FINDING THE CRATER

OVERVIEW

This activity supports the HHMI short film *The Day the Mesozoic Died.* Students will examine geological evidence of the asteroid impact that caused the mass extinction at the end of the Cretaceous Period. The evidence is found at 10 different sites around the world and provides clues about the location of the crater. Students will evaluate the evidence from each site, map the locations of the different sites, and then propose a general location for the impact crater. This activity tests a diverse set of skills, including mapping, mathematical scaling, and interpretation of mixed visual, graphic, and textual evidence.

KEY CONCEPTS AND LEARNING OBJECTIVES

- The analysis of fossils and elements found in rocks and sediments worldwide provides evidence for events that occurred millions of years ago.
- Sedimentary rock layers are formed by the deposition of material at Earth's surface; these materials may come from weathering and erosion, be transported by water, or "rain" down from the atmosphere.

At the end of this activity, students should be able to:

- Interpret stratigraphy diagrams to identify the different types of rocks and deposits found in rock layers, such as mudstone, breccia, and limestone;
- Plot longitude and latitude on a world map; and
- Evaluate geological evidence to determine the location of the impact crater.

CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	MS-ESS1-4, MS-ESS1.C, MS-ESS2-2, HS-ESS1.B, HS-ESS1.C, HS-ESS2-2, HS-ESS2.A
Common Core (2010)	CCSS.ELA-Literacy.RST.6-8.3, CCSS.ELA-Literacy.RST.6-8.4, CCSS.ELA-Literacy.RST.6-8.7, CCSS.Mathematics.MP.2, CCSS.ELA-Literacy. RST.9-10.7, CCSS.ELA-Literacy. RST.11-12.7,

KEY TERMS

Spherule, tektite, iridium, ejecta, shocked quartz, breccia, stratigraphic diagram, foraminifera, nickel-rich spinels

TIME REQUIREMENTS

This activity is designed to take one to two 50-minute class periods.

SUGGESTED AUDIENCE

This activity is appropriate for middle school science as well as high school earth science or general science classes.

PRIOR KNOWLEDGE

Students should be familiar with the law of superposition and how to plot longitude and latitude on a map, so it may be helpful to review those concepts in class or to assign students to review on their own. You may also review the geological timescale with your students. Note that the film refers to the early Tertiary Period, which is now called the Paleogene Period; please refer to the In-Depth Guide for more details. Note also that in the film the date of the asteroid impact was given as 65 million years ago, but that date has since been revised to 66 million years ago.

MATERIALS

Students will need:

- World Map (provided)
- Colored pencils (e.g., red, orange, and yellow)
- "K-T Boundary Sites" information sheets (provided)

SUGGESTED PROCEDURE

The steps below can be adapted to different audiences. (See "Teaching Tips" for some suggestions.)

1. Show Act 1 of the film *The Day the Mesozoic Died*. Pause prior to the crater being revealed in Act 2.
2. Use the accompanying PowerPoint presentation to present the evidence that an asteroid impact would create nickel-rich spinels, spherules, tektites, and shocked quartz. Students should understand that this evidence may vary in quality and amount depending on how far from the impact it's found.
3. Divide the class into 10 teams of two to four students each.
4. Provide each team with the world map found in an accompanying document. You may need to review the meaning and use of the latitude and longitude lines.
5. Arrange the pages in the accompanying 10-page document labeled "K-T Boundary Sites" at 10 evidence stations around the classroom. (You may want to print the 10 pages in color and laminate them so that they can be used several times.)
6. Assign each team to a station and ask students to evaluate the evidence they find there.
7. At each station, students should: 1) use the longitude and latitude information to find the site on the map; 2) decide whether the site is close to, at an intermediate distance from, or distant from the impact crater based on the evidence found at the site; 3) indicate the site on the map as a colored dot—a red dot for sites that are close, orange for intermediate, and yellow for distant; and 4) write the iridium concentration found at that site, if available.
8. Give students 2 to 3 minutes to examine the evidence at each station. At their final station, students should complete the work for that particular station and propose a location for the crater.

TEACHING TIPS

The following points are suggestions for adapting this activity to different classroom settings and audiences.

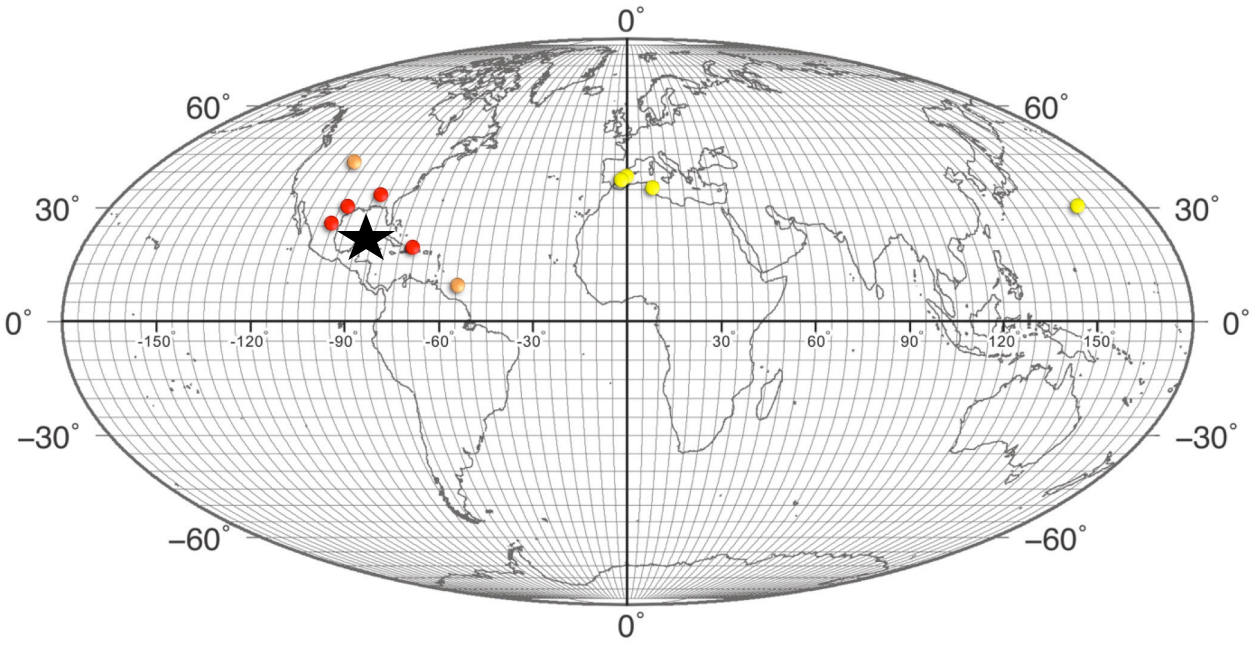
- Slide 15 of the PowerPoint presentation indicates how to determine whether a particular site is close to, at an intermediate distance from, or distant from the site of the impact. If you teach middle school students, it may be appropriate to review this slide with them and leave the slide on the screen as they carry out the activity or print it as a handout.
- If you teach high school students, you may choose to skip this slide and let students come up with their own hypothesis for which sites are at which distance. If you select this approach, it will be helpful to instruct the students to make notes about the characteristics of the K-T event deposits at each site (i.e., type and size of debris, and thickness of deposit). When they return to their desks, they could determine which characteristics are variable among different deposits and what this variation might say about proximity to the crater.
- Instead of setting up evidence stations, you could provide each group of students with a copy of the entire 10-page document. This option might work best if the students have to come up with their own hypothesis for which sites are at which distance, as it will be easier for students to develop a hypothesis if they see and evaluate all the locations at once rather than move from station to station.
- The activity can also be done as a whole-class exercise. In this case, you may print a larger version of the map and tape it to a wall. Each student team will be responsible for looking at the evidence at only one station and adding their "dot" to the map.

DISCUSSION QUESTIONS

- After completing the activity, you may discuss with your students why they think the size and nature of the ejecta debris particles might differ depending on the distance from the impact site. Students should realize that larger particles ejected into the air generally will not travel as far as smaller particles. Large rocks carried by giant waves generated by the impact will

only be found close to the impact site. Students may have realized that the amount of iridium found at K-T boundary sites worldwide does not correlate with the distance from the impact. That's because iridium was released from the asteroid as fine particles when the asteroid vaporized. These fine particles would have traveled to the atmosphere and been transported all over Earth.

- Students should indicate that the impact site is likely to be in North America since that is where all the sites classified as close to the impact site are located. Students may have come to a different conclusion depending on their hypothesis as to which sites were close. Different answers are acceptable as long as students rely on evidence to make their predictions.



The mapped locations should look similar to the illustration below. Red dots represent K-T sites close to the crater, orange dots sites at an intermediate distance, and yellow dots sites that are far away. The suspected location of the crater is indicated by a star.

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