LONG DISTANCE DETECTIVE

MATERIALS

Each group will need

- crater sample
- modeling clay
- cardboard base
- ruler
- lamp or spotlight
- protractor
- calculator with tangent
function or tangent table

WHAT IS HAPPENING?

Planetary scientists collect most of their information from photographs and other kinds of images created by remote means. Finding out how to extract information using remote techniques—such as telescopes—is an important part of the detective work scientists do. In fact, nearly all that we know about planetary and other solar bodies comes from what we can see and infer from information collected by remote means.

How can remote instruments provide so much information? In this activity, students learn some of the techniques planetary scientists use to draw information from the function or tangent table data their instruments collect. They also learn how models are used to double check the findings scientists make from these remote techniques.

Factors other than depth will determine whether a robot can climb out of a crater: steepness of the crater rim, whether the surface is covered by small or large blocks of rubble, and so on. Unfortunately, better photographic data is necessary before these subjects can be addressed.

IMPORTANT POINTS FOR STUDENTS TO UNDERSTAND

- Data collection often is done remotely.

- Considerable information can be extracted from relatively small amounts of data—
but this requires ingenuity.
- Geometry has important applications in planetary sciences and in interpreting space
photos or aerial photos of Earth.

PREPARATION

Before you begin this lesson, you need to create a simulated crater for each group to model. It is possible for several groups or a whole class to share one sample crater. These samples can be created using a streamlined version of the procedure described in Activity 3. Having students work with soft modeling clay will allow you to recycle the clay for additional classes.

This procedure is divided into three parts for a reason. First, students are given an opportunity for team discovery in solving the problem at hand. Because the second part of the procedure contains one solution to that task, distributing this part at the start will ruin that process. Give students some time to develop their own solutions (approximately 15 minutes). Students should be familiar with the mathematical concept of tangent. You might review this while Part II is underway. Be sure to have a calculator with a tangent function handy. An alternative is to have tables of tangent values ready to distribute.

Figure 4 can be made available to students either by photocopying the image presented on page 33 or by printing the file of this image from Craters-CD. The image on the CD-ROM (file name: Moon405.tif) is an unlabeled version of Figure 4. You will need to present numerical information separately. In addition, you may choose to use other images. Craters-CD contains two additional images where the angle of incoming light is known: Moon404.tif and Other617.tif (Gaspra). See Figures 5 and 6. Data about the angle of incoming light and crater diameter can be found in the text descriptions.

SUGGESTIONS FOR FURTHER STUDY

Challenge students to develop their solutions from Part I further. Have space scientists actually used such a technique in their work? How would your students go about testing their solution using the Moon? The technique students learn in Part II of this activity is analogous to one used by foresters to measure the height of trees and by surveyors to measure the height of mountains. Challenge students to explore these applications.

FIGURES 5 and 6 Additional images useful for this activity: Moon404.W (our Moon) and Other617.tif (Gaspra). Specific information about each image can be found on Craters!-CD.

Now that students know how to determine crater depth, they can compare depth to width ratios for different craters on the same and for craters on different planetary bodies. Is there a consistent ratio?

CONNECTIONS

Scientists use many techniques to investigate phenomena in locations too remote to visit easily. Such locations include other planets, deep space, the bottom of the ocean, and Earth's interior. Investigation of objects that cannot be studied directly is common to many fields of science—from the study of crystal structure to reveal molecular arrangement of molecules to the analysis of brain activity during human speech. Encourage students to examine these types of activities and the techniques used for remote investigation.

Students can investigate the use of photographic analysis in fields such as history, forensics, and anthropology.

ANSWERS TO QUESTIONS FOR STUDENTS

1. Students should obtain the results shown in the key to Data Table 2. Hint: tan(5.28°) is ~0.0924. Be sure to allow for variation in measurements and encourage attention to the number of significant digits. Note also that the angle of illumination cited, 5.28°, is an approximation; it actually varies slightly at different points in the picture and is a bit higher for Crater C. Using sophisticated techniques, astronomers have calculated the crater depths as: Crater A = 3.077 km, Crater B = 2.770 km, and Crater C = 1.850 km. Though large, Crater C is not deep. Ask students to investigate why. (It has been partly filled in by lava, which creates the broad, flat floor.)

2. Numerous factors can affect the explorer's ability to climb out of craters. Rubble on the crater's floor and the steepness of crater walls, for example, pose significant problems. Unfortunately, higher resolution photos would be necessary to assess these problems.

DATA TABLE 2 – KEY

	Crater A	Crater B	Crater C
Diameter of Crater	56 km	38.5 km	80 km
Length of Shadow Cast	34.7 km	26.3 km	81 km
Angle of incoming light	5.28°	5.28°	5.28°
Calculation of Crater Depth	3.2 km	2.43 km	0.75 km