Geology 120 Experimental Simulation of Impact Structures – Part One

Names ____________________ ____________________ ___________________

Introduction: Impact craters are remnants of the collision of two objects. One object is the Impactor, or the object that arrives from space. When the impactor (meteorite) strikes the Earth a crater might be formed. These craters have common shapes and structures but the size can be highly variable. In lab this week, we will explore how different variables associated with the impactor might affect the size and shape of the resulting crater.

Assignment:

This part of the exercise is to be completed before you arrive in lab next week.

Step A: Observation - Identification of Impact Craters

Using the computer application Google Earth, navigate to the three locations that are listed below. Google Earth is available on the computers in the Geology computer lab, as well as in the Library and other college computer labs.

At each of these impact structures:

- describe its shape (simple, complex) and relative symmetry
- use the ruler tool  to determine how large the structures are.

Location 1:
Manicouagan, Canada (51°23’N 68°42’W)
Diameter: _______________kilometers
Description

Location 2:
Clearwater West, Quebec, Canada (56°13’N 74°30’W)
Diameter: _______________kilometers
Description

Location 3:
Bosumtwi, Ghana (6°30’N 1°25’W)
Diameter: _______________kilometers
Description

Location 4:
Meteor Crater, Arizona, USA (35°1.6’N 111°1.4’W)
Diameter: _______________kilometers
Description

Step B: Scientific thesis and testing

It is obvious from the four impact structures that you researched that there is a great deal of variability in their size and as you consider how they were created several variables should come to mind:

- Size of the impactor
- Mass of the impactor
- Velocity of the impactor
- Angle of the impactor

For each of these variables please

1. develop an hypothesis, (or multiple hypotheses) relating how changes in each variable might affect the size of the resulting crater. This can be done in the form of a simple sentence or two for each variable
2. design a simple experiment that could be conducted in our laboratory room in Van Wickle that might be used to test your hypothesis – be creative!

Size of the impactor:

Mass of the impactor:

Velocity of the impactor:

Angle of the impactor:

Geology 120 # Experimental Simulation of Impact Structures – Part Two

Names ____________________ ____________________ ___________________

Introduction: So far, each group has developed a working hypothesis for the relationship between the following variables and the resulting impact crater:

- Size of the impactor
- Mass of the impactor
- Velocity of the impactor
- Angle of the impactor

Now we will try to test the hypotheses that you all developed using four different experimental set-ups. In each we will be able to vary one of the parameters while we hold the others relatively constant. It is important to realize however that, in reality, what is actually changing is the Kinetic Energy of the impactor, which is a combination of mass and velocity and is defined by the following relationship:

$$KE = ½ (mv^2)$$

m is the mass of the object (kilograms) v is the velocity (meters per sec^{-1})

KE = Kinetic Energy is expressed as Joules, or Kg m^2 s^{-2}

Station A: Mass

Variable: Impactor Mass

Constants:

1. Velocity: 1 meter height = 443 cm sec^{-1}
2. Size: 3.3 cm

Experiment:

1. Weigh each object
2. Drop each object three times measuring the width of the crater after each drop (after each drop re-level the sand).
3. Calculate the average crater diameter for each object.

	Mass (gms)		Average Crater Diameter	Impact Crater Diameter (cm) TEST 1	Impact Crater Diameter (cm) TEST 2	Impact Crater Diameter (cm) TEST 3
Object A						
Object B						
Object C						

4. Using the Excel spreadsheet template provided, construct a graph of the relationship between the mass and the average crater diameter (this will happen automatically when you enter the data into the spreadsheet)
5. An equation for the best-fit line to your data set will also be shown in the plot window.

Prediction and Test:

6. Use the equation to predict the size of the crater for the unknown Object X:
   a. measure the mass of Object X
   b. put it into the equation to see what the predicted crater size is.
7. Create (three trials) and measure the crater resulting from an impact with object X.
8. How do the predicted and observed craters compare?

Predicted Crater size:				
Measured Crater size	Ave:	1.	2.	3.

9. How does this compare to your original hypothesis?

Station B: Size

Variable: Impactor Size

Constants:

Velocity: 1 meter height = 443 cm sec^{-1}

Mass: approximately 610 gms

Experiment:

1. In the table below record the diameter of each object.
2. Drop each object three times measuring the width of the crater after each drop (after each drop re-level the sand).
3. Calculate the average crater diameter for each object.

	Object Diameter (cms)		Average Crater Diameter	Impact Crater Diameter (cm) TEST 1	Impact Crater Diameter (cm) TEST 2	Impact Crater Diameter (cm) TEST 3
Object A	6.6					
Object B	9.0					
Object C	17.8					

4. Using the Excel spreadsheet template provided, construct a graph of the relationship between the impactor diameter and the average crater diameter for each object (this will happen automatically when you enter the data into the spreadsheet)
5. An equation for the best-fit line to your data set will also be shown in the plot window.
6. How does this compare with your original hypothesis?

Station C: Velocity

Variable: Impactor Velocity

Constants:

Size: approximately 5.7 cm diameter (single object)

Mass: approximately 610 gms

To simulate different velocities we will be dropping the object from different heights above the surface. The object will accelerate at the rate of 980 cm sec^{-2}. So the velocity of the object at impact will be greater the longer it "falls". The velocity can be calculated using the formula:

$$V = SQRT(2 * 980cm\ sec^{-2} * height)$$

Experiment:

1. Hold the object at each of the heights listed in the table below.
2. Drop each object three times measuring the width of the crater after each drop (after each drop re-level the sand).
3. Calculate the average crater diameter for each object.

	Drop Height (cms)	Resulting Velocity (cm sec^{-1})	Average Crater Diameter	Impact Crater Diameter (cm) TEST 1	Impact Crater Diameter (cm) TEST 2	Impact Crater Diameter (cm) TEST 3
Object A	100	443				
Object A	150	542				
Object A	200	626				

4. Using the Excel spreadsheet template provided, construct a graph of the relationship between the impactor velocity and the average crater diameter resulting from each velocity (this will happen automatically when you enter the data into the spreadsheet)
5. An equation for the best-fit line to your data set will also be shown in the plot window.

Prediction and Test:

1. Use the equation to predict the size of the crater for two additional velocities:
    a. Drop the object three times from 300 cm: velocity = 767 cm sec^{-1}
    b. Drop the object three times from 500 cm: velocity = 990 cm sec^{-1} (this is done in the stairwell)
2. Create and measure the crater resulting from each impact.

	Drop Height (cms)	Resulting Velocity (cm sec^{-1})	Predicted Crater Diameter	Average Crater Diameter	Impact Crater Diameter (cm) TEST 1	Impact Crater Diameter (cm) TEST 2	Impact Crater Diameter (cm) TEST 3
Object A	300	767					
Object A	500	990					

3. How do the predicted and observed craters compare for each velocity?

4. How does this relationship compare to your original hypothesis?

Station D: Angle of Impact

Variable: Angle of Impact

Constants (paintball):

Size: approximately 1.7 cm diameter (single object)

Mass: approximately 3.22 gms

Velocity: approximately 9,100 cm sec^{-1} (300 ft sec^{-1})

For all of the previous simulations we have used a vertical impact angle. However, the fact is that most objects impact the Earth at approximately a 45^{o} angle. You have made an hypothesis about how you feel the shape of the crater might change given non-vertical angles of impact. To test this we will create impact craters by shooting a paintball into the sand at a 90^{o} and 45^{o} angle and comparing the shapes of the two craters.

Experiment:

1. Shoot a paintball at a 90^{o} angle.
2. Measure two diameters (perpendicular to each other) of the resulting crater and write a short description of the shape.
3. Shoot a second paintball at a 45^{o} angle.
4. Measure two diameters (perpendicular to each other) of the resulting crater and write a short description of the shape. Don't try to fit your assumptions on the actual data.

	Diameter N-S (cms)	Diameter E-W (cms)	Brief description of each crater (symmetrical, elliptical, irregular, etc.)
Vertical			
45^{o} angle			
Vertical			
45^{o} angle			

5. What would you conclude about the relationship of the shape of the crater versus the angle of impact?

6. How does this compare to your original hypothesis?

Station D: Relationship of crater size versus impactor size

In Part One you measured the diameter of four different craters. If you have read anything about these craters or been listening in lecture you will realize scientists have estimated the size of the impactor that created each crater. Since the impactor is vaporized on impact the question is how these estimates are made.

The experiment with the paintball more realistically simulates an actual impact since the paintball also disintegrates on impact.

<u>Experiment:</u>

1. Calculate the average diameter of the crater from all the measurements in the previous table:

    ____

2. Calculate the ratio of the crater diameter to the impactor diameter:

    ____

<u>Extrapolation:</u>
Use the ratio calculated above to estimate the size of the impactors that might have created the craters you measured in Part One – you can do this in kilometers (kms):

a. Manicouagan, Canada
   crater diameter ________________ impator diameter ________________

b. Clearwater West, Quebec, Canada
   crater diameter ________________ impator diameter ________________

c. Bosumtwi, Ghana
   crater diameter ________________ impator diameter ________________

d. Meteor Crater, Arizona, USA
   crater diameter ________________ impator diameter ________________

Critical Analysis

1) Brief discussion: Were your hypotheses supported by the results of these experiments?

2) If any of your hypotheses were contradicted by the results, how would you change you hypothesis?

3) Were any of these experimental simulations more effective than any other? If you think one or more of the simulations were not very good, how would you change it before you retested your hypothesis?

To turn in (all stapled together - with your names on each section):

- Part One
- Part Two (these sheets)
- A copy of the Excel calculation spreadsheet.
  - on your computer, save the Excel file using one of your team-members names
  - e-mail it to your lab instructor (malincol or wilsonj) who will then print it out for you.