2.4 Crater Counting for age determination

After learning about impact craters in the last chapter let us focus on the scientific meaning of this important surface feature. As already mentioned, a lot of research has been done on impact cratering to gain additional information about the target history and age.

The spatial density of craters (number of craters per unit area) and the crater size frequency distribution (number of craters per unit area as a function of crater size) give us important information about the target and differs a lot throughout the solar system. This is the result of the cratering and crater removal rate.

Cratering Rate: Scientists assume that the cratering rate is inconsistent within the last 4 billion years. In the early times of our solar system the bodies were not in order, the orbits not defined, and the planets not fully grown. A lot of large sized impacts occurred during that era, which is also named the Heavy Bombardment. The change of the cratering rate over time is not fully understood and still a topic for discussion. While the solar system came in order impacts happened less likely. So the cratering rate dropped off rapidly within the first billion years to reach a roughly constant cratering flux during the last 3 billion years. That means it is less likely that planetary bodies are being hit by impacts, the rate of large sized impacts decreased dramatically as well.

How can we link the impacts we see on a planetary surface to a specific age? This is one of the achievement of the lunar landings. Astronauts brought samples from different impact craters back to Earth. Nine missions provided in total 382 kg of lunar rocks and soil, which were analyzed and dated using radioisotope dating. By knowing from which region the samples came, the obtained ages could be linked to the region and craters itself, providing absolute ages of the lunar crust. Based on that, isochrones are calculated throughout the last billion years for the Moon. Those help to interpret the results of your crater counting. There is ongoing research in the topic of surface ages and dating as well.

Crater Removal: The shape of the impact craters is first of all depend on the target and impactor properties. Additionally, there is the crater modification stage, in which various processes flatten the crater rim and fill up the crater interior. The modification of the crater will reach its maximum if the crater is no longer visible on the planetary surface, at that time we consider this crater removal. Endogenic and exogenous processes are responsible for crater removal. Endogenic sums up all processes that originate within the planetary body (e.g. volcanic activity, tectonics, wind erosion, water and ice erosion, gravity related erosion). Lava blankets can fill up impact craters until they are not recognizable anymore. Wind and water erosion flatten the terrain until the rim and floor of a crater is not identifiable. Exogenous are processes that do not originate from the planetary body itself. Impact related ejecta and tectonic movements are considered exogenous processes.

Surface areas with more craters are older than areas with barely any or only small sized impact craters. Small craters will erode quickly, because their morphology is less dominant. Old craters will take longer to erode and eventually they do not have a sharp and distinct crater floor, rim, and ejecta. You will hardly see small old craters, as they are removed most easily from the surface over time. Crater removal rates do not only depend on the region on a planetary body, but also on the planetary body itself and its activity of its endogenic processes.

Task:

1. Which body in our solar system has the least amount of impact craters and why?

2. Obtain surface ages by conducting a manual Hartmann plot.
    a) Use the provided table with crater diameters. Perform a Hartmann binning and input the results into the plot (craters in each bin/km^2 to diameter) to obtain the surface age for area 1. The shown isochrones are 200 Ma, 500 Ma, 1 Ga, 2 Ga, 3 Ga, and 4 Ga.
    b) Conduct the same study with area 2. How does the change of area relate to the surface age?
3. Perform crater counting to obtain surface ages of your mapping area.
    a) Perform a crater counting within JMARS in three different regions.
    b) Use the software crater stats to input your size distributions.
    c) Adapt the curve to obtain a surface age.
    d) What is the surface age of your three chosen areas?
    e) What does that mean?

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Guide 2.4 for Crater Counting and Crater Stats, Table Task 2, Hartmann Plot, Example Diam File