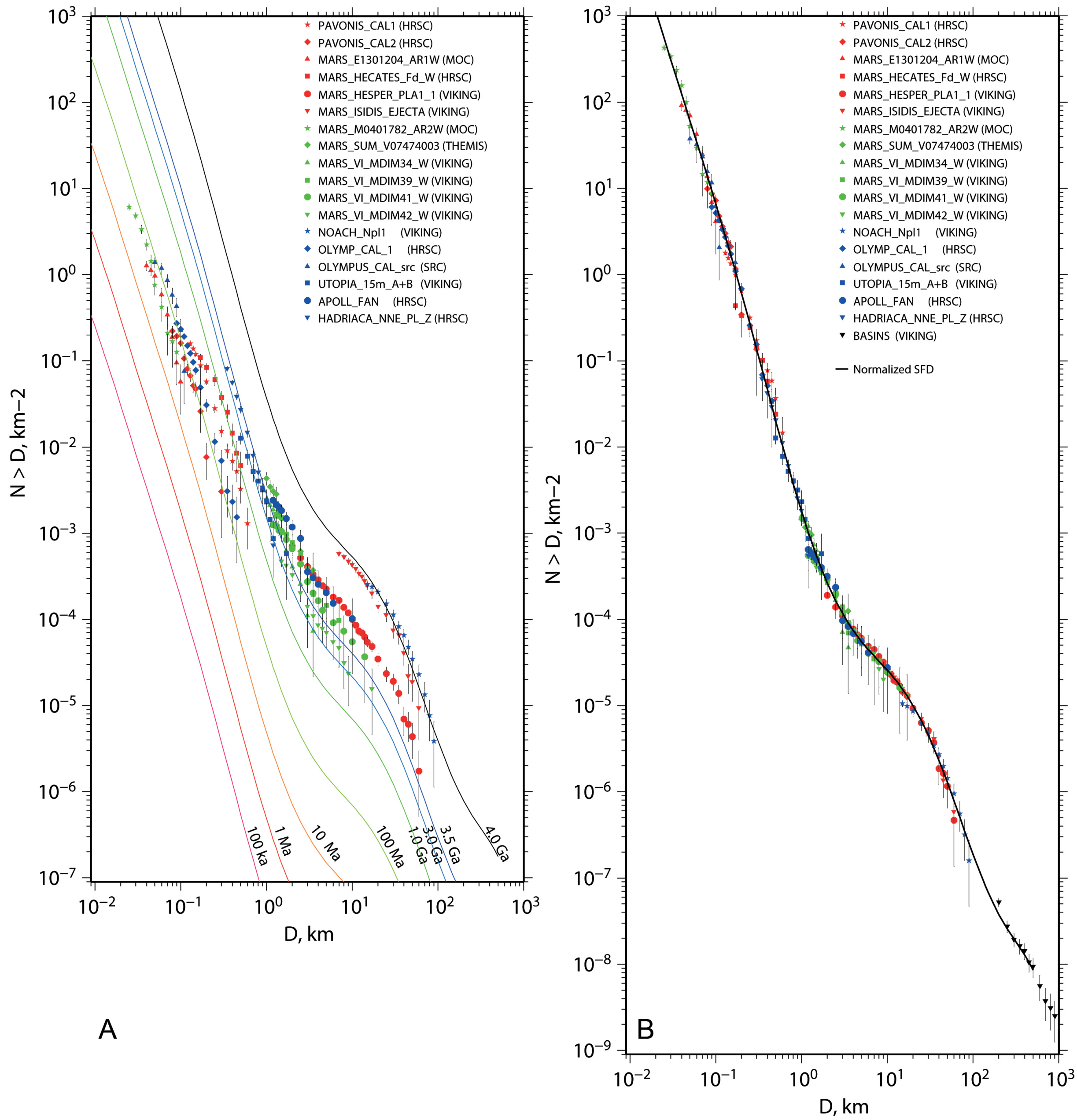

Figure 11.1.: The Martian Size–Frequency Distribution: (A) Assemblage of crater size–frequency measurements obtained for counts performed on HRSC, SRC, VIKING, THEMIS, and MOC imagery. They represent typical crater size–frequency measurements of differently aged surfaces. The set of isochrons indicate the expected distribution applying the Hartmann/Neukum chronology model for different ages, which makes it possible to derive crater retention ages from the measurements by way of visual interpretation of a graph. Usually, we derive ages by fitting the crater production function to the measurements and obtain a numerical value N(1) for a reference crater diameter (usually 1 km). (B) The same assemblage of crater size-frequency measurements normalized to the UTOPIA 15m A+B measurement, which represents a measurement in the medium-sized crater diameter range. The black curve is the lunar crater production function transferred to Martian conditions, representing a surface age of 3.25 Ga. The good fit strongly suggests that the impactor size–frequency distribution is really the same for the Moon and Mars and our previous procedure of transferring the lunar crater size–frequency distribution to Mars was carried out correctly.

to Martian conditions (Ivanov, 2001). The good agreement between the normalized assemblage and the theoretical Martian crater production function strongly suggests that the impactor population is the same for the Moon and Mars and the procedure for transferring the lunar crater size–frequency distribution to Mars has been carried out correctly.