Teaching Notes for EXPLORING IMPACT CRATERING Lab

Required materials for this lab:

- 8-12 boxes of sand (one box per group)
- 8-12 boxes of 6 balls (one box per group)
- 24 rulers (one per student)
- 24 meter sticks (one per student)
- Ream of graph paper (enough for 6 graphs per student)

Impact cratering is one of the four geologic processes that effect the surface of a planetary body. This lab will have the students examine how these craters were created and some relationships between different crater characteristics.

The introduction to the lab should include a discussion about the difference between simple and complex craters. Be sure to use Figure 2 in the lab to show the difference between them. You should also mention that a typical speed of 10-30 km/s produces a crater 10-20 times larger than the impacting object.

Be sure to hit upon the different characteristics of the different types of craters. Simple craters are usually less than 1 km in diameter and have a bowl shaped depression. They have a depth-to-diameter ratio of 1:5 to 1:7. The initial crater is called a transient cavity and material will usually fall back into the crater due to the low energy of the impact and is called breccia fill. Figure 3 in the lab is Moltke crater on the moon and illustrates a simple crater.

Complex craters are usually shallow (having a depth-to-diameter ratio 1:10 to 1:20) with relatively flat floors. The inner wall of the crater rim has slump blocks and terraces. Complex craters have 3 classes of sizes. The craters that are 1-10 km in diameter have *central peaks* in the primary crater. These are formed from a rebound (uplift) of material (due to larger speed & energy of impactor) and then a collapse back into crater floor. The next size craters are about 100-300 km in diameter and have *peak rings* that are seen as a characteristic ring of mountains within the crater. The third size of craters are 1000 km in diameter and have a *multi-ring basin* formed by large impactors travelling with high speed & energy.

The images shown as examples in Figure 4 are as follows: a) This image is of a *complex crater* with a central peak. It is of Tycho crater on the moon. b) This is an example of a *peak ring crater* and is of Barton crater on Venus. c) This is a *multi-ring* crater and is of Mona Lisa crater also on Venus. The last two images are from the radar imaging done on Venus. These do not have sun angle vectors because of the method in which the images were taken – be sure you are familiar with the use of radar imaging. Light is high altitude, dark is low altitude.

The last type of crater is a rampart crater. These craters have lobate (lobe-like) forms associated with the crater - similar to those seen with volcanic & mud flows. They are characterized by teardrop shapes of material coming from the crater. The example image, Figure 5, is from Mars and is of Yuty crater.

<u>For exercises</u>

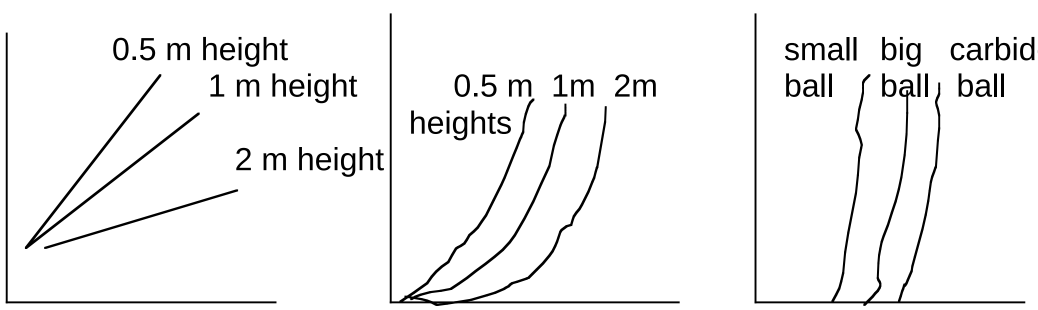
<u>Masses and sizes of the metal balls:</u>

0.5 inches	7.7g
0.625 inches	15.9g
0.75 inches	27.3g
0.875 inches	44.3g
1.0 inch	66.7g

When you begin the exercises make sure that you have gone through each process yourself. For **exercise 1** make sure the students drop the balls at a ~90 degree angle to sand for craters where data is taken. They can throw the balls at other angles and draw pictures of them but the data table should be data for only the 90-degree drops. When the students measure the diameters of the craters a good way to measure the diameters is to take 2 diameter measurements perpendicular to each other and average them. Be sure to have the students include measurement error for the diameters to be used on their graphs as error bars.

Examples of graphs for this exercise:

Impactor diameter vs. Crater diameter — Impactor mass vs. Crater diameter — Velocity vs. Crater diameter



In **exercise 2**, to simulate an internal "explosion" the balloon should be pumped up so the balloon breaks. To simulate an internal "eruption" it should be a balloon flush on the end of the tubing and under the sand about one inch.

In **exercise 3** the students will be making a data table in order to compose graphs and examine relationships. To see if the experiment supports the relationship between crater diameter & Kinetic energy of the impact you need to guide the students in plotting the relationship on their graphs and determining whether their data fits that relationship or not. You will need to discuss graphical relationships such as a linear increase/decrease and exponential increase/decrease along with examples (e.g. driving a car). They should also calculate the errors in velocity and KE from their measurement error to be included in the graphs as error bars. You may need to help them through this and remind them of the uncertainty equation for each variable they use.

The questions asked in the analysis/questions section of the lab should be addressed in the lab write-up. Be sure to explain how to include data tables and graphs in a lab write-up.

Examples of graphs:

Log(Crater diameter) vs.
log(Kinetic energy)