Impact Cratering Lab

Materials: Bin, flour, cocoa powder in shaker, apron, trash bag, meter stick, ruler, graph paper.

Introduction

In this lab you will be "creating" impact craters by dropping rocks and/or marbles in a bin of flour with a thin layer of cocoa on top. The cocoa allows you to trace the surface layer, and the flour represents the subsurface layer. The point of this lab is to study the morphology, or shape, of the craters and how it is affected by parameters of the impactors. In particular, you will study the shape of the crater, the height and shape of it's rim, its depth and breadth and the size and shape of the ejecta, which is the subsurface material that is distributed over the surface after the impact.

Cautions:

(1) This lab can get messy! Wear your aprons and budget time for cleanup at the end of each lab period, including sweeping the floor!
(2) Don't waste materials! You only need a thin layer of cocoa each time you "resurface" the bin, and you don't need to resurface after every impact. When you are studying individual impactors, spread them out across the bin, dropping several in different areas before resurfacing.

Setup:

(1) Take a trash bag and cut it out into a maximally sized (single layer) rectangle
(2) Clear a large area on the floor and spread out the bag there
(3) Place the bin in the center of the trash bag mat and fill it ~3/4 of the way with flour
(4) Shake the bin side to side so that the flour layer evens out into a flat surface
(5) Sprinkle a THIN layer of cocoa on top with the shaker

Make a prediction below as to how you think the appearance (shape, depth, size, etc.) of your craters will change based on the height, angle, size, mass and density of the object being dropped. For each, be specific about whether you think the relationship will be direct or indirect, a strong or weak effect.

Height:

Angle:

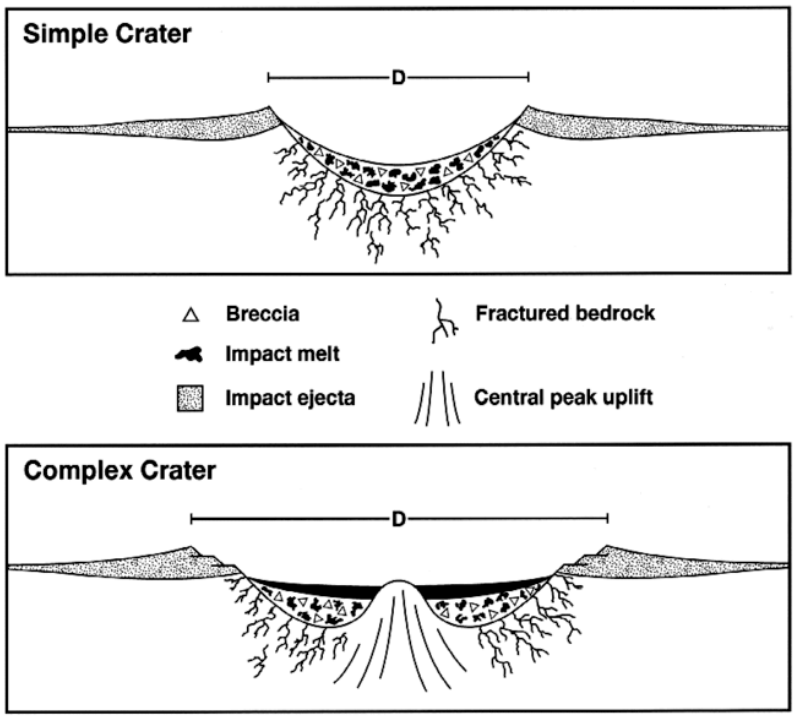
Size:

Mass:

Density:

Drop a single rock into your bin from ~50cm above its surface. Draw what you see below both in a top-down view (looking down at the bin) and a side profile view (a cut through the center of the crater as though you cut your crater in half and were lying on the floor looking at it sideways). Use shaded areas to indicate the location of cocoa and white areas to indicate the location of flour. Label the crater rim, ejecta (again, this is the subsurface material (flour) that will radiate out from the crater) and floor of the crater, as well as any other features that you observe.

One of the many things that we can study about a crater when we find one is its *morphology*, or shape. Study the two diagrams below, which show the difference between simple and complex crater morphologies. Note that the diagrams show the craters *in profile*, whereas you will be looking at them from the top down. Given that your "impacts" will be small objects impacting flour with a layer of cocoa on top (and not rock hitting rock), which of the features shown do you think will be observable? Decide how you will determine whether a crater is simple or complex and describe your method below. Keep this in mind as you describe the "appearance" or craters during your lab.



Part 1: Investigate the effect of height

Drop the same meteor (a small/medium rock of your choosing) from different heights above your "surface". Each time, make sure that you are dropping it in a flat (uncratered) portion of your bin with a fresh coat of cocoa powder on top. Do not apply a fresh coat to the whole bin every time- try to use the whole bin area then smooth the whole thing out and apply more cocoa. You need to use the same rock each time, but note that it is somewhat difficult to extract without "ruining" your crater, so make your measurements first BEFORE you extract the rock and move on to making the next crater. **When describing the "appearance of the crater", make note the following**:

(a) shape of crater (cicular? elliptical?)
(b) shape and amount of ejecta
(c) maximum distance (in cm) of ejecta from crater rim
(d) simple or complex

Height	Depth of Crater	Diameter of Crater	Appearance of Craters
50cm	1. 2. Average:	1. 2. Average:	
75cm	1. 2. Average:	1. 2. Average:	
100cm	1. 2. Average:	1. 2. Average:	
125cm	1. 2. Average:	1. 2. Average:	
150cm	1. 2. Average:	1. 2. Average:	

Using a sheet of graph paper, plot crater depth and crater size as a function of height *on the same plot*. To do this, make *two* y-axes (one along the righthand side of your plot for crater size and one along the lefthand side for crater depth) and one shared x axis (of height). Plot the two sets of points in two different colors and sketch in a "best-fit" line through each set of points (hint: for a best fit line, half of your data points should lie above it and half below it). Choose the scale of your axes wisely so that you use up the majority of the paper. Make sure to label your axes and title the graph, and to label your two sets of data points and best fit lines with a "legend" in one corner of your graph (see example below). Attach your graph to the group lab that you will hand in.

*	depth data
---	depth best fit line
+	size data
___	size best fit line

Using the data that you collected in table 1 and plotted in your chart, describe how each of the following change with height. **Use specific numbers from your data to justify your claim.**

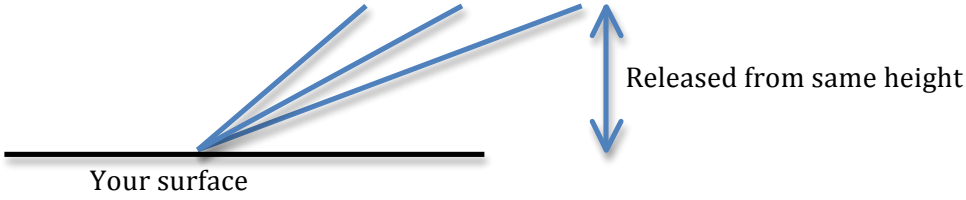
Crater Depth:

Crater Diameter:

Crater Appearance:

Part 2: Investigate the effect of angle

How does angle affect the shape, depth, etc of a crater? Construct a "ramp" made of meter sticks such that a round "meteor" (a marble) can roll smoothly down it to impact the bin. In all cases, make sure that the meteor is being released from the same straight line distance from the ground as shown in the diagram shown below. This may require some trigonometry or the careful use of a protractor to do well, so ask your instructor for help. The marbles will be very difficult to extract without disrupting the crater, so again measure the crater parameters before you extract it.



Describe or sketch your experimental setup below. You should specifically address how you will ensure that the marble is released from the same straight line distance from the ground, how you will position the ramp so that you don't disturb the flour, and how you will determine the angle. When you are finished designing your setup, complete the experiment, filling in the table on the next page.

Angle	Depth of Crater	Diameter of Crater (smallest/largest if elliptical)	Appearance of Crater
10 degrees	1. 2. Average:	1. 2. Average:	
45 degrees	1. 2. Average:	1. 2. Average:	
70 degrees	1. 2. Average:	1. 2. Average:	
90 degrees	1. 2. Average:	1. 2. Average:	

Summarize the results of this investigation. You do not need to make another chart, but you do need to be specific in quoting evidence from your investigation.

Part 3: You Design an Investigation

Question to investigate: Is it the object's size (volume), mass, or both (density) that dictates the size and depth of the crater?

Several tables are given on the next page to help you get started. Examine them, discuss with your groupmates, classmates and instructor as needed and then develop a procedure for your experiment. How are you going to measure the relevant values? How many objects will you use? How many trials will you do? There are balances, rulers, etc. available at the front of the classroom, as well as a selection of objects that you might use as impactors. Study them and decide which you will use. Describe your procedure in numbered steps below. *Caution: Good experiments change only one variable at a time, so you should describe which variables you are changing and which are staying the same at each step in your procedure. For example, if you change both the height and mass of an object between trials, you won't be able to separate how each affects your results.*

Now carry out your experiment. Feel free to design your own tables or use the ones below.

Object	Size	Mass	Volume	Density

Object	Depth of Crater	Diameter of Crater	Appearance of Crater
	1. 2. Average:	1. 2. Average:	
	1. 2. Average:	1. 2. Average:	
	1. 2. Average:	1. 2. Average:	
	1. 2. Average:	1. 2. Average:	
	1. 2. Average:	1. 2. Average:	

Describe your conclusion regarding the question *Is it the object's size, mass, or both (density) that dictates the size and depth of the crater?* below. Use the data that you collected to justify your claim. If your data were inconclusive, describe why you think this is and design a better experiment to test this question.

Section 4: Discussion/Wrap Up

This experiment was based on the assumption that we are able to mimic the "real world" in a scaled down way. Name at least two factors that you suspect will effect how impact cratering works (size, depth, appearance) in the "real world". In other words, where and why might you expect our flour/cocoa-powder analog to fall short in mimicking the reality of impact cratering on planetary surfaces accurately?

List two key general properties that effect the size and appearance of impact craters that you suspect ARE well-represented in this flour-cocoa model and describe them.

Revisit the predictions that you made on the first page of the lab. Which ones proved accurate, which were inaccurate, and which are you still unsure of? In each case, describe why you feel your hypothesis was proven, disproven or is still up for debate.