THERE'S NO PLATE LIKE HOME, OR IS THERE?

MATERIALS

Part I
Work in small groups.
Each student will need
- **at least one topographic or geologic map of an area on Earth**
- **one sample image of the Moon's surface**

Part II
Work in small groups.
Each student will need

- **blank map of North America**

OBJECTIVE

In this activity you will investigate the frequency of impact sites on Earth and work to explain why Earth's surface is not as heavily cratered as other planetary bodies.

BACKGROUND
The Moon has an enormous number of impact craters, as do many other planetary bodies Radiometric dating of rocks from the Moon indicates (a.) most of its surface is between 3 and 4 billion years old, (b.) the Moon itself is about 4.5 billion years old, and (c.) the Moon stopped being geologically active about 2 billion years ago. Identical dating techniques place Earth's origin around 4.6 billion years ago. Here is the paradox: if Earth is about as old or slightly older than the Moon, why does the Moon have so many impact craters and Earth have so few? Does Earth somehow avoid bolide impacts, or is there another explanation?

Part I: Investigating Samples

PROCEDURE

1. Ask your teacher for maps of different regions on Earth. Examine these maps closely. Make the following records in Observation Box 1: What location are you investigating? What is the scale— how many millimeters on the map are equal to one kilometer on the

actual landscape? How many square kilometers are represented in the map you are studying?

2. Carefully search your map for craters and evidence of craters. In Observation Box 1, record the latitude and longitude of any craters or evidence of craters you find.

3. After each member of your group has examined at least one map, compile your team's results. How many craters were located? How many total square kilometers were examined? Calculate the number of craters per 1,000 square kilometers.

OBSERVATION BOX 1

Search for crater sites in North America

LOCATION

scale: ____ millimeters = 1 kilometer
size: ____ square kilometers shown on map

IMPACT SITES IDENTIFIED

1. ____________	11. ____________
2. ____________	12. ____________
3. ____________	13. ____________
4. ____________	14. ____________
5. ____________	15. ____________
6. ____________	16. ____________
7. ____________	17. ____________
8 ____________	18. ____________
9. ____________	19. ____________
10. ____________	20. ____________

QUESTIONS/CONCLUSIONS

1. Compare your results with a similar surface area on the Moon. Qualitatively, are craters on

Earth more frequent, as frequent, or less frequent than craters on the Moon? If you can give a quantitative answer, by all means do so.

2. Within your group, discuss reasons for the results in Observation Box 1 and in Question 1 above. What could explain the differences in crater frequency? How would you test these possible explanations?

3. How is Earth 's surface different from the Moon's? How could these differences help explain your observations?

4. Examine Figures 1 (Barringer Crater) and 2 (Clearwater Lakes). Where in North America are these craters located? Does the difference in their age or location provide clues to the explanation you are seeking regarding craters on Earth?

5. What different physical and geological processes do you suppose have acted on these two craters since their formation? Does this difference provide more clues about the absence of craters on Earth?

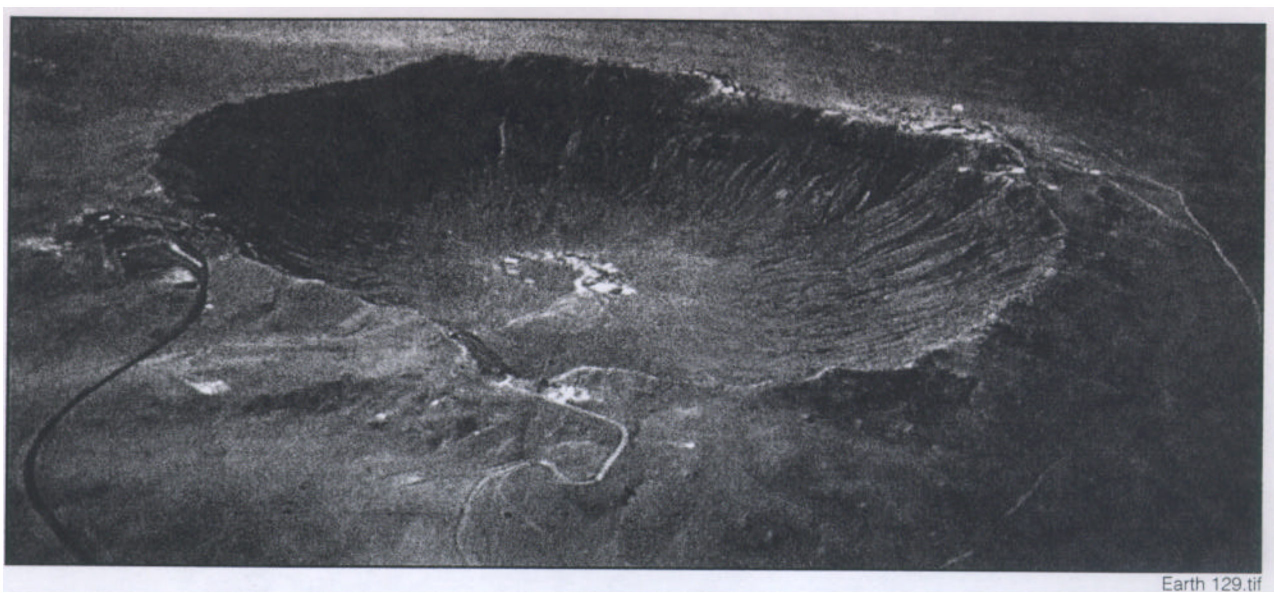

FIGURE 1A Barringer Crater, Arizona, is the largest and best preserved bolide impact site in the United States. The crater has a rim diameter of 1.2 kilometers, and is more than 180 meters deep. The rim is raised nearly 50 meters above ground level.

6. Think about the differences between these two statements:

a. Craters are much less frequent on Earth than on the Moon.

b. Impacts are much less frequent on Earth than on the Moon.

How are these statements different, as far as the observations in this activity are concerned?

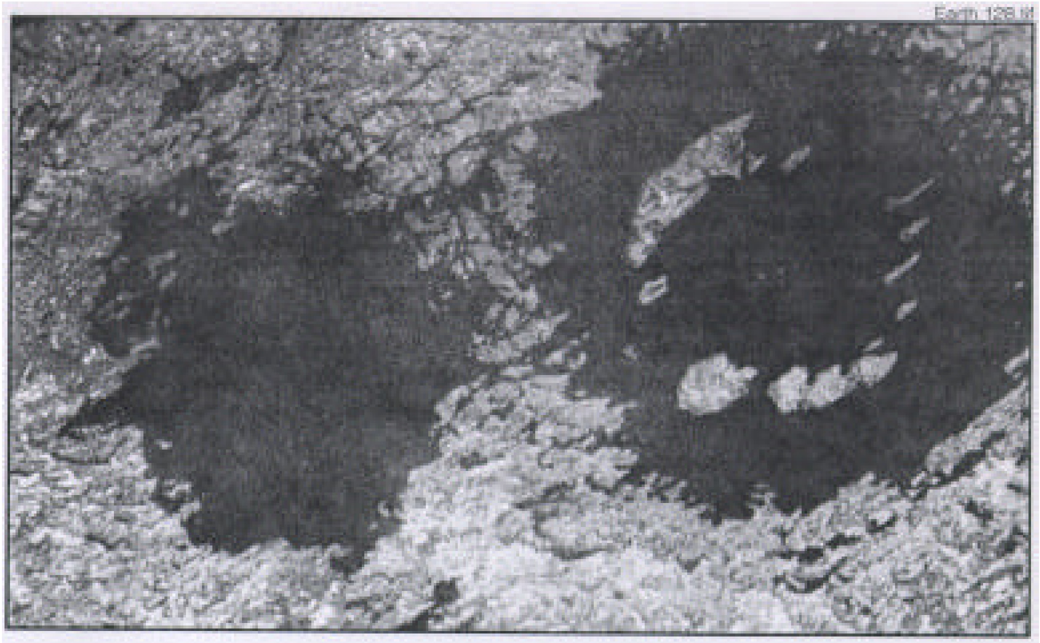

FIGURE 2 Twin impact craters of ClearwaterLakes, Quebec. These formed simultaneously by two separate meteonte impacts, probably an asteroid and its satellite asteroid. Asteroid Toutatis (Figures 3 and 4 in Activity 18) is an example of the binary asteroids that can explain double craters. The larger lake (right) has a diameter of about 32 kilometers.

Part II: Surveying North America

In Part I, you found that craters were much less frequent on Earth than on the Moon. You also suggested reasons to explain this difference. Looking for craters in Part I may have left you with the impression that very few craters are known on Earth. This would be wrong. Geologists have identified many impact sites around the globe. Of course, compared to the Moon, craters are relatively rare on our planet. Because it has no atmosphere, the Moon's surface does not weather. There is almost no erosion or deposition (except for "sand blasting" effects of small meteorites). Because it now has neither volcanic nor tectonic activity, the Moon has a static surface—craters are not obliterated by other geological processes. In fact, the surface that you see today on the Moon has been its surface fat least 2 billion years. As a result, the Moon's entire surface provides a chance to examine more than 2 billion years of accumulated impacts. Smaller bolides incinerate entering Earth's atmosphere.

FIGURE 1B Another view of Barringer Crater, Arizona,
this time from the rim using a wide-angle lens.

Earth is different. Earth's atmosphere causes weathering and erosion on the surface. Volcanoes and tectonic activity also constantly change Earth's surface. Combined weathering, erosion, and tectonic activity remove most evidence of bolide impacts on Earth. This is also true of some other planetary bodies—e.g., Venus has violent windstorms and sandstorms.

In addition, because rocks on Earth's surface vary in age, impact rates are hard to study. The longer a surface is exposed to possible impacts, the more craters it should have. The oldest rocks so far found on Earth are 3.8 to 3.9 billion years old, but these are rare. Rocks from the Precambrian (before about 600 million years ago and as old as about 2.5 billion years old) are found on every continent. They are most abundant in eastern Canada, northern Europe, and sub-Saharan Africa. However, most of Earth's surface is covered by rocks that are relatively young. For example all ocean basins—this amounts to about 75 percent of the planet's surface—are less than 20() million years old. With all this change going on, existing impact sites can he removed from Earth's surface, and newer surfaces have less chance of showing an interact in the first place!

If you had trouble finding craters in Part I, don 't think Earth is immune from bolide impacts. Most ordinary maps show virtually no impact features on Earth except for the Barringer Crater in Arizona. Does this mean none exist? In this part of the activity, you will work with a sample of known impact sites across North America. Many of these craters are nearly covered by sediments or eroded away. Most have been found only after careful geologic study. This will provide you with a sense of how many crater sites are known and where they are located. Please note, however, that the choice of North America for a study site is simply a matter of convenience. Craters have been found on all seven continents.

DATA TABLE 1

39 known or likely impact sites on North America

LATITUDE	LONGITUDE	DIAMETER (KM)	AGE (MILLION YEARS AGO)	LATITUDE	LONGITUDE	DIAMETER (KM)	AGE (MILLION YEARS AGO)
46°N	81°W	140	1850 ± 150	36°N	87°W	14	200 ± 100
44°N	76°W	2	550 ± 100	47°N	103°W	9	200
43°N	89°W	6	500	58°N	109°W	37	117 ± 8
46°N	78°W	3.8	450 ± 30	56°N	102°W	12	100 ± 50
60°N	111°W	6	440 ± 2	49°N	95°W	2.7	100 ± 50
57°N	66°W	8	400 ± 50	30°N	102°W	13	100
62°N	102°W	12.5	400	59°N	117°W	25	95 ± 7
47°N	70°W	46	360 ± 25	21°N	89°W	180	66
36°N	85°W	3.8	360 ± 20	49°N	110°W	10	65
48°N	80°W	30	350	42°N	94°W	32	61 ± 9
37°N	91°W	5.6	320 ± 80	29°N	99°W	2.4	40
39°N	83°W	6.4	320	55°N	63°W	28	38 ± 4
50°N	73°W	4	300	46°N	80°W	8.5	37 ± 2
37°N	92°W	6	300	75°N	89°W	20	21.5 ± 1.2
40°N	87°W	13	300	61°N	73°W	3.2	5
36°N	83°W	6	300	35°N	111°W	1.2	0.05
56°N	74°W	22	290 ± 20	37°N	99°W	0.011	?
56°N	104°W	5	250	31°N	102°W	0.168	?
51°N	98°W	23	225 ± 40	38°N	109°W	5	?
51°N	68°W	100	212 ± 2				

—*Source: This data was collected from Terrestrial Impact Craters, a Hypercard® stack created by Jim Vedda and Chuck Wood, Department of Space Studies, University of North Dakota. This stack was based on data in R.A.F Grieve, et al., "Astronaut's Guide to Terrestrial Impacts Craters," LPI Technical Report 88-03, 1988. An expanded survey of impact craters on Earth is provided by Richard Grieve, "Terrestrial Impact: The Record in the Rocks," Meteoritics, 1991, volume 26, pp. 175-194.*

PROCEDURE

1. Obtain a blank map of North America (Figure 3). The lines on the map indicate longitude (vertical lines) and latitude (horizontal). Latitude is given in degrees north from the equator. Longitude is given in degrees west of the prime meridian, located at an observatory in Greenwich, England.

2. Data Table 1 lists 39 known and likely impact sites on North America, arranged by the estimated

date of impact. Approximate crater diameter also is provided for comparison. Read this chart as follows: Barringer Crater in Arizona has the coordinates 35°N 111°W, is 1.2 kilometers in diameter, and was formed approximately 0.05 million (50,000) years ago. Draw a data point on your map for each of the impact sites provided in Data Table 1.

3. After everyone in your group has completed plotting the data points, discuss how best to interpret your maps.

DATA TABLE 2

CRATER DIAMETER (KM)	NUMBER OBSERVED
under 2.0	____________
2.0–3.9	____________
4.0–7.9	____________
8.0–15.9	____________
16.0–31.9	____________
32.0–63.9	____________
64.0 and over	____________

QUESTIONS / CONCLUSIONS

1. Are there more crater sites on your map than you expected? Are there patterns to the distribution of crater sites in North America or does this distribution seem to be random? Is this distribution other than what you had expected?

2. How might you explain this distribution?

3. Investigate the size distribution of the craters listed in Data Table 1. Summarize the size distribution in Data Table 2. Is the size distribution different from what you expected? \AT halt explanation can you offer to explain the difference?