# GLY 103 Laboratory
# Lab 5: Impact Processes

Impact cratering is a catastrophic event that affects all of the solid bodies in the solar system: Mercury, Mars, Venus, the Earth and Moon, and the satellites of the outer planets. An impact crater forms when a projectile (e.g., an asteroid, meteorite or comet) impacts a surface with a velocity faster than the speed of sound—at a hypervelocity. The average velocity of an asteroid striking the Earth is 15-25 km/s, or 15,000 – 25,000 m/s. For comparison, you drive down the highway at ~0.025 km/s (or 25 m/s).

Formation of impact craters is the result of enormous amounts of kinetic energy transmitted from the projectile to the surface. Some of the energy goes into compressing the ground; some into excavating material out of the crater (also called ejection); some into breaking up the ground (called **communition** or **brecciation**); and there is enough energy remaining to actually melt some of the surface material. The material from inside the crater that is ejected farthest away from the point of impact is the material that was closest tot he surface—because this stuff receives the most energy from the impact event. The material far beneath the surface and near the bottom of the crater doesn't receive as much energy, so it's not thrown as far away from the crater. Hence, when you examine the material thrown out of a crater (the **ejecta**), the material deposited farthest away was closest to the surface prior to impact.

## PART I: Impact Angle

Place a thick layer of sand in one of the trays provided and prepare a smooth, flat surface by scraping a ruler or board across the sand. *Lightly* dust the sand surface with one color of powdered tempra paint—you need a layer of paint about *one grain thick*. Divide the tray into four target areas.

Have the TA approve your setup before proceeding!

A. In one section, make a crater using the slingshot to launch a projectile fired at a 90° angle from the surface. Make sketches of the "map" and cross-sectional views of your crater. Note on your sketches where the two different types of sand are located and how they are distributed with respect to each other. Also note where the "oldest" material (the bottom layer) and the "youngest" material (the top layer) are within the ejecta.

B. In another section, produce a crater with the same sized projectile launched at about a 65° angle from the surface. Make sketches following the procedure in part I.A. Does this crater differ from the previous one? How?

C. In yet another section, produce a crater with the same sized projectile launched at about a 45° angle from the surface. Make sketches following the procedure in Part I.A.

D. In the fourth section, produce a crater with the same sized projectile launched at about a 5-10° angle from the surface. Make sketches as before. Does this crater differ from the previous one? How?

**Part II.** Examine the sand craters and your sketches. What relationship can you find between impact angle, crater shape, and the distribution of ejecta?

**Part III.**
The amount of kinetic energy transmitted by the projectile to the ground can be related by the following equation:

$$KE = (1/2)mv^2$$

in which m is the mass and v is the velocity of the projectile.

Recover the projectiles from the tray and smooth out the surface. Divide the surface into four sections again. Get four 8mm projectiles (marbles).

Make the first crater by dropping the projectile from a height of 10 cm above the surface, the second from a height of 2 m. The third projectile should be launched from a slingshot that is extended ~15 cm and far enough away from the surface so that the rubber sling will not touch the sand when it's released. The fourth projectile should be launched using a slingshot extended ~25 cm.

A. Measure the crater diameters and calculate the kinetic energy (KE) released by each impact by filling out the table on the next page.

| Shot | Velocity (cm/s) | mass (g) | KE | Crater Diameter (cm) |
|---|---|---|---|---|
| 1 | 2 | 2.0 | | |
| 2 | 200 | 2.0 | | |
| 3 | 1000 | 2.0 | | |
| 4 | 3000 | 2.0 | | |

B. What relationships can you find between crater size and kinetic energy?

C. What would happen in your experiments if you used a projectile with a greater mass?

D. What would happen if you launched a projectile with a greater velocity?

**Part V: Effects of Topography**

A. Recover the projectiles, smooth out the sand, and divide the tray into two sections. In one half, form a ridge of sand about 10 cm high and leave the other half flat. Use two projectiles to form one crater on the slope of the ridge and another on the flat half, trying to maintain the same impact angle and energy. Describe the differences between the two craters.

**Part VI. Clean up!!**

**Part VII. Pumpkin Drop**
Select two pumpkins. Measure the diameter and mass of each. Predict what you think will happen when we drop them off the roof.

Divide the class into two groups. One group will proceed to the roof with the pumpkins, a stopwatch, and a radio. The other group will proceed to the southwest corner of the NSC with a garbage bag, a stopwatch, a radio, and a tape measure.

Using the radios to coordinate, drop the small pumpkin and have the time of the fall recorded by both the roof and ground crews. The ground crew will measure:
1. the diameter and depth of any crater that forms;
2. the greatest distance that the ejecta traveled; and
3. the greatest height that the ejecta splatters.

Ground Crew fall time:

Roof Crew fall time:

Crater depth & diameter:

Greatest ejecta dispersal:

Greatest ejecta height:

The ground crew will clean up the first pumpkin and the procedure will be repeated for the second pumpkin.

Ground Crew fall time:

Roof Crew fall time:

Crater depth & diameter:

Greatest ejecta dispersal:

Greatest ejecta height:

Return to the classroom.

A. Did the pumpkins behave as you expected? Why or why not?

**Part VIII:  The Lunar Surface**
If there is time, examine the images of the lunar surface.  Keeping in mind the results from Part V, can you explain why there are more craters on the lunar maria (the dark, smooth plains) than on the lunar highlands (the bright, rugged hills) even though radiometric dating shows that the highlands are older?

Can craters be used as geologic "clocks" to determine the relative ages of the highlands and maria?  Why  or why not?