Impact Craters

Lesson 3 – Catching A Killer Crater: Scientific Detectives

Catching a Killer Crater: Scientific Detectives

Grade level: 7-12 modifiable

Time needed: 2-3 class periods

Objectives:
- Use the scientific method to generate a proposed explanation, make predictions, gather data, and interpret results for the question presented
- Recognition and application of ideas surrounding the prominent theory that a meteor impact resulted in the demise of the dinosaurs
- Evaluation of scientific evidence and determination of its relevance
- Judgment of how well conclusions are supported by data gathered

Arizona State Standards
6SC-F5. Identify major features of natural processes and forces that shape the earth's surface, including weathering and volcanic activity. **PO3.** Identify natural processes, (e.g. earthquakes, floods, volcanic eruptions) that rapidly shape the earth's surface.
6SC-E2. Describe common objects in the solar system and explain their relationships. **PO2.** Explain the relationship between common objects in the solar system and the universe.
1SC-P1. Propose solutions to practical and theoretical problems by synthesizing and evaluating information gained from scientific investigations. **PO1.** Evaluate scientific information for relevance to a given problem. **PO2.** Propose solutions to a problem, based on information gained from scientific investigations.

Lesson:
Students will use the Impact Crater Suspect List to chose four possible suspect craters that could have led to the extinction of the dinosaurs. They will use the evidence presented in the Background Information section to narrow down their suspects. They will then research the four suspects using the WWW and develop a presentation for the class. The presentation must include the following:
- Name of each crater.
- Age of each crater.
- Image of each crater.
- Latitude and longitude of each crater.
- Country that each crater is located in.
- A geologic, topographic, cross section, or map of each crater.
- Discussion sections on the discovery process of the crater, the geology of each crater (i.e. what kind of rock is was formed in, what the rock layers look like now, associated faults, ejecta, etc…)
- Three reasons why each crater was chosen
- A conclusion stating whether, after doing the research, they think one of their craters is the one that might have led to the extinction of the dinosaurs.

This is a good opportunity to allow students to experiment with PowerPoint software. However, presentations can also be made using overheads, poster boards or any other visual materials.

Procedure:

- Use *Overhead 1* to show the locations of terrestrial impact craters. Tell students that one of these craters is thought to be the one that caused the extinction of the dinosaurs.
- Show *Overhead 2* and discuss the impact craters shown to give students an idea of what they are looking for physically. Divide students into groups of 4.
- Pass out an *Impact Crater Suspect List* to each group. This is a statistical dataset of terrestrial impact craters.
- Pass out the *Background Information* and *Additional Information* sheets to students. Have them read the passages. These provide information to aid in the narrowing down process.
- Students should narrow the suspect list down to four impact craters based on evidence learned from the introductory passage. Discuss selections in student groups.
- Once each group decides on four craters that they think might be the culprit, have students turn in their selections with two reasons why the chosen craters might be the culprit (i.e. crater x is 65 million years old and is large).
- Pass out the instructions and grading rubric (determined by teacher) for student presentations. Scores will be based on the research they do in the next few days. Allow students access to computers and the WWW in order to have the opportunity to research each of their chosen craters and construct their presentation.
- Each student will then research one of the four craters. Finally, the group will deliver one presentation on all their research

Assessment:
Allow students a few days to work on their research and presentations. When completed, students will present their research to the class. A grading rubric can be constructed based on the criteria to be included in the presentation. Points can also be awarded for participation.

(Optional grading RUBRIC)

This is project can be worth 20 points.
Student presentations grading rubric:

- **10 points – Information**
  - Name, location (country, region, and latitude and longitude) — 2 points
  - Physical characteristics of your craters (diameter and depth) — 2 points
  - Age of your craters — 2 points
  - All the evidence you can find to support your decision. (K-T clay properties, rocks and other materials present, core samples, fossil evidence, etc…) — 4 points

- **5 points – Visual aids** – each overhead, poster, picture, and diagram, PowerPoint slide, or object counts as one visual aid:
  - Use of 3 or more visual aids — 5 points
  - Use of 2 visual aids — 4 points
  - Use of 1 visual aid — 2 points
  - Use of NO visual aids — 0 points

- **5 points – Participation**
  - If you speak for one section of the presentation you get the full 5 points

Conclusion:
After student presentations, compare and contrast the final verdicts for each group. Dis all of the groups come to the same conclusion? Ask them questions similar to the following:

1. Since many/most/all of you concluded that the same crater is evidence for the impact that caused the extinction of the dinosaurs, does that that mean that the crater actually is the evidence of the culprit impact?
2. Did you come to your conclusion by eliminating other possibilities in which the evidence was not as strong?

Show students *Overhead 3*, which is a gravity map of the Chicxulub impact structure located off the tip of the Yucatan Peninsula in Central America. This crater id buried underwater, and it can only be seen through remote sensing measurements –i.e. gravity or seismic reflection. This is the crater that many scientists believe may be responsible for the killing off of the dinosaurs and ¾ of all life 65 mya.

** Additionally, the videos “The Doomsday Asteroid” and/or “Asteroids: Deadly Impact” may be shown before the lesson to introduce concepts or after the lesson as concept reinforcement.

Vocabulary:
Shocked quartz, iridium, bolide, K-T Boundary, asteroid, stratosphere, stratigraphic column

References and Resources:

* Exploring Meteorite Mysteries. **Lesson 14—Direct Hit at the K-T Boundary**. NASA EG-1997-08-104-HQ. (provided)

* **Meteorite! The Last Days of the Dinosaurs**, Richard Norris, 2000, Raintree Steck-Vaughn Publishers, Austin, TX, 64p. (provided)

* **The Doomsday Asteroid.** NOVA® video # 2212, WGBH Educational Foundation, 1995. (approx. 60 minutes) (provided)

* **Asteroids: Deadly Impact**, National Geographic video, NGT, Inc., 1997. (approx. 60 minutes) (provided)

* **Earth Impact Database**, Geological Survey of Canada: http://www.unb.ca/passc/ImpactDatabase/

* **Terrestrial Impact Craters**, Calvin J. Hamilton: http://planetscapes.com/solar/eng/tercrate.htm

* **Terrestrial Impact Craters and their Environmental Effects**, Lunar and Planetary Laboratory, University of Arizona: http://www.lpl.arizona.edu/SIC/impact_cratering/intro/IntroImpact.html

* **Asteroid and Comet Impact Hazards**, NASA: http://impact.arc.nasa.gov/

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Background Information

The death of the dinosaurs was part of a large extinction – a time when three quarters of all the species on earth vanished. Most scientists believe that this mass extinction could have been the result of a giant **asteroid** striking the earth. This impact more than likely left a crater much like we see on other rocky planets and the moon. In this lesson, you will become the scientists and, based on the facts and clues given, your group will determine which terrestrial crater is evidence of the killer asteroid, if such a crater exists at all.

Dinosaurs roamed the planet for nearly 165 million years until approximately 65 million years ago, when suddenly they vanished. Many types of plants and marine animals also vanished during this time. This change in life on Earth and the fossils left behind mark the end of the Cretaceous period of geological history and the beginning of a new era, the Cenozoic, and a new period, the Tertiary. Geologists commonly call this point in time the **K-T Boundary**. **K** is the geology abbreviation for Cretaceous. The K-T Boundary is revealed in the form of a specific rock layer composed of a few centimeters of clay. This clay is found in most every outcrop of the K-T Boundary around the world. Below the clay are abundant fossils of Cretaceous animals, including dinosaurs and marine animals and organisms. Above the clay layer, in the same kind of rocks the fossils are gone. The clay layer is even present in core samples from the ocean floor. Fossils in units below and above the clay layer have been analyzed. The unit below the clay layer has abundant varieties, nearly 70 different types of single-celled foraminifera. Remarkably, the layer above the clay unit also has foraminifera, however, the variety is gone (only 3 or 4 types) and the organisms are all shaped differently than they were before (Norris, 2000). This clay layer denotes and extraordinary change in global ecology which may have resulted in the extinction of three quarters of the life forms on earth.

One theory is that the K-T extinction was caused by the impact of an asteroid. In 1980, scientists Louis and Walter Alvarez, from the University of California at Berkeley decided to test the "meteor/asteroid hypothesis". They predicted that the K-T clay might contain meteorite material if a meteor actually hit the Earth at that approximate time. The Alvarez's postulated that if they searched the clay layer, which could represent fallout material from an impact, the element **iridium** might be present in the clay. Iridium is a rare transition metal found only in small quantities on Earth. It is about 5000 times more abundant in most meteorites. The Alvarez's tested their hypothesis by analyzing samples of the K-T clay for meteoritic material. Not only did they find 400 times the normal amount of iridium, but they also found microscopic diamonds, and **shocked quartz**. These materials can only be made under intense heat and pressure. Thus, the Alvarez's hypothesis was supported in that they did find meteoritic material. Is it enough evidence to prove that a meteor had killed off the dinosaurs? There are still many questions left unanswered. How could a meteor impact have caused mass extinctions all over the world? How big would the impactor have to be to cause such annihilation, and most importantly, where was the crater that could have caused this mass destruction?

Everything at the impact site would have been vaporized and the blast wave would have killed all life to a distance of 500-1000 kilometers (300-600 miles). Earthquakes, tsunamis, and hurricanes could have been associated with the impact and could have also killed many animals farther away from the impact site. But could these effects have been global? The evidence is in the K-T clay, which is found all over the world. The clay was originally dust from the impact. It spread throughout the atmosphere before settling to form the clay layer. Additionally, the K-T clay is rich in soot, suggesting that huge fires could have resulted as a consequence of an enormous impact. The dust and soot would have ascended into the **stratosphere** and blocked out the sun for months. Temperatures could have fallen 20° to 30°C. Only the most enduring animals and plants could have survived until the sun broke through the thick dark clouds.

Where did the meteor land? The impact of a 10 kilometer meteor must have made a crater somewhere on earth's surface. But where? Which crater is the culprit? This is your chance to pick the killer crater from a line up of suspects. Just don't bother looking for a motive!

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Additional Information

Please read the Background Information section (attached) if it has not already been read aloud.

Now that you have selected your four suspects, its time to narrow it down to the culprit.

***Remember you are scientific detectives and can only use the evidence gathered to try your case.

Useful Information:

What we are looking for in our culprit crater:

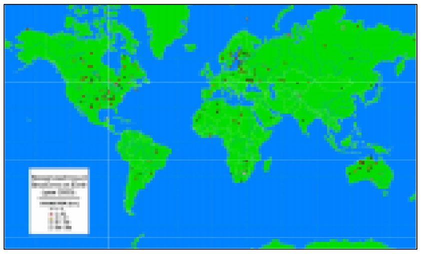
- Age of crater
- Size of crater and **bolide**
- Evidence of impact (overturned rock bedding, shocked quartz, shatter cones, etc)

What have scientists observed?

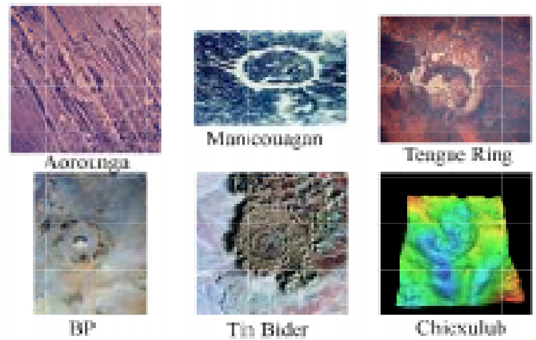
- At the K-T Boudary ¾ of all life appeared to vanish from the face of the earth, including the dinosaurs
- Clay layer representing this time period in rock **stratigraphic column**
- Clay layer contains soot
- Clay layer contains iridium, shocked quartz, and glass

Vocabulary:
Shocked quartz, iridium, bolide, K-T Boundary, asteroid, stratosphere, stratigraphic column

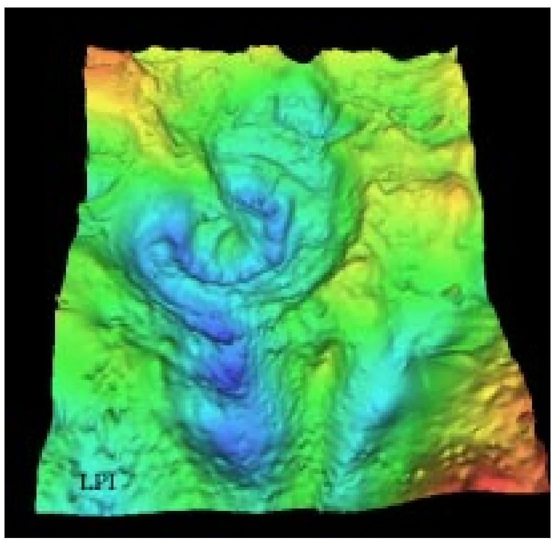
OVERHEADS



Overhead 1. Locations of terrestrial impact craters.



Overhead 2. Terrestrial impact crater images.



Overhead 3. Gravity map of Chicxulub impact structure.