2.3 Impact Craters as Key Feature

Collisions happen frequently at all bodies in our solar system. Those impacts are violent events due to the impact velocity (e.g. on Earth impact velocities are between 10-40 km/s). An impact is a depression in a target body that is often surrounded by an ejecta blanket. Ejecta is formed by material, which was excavated by the impact event.

The composition, size, and speed of the impactor and target body are influencing the crater dimensions. Crater formation is divided into three stages:

1. Contact and Compression Stage
   The collision occurs and kinetic energy is transferred to the target body in form of shock waves. Due to high pressures rocks in the impact area vaporize. The propagation of shock waves highly depends on the target material.

2. Ejection/Excavation Stage
   After the collision a plume, consistent of vaporized material, expands up and outwards. At the same time the shock wave gets gradually weaker by further expansion through the target body. Rarefaction waves behind the shock wave decompress the target and initiate the excavation of material. Material down to 1/3 of the transient cavity (maximum depth while crater formation) is excavated over several minutes or pushed upwards to form the future crater walls and rim. Underlying material is being highly compressed. Large craters have usually a small crater depth, whereby small craters have a relatively deep crater depth. Craters at the end of the excavation stage are called transient craters. The shape of a transient crater is only depended on impactor

properties (velocity, composition, speed, size, impact angle) and target properties (gravity, composition, surface structure).

3. Collapse and Crater Modification Stage
   Transient craters are being modified by various geological processes over time. Erosion done by wind, water, ice, volcanoes, and other impacts will smoothen the crater morphology until it is completely erased of the surface.

Craters can be classified in different crater types based on their morphology.

1. Simple Craters
   They are bowl shaped depressions in the ground up to 7-12km in diameter. The depth is usually about 1/5 its diameter.

2. Complex Craters
   These craters are above 7-12km in diameter, but have usually sized up to hundreds of km. They have a flat floor and a central peak. Sometimes terraces are located on the interior rim sides, due to collapse of the crater walls.

3. Multiring Basin Craters
   Basins occur only on the largest craters in the solar system. They do not have one crater rim, but rather a concentric ring system surrounding the crater.

Often impact craters are also classified into primary and secondary craters. Primary craters are the direct result of an impact. Whereby, secondary craters are formed by excavated material ejected from a primary crater. Secondary craters can be oriented in crater fields or chains. Sometimes bright linear features that radiate outwards an impact crater can be identified (especially on the Moon). Those features are called Rays and originate from lighter subsurface material, which was ejected by the impact. The unit consisted of excavated/ejected material around the crater is called ejecta blanket and based on its shape, color, layering, and size it can provide important information about the subsurface material. The unit inside the crater is called breccia and usually consists out of high temperature and pressure minerals, due to the impact itself. Find grained material on a body's surface is called Regolith. It is through impact cratering ground down material, which can form several meters of a surface.

Impact craters are of high importance for planetary scientists, because they represent the most dominant landform on planetary bodies. If you observe the Moon through a telescope, or remember your mapping project, you will recognize the highly cratered surface of our neighbor.

A lot of research has been done on impact cratering to better understand the impact mechanics and gain also additional information about the target history and age.

Task:

1. Classify the nine craters into the three different crater types.
2. Fill out the blank fields in the schematic illustration of impact crater formation.
3. Read the Article from "G. G. Michael & G. Neukum (2010): Planetary surface dating from crater size-frequency distribution measurements: Partial resurfacing events and statistical age uncertainty" until next week.

Download:
Task Image 1, Task Image 2, Paper Michael & Neukum