Cratering and the Lunar Surface

Firstname Lastname

Date

1. Replace the red text at the top of this page with your name and the date.

2. As you enter your work, please make sure that your answers stay red (like this). This will make them easier to see, and thus it will be easier for us to grade them accurately. To convert black text to red, highlight it and then click on the “A” symbol in the menu bar above, to the right of the “**B**”, “*I*”, and “U” symbols. Select the red square to turn your highlighted text red.

3. Delete these 3 initial instructions from this template as soon as you have followed them.

Activity: The Lunar Surface, Craters, and Relative Dating

1. Complete the following nine questions by removing the incorrect answers, leaving only the correct ones.

(a) Which landing site better represents the lunar mare region? (Apollo 12 / Apollo 16)

(b) Which landing site better represents the lunar highlands region? (Apollo 12 / Apollo 16)

(c) Which of the following craters lacks a central peak? (Lansberg / Eppinger / Taylor)

(d) Which of the following names on the Apollo 12 site image denotes a mountain chain? (Mare Insularum / Montes Riphaeus / Luna 5)

(e) Which of the following craters on the Apollo 16 site image no longer has an intact, well-defined circular rim? (Alfragenus / Theon Senior / Theon Junior / Zollner)

(f) Which lunar mission landed in an area crossed by a prominent lunar ray? (Apollo 12 / Apollo 16)

(g) Which landing site appears to have a greater density of craters? (Apollo 12 / Apollo 16)

(h) If Crater Eppinger has a diameter of six kilometers, what is the diameter of the smallest crater shown in this image? (0.1 kilometers / 1 kilometer / 2 kilometers / 3 kilometers)

(i) The largest crater identified by name on the Apollo 16 image has a diameter of: (30 kilometers / 40 kilometers / 50 kilometers / 100 kilometers)

2. Next consider a region at the lunar highland-mare interface. Consider four events:

(a) the lava flow associated with the impact that created the Mare Nectaris

(b) the impact event that created crater Rosse, sitting in the Mare Nectaris

(c) lunar highland crater production

(d) a lunar ray which is observed to pass over and rest on Rosse.

Order these four events in time, from earliest to latest: Sort [A - B - C - D] correctly.

Explain why you ordered them as you did.

Replace this text.

3. Now build two plots, showing the density of new craters found superimposed atop large craters which formed at various times in the distant past.

(a) In your first plot, track the large crater age versus the surface density of later, superimposed craters for the first four of the large craters listed in Table 3.2.

Insert first plot here.

(b) Use the best-fit line on the plot to estimate the age of the crater Giordano Bruno, in Myr. Derived age: Replace this text.

(c) Does your age estimate support or counter Hartung's hypothesis? (Support / Counter)

Explain your answer.

Replace this text.

(d) In your second plot, add in the two oldest craters (Aristarchus and Copernicus) listed in Table 3.2 to the data to be plotted.

Insert second plot here.

Based on the distribution of all six data points, and the best-fit lines, has the lunar cratering rate changed significantly over the last 850 million

years? (Yes / No)

Explain your answer.

Replace this text.

Activity: Forging Craters

1. Start by listing the factors you that think might define a crater's size and appearance.

Replace this text.

Crater Diameter Measurements I (cm)[[1]](#footnote-1)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hght. (cm) | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Trial 6 | Trial 7 | Avg₅ ± σ |
| 25.4 |  |  |  |  |  |  |  |  |
| 50.8 |  |  |  |  |  |  |  |  |
| 76.2 |  |  |  |  |  |  |  |  |
| 101.6 |  |  |  |  |  |  |  |  |

Velocities for given heights are 223, 316, 386, and 446 cm per second.

Notes:

Replace this text with your notes, after filling in table data.

Crater Diameter Measurements II (cm)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hght. (cm) | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Trial 6 | Trial 7 | Avg₅ ± σ |
| 152.4 |  |  |  |  |  |  |  |  |
| 203.2 |  |  |  |  |  |  |  |  |
| 304.8 |  |  |  |  |  |  |  |  |
| 406.4 |  |  |  |  |  |  |  |  |

Velocities for given heights are 547, 631, 773, and 892 cm per second. If you use different drop heights, be sure to calculate different velocities.

Notes:

Replace this text with your notes, after filling in table data.

9. Discuss your findings in the space below. In particular, comment on observed ray patterns and lengths, any non-circular craters and central peaks seen, and anything else of interest.

Replace this text.

Activity: What Determines How Big an Impact Crater Is?

1. Plot the crater diameters, including associated errors, against velocity for the data you entered into Tables 3.3 and 3.4.

Insert third plot here.

The best-fitting model is: ( Model 1 / Model 2 / Model 3 ).

The relation between *D* and *v* is: ( *D* ∝ *v* / *D²* ∝ *v* / *D* ∝ *v²* )

Is this the result you expected? Why, or why not?

Replace this text.

2. Use the Earth Impacts Effect program to answer the following questions.

(a) Consider two hypothetical impact events occurring in the uninhabited

area between Deming and Columbus, in a sedimentary rock region some

50 miles from Las Cruces, NM.

Impact A: A 100-meter icy comet traveling at 50 km s⁻¹ strikes at a 45o angle.

Impact B: A 40-meter iron-dominated rock traveling 20 km s⁻¹ strikes at a 45o angle.

Answer each of the six questions below by removing the incorrect answers, leaving only the correct ones. Which impact would:

i) be caused by the object carrying the most kinetic energy? ( A / B )

ii) produce the largest crater? ( A / B )

iii) be the most unusual (the rarest)? ( A / B )

iv) sound the loudest in Las Cruces? ( A / B )

v) produce the largest earthquake in Las Cruces? ( A / B )

vi) disturb the air most in Las Cruces? ( A / B )

(b) Click on “impact examples” (just below “Enter Impact Parameters”) and compare the size of the projectile that created Meteor Crater to the one that ended the reign of the dinosaurs and created Chicxulub Crater.

Replace this text.

(c) Chicxulub Crater has a diameter of 113 miles. What size would it be under the following three circumstances?

i) The projectile landed on sedimentary rock rather than in 100-meter deep water.

Diameter = Replace me! miles.

ii) The projectile was made of iron rather than rock.

Diameter = Replace me! miles.

iii) The projectile landed on sedimentary rock and was made of iron.

Diameter = Replace me! miles.

Final (post-lab) Questions

1. A careful examination of the lunar surface reveals that most lunar craters (a) come in widely assorted shapes, (b) are very oval shaped (elongated), or (c) are circular. (Remove incorrect answers.)

2. Is it easier to obtain relative or absolute ages for lunar surface features? Why?

Replace this text.

3. Suppose current lunar cratering rates were found to be much higher than those averaged over the last 100 million years. Would this be a cause for concern? Why, or why not?

Replace this text.

4. How did the craters that you created differ from lunar craters? Were your initial guesses about which factors would determine the sizes and

appearances of your craters confirmed, or denied?

Replace this text.

5. Nearly all lunar craters are circular because the projectiles that create them (a) travel almost straight down through the atmosphere, or (b) have high impact velocities, producing explosions on impact. (Remove incorrect answer.)

6. For a projectile of a given mass, what factors besides its impact velocity

determine the resulting crater diameter?

Replace this text.

7. Suppose that the huge meteoroid that created the Chicxulub crater was ten million times more massive than the much smaller object that forged the Meteor Crater in Arizona, but they were both traveling at 20 km s⁻¹ on impact.

(a) Compute the kinetic energy, in units of megatons of TNT, associated with the Chicxulub progenitor object just before the moment of impact, by using the information derived in Example 3.3.

Replace this text.

(b) Compare this amount of energy with the most powerful man-made

explosive device ever detonated, a hydrogen bomb yielding 50 megatons

of TNT.

The Chicxulub impact event was replace me! times more powerful.

Summary (300 to 500 words)

Replace this text.

Extra Credit

Replace this text.

1. Measure 7 craters at each drop height, and then enter the average value and standard deviation of the innermost 5 trails as “Avg₅ ± σ”. [↑](#footnote-ref-1)