

Using the Cretaceous Impact Event to Teach Science Process

Sixty five million years ago, a 10 km wide meteorite crashed into what is now Mexico's Yucatan Peninsula, creating a 177 km wide crater and a mass extinction across the globe. People are familiar with the fossil evidence of the dinosaurs' demise but an equally exciting and important source of data comes from deep sea ocean cores that can be easily explored in the classroom! The following activity encourages students to make observations and generate questions about a deep sea core from Leg 171B which contains evidence from the impact event and resulting changes in the ocean community. Students will collect information about the core through asking questions then using their critical thinking skills to explain the patterns they see in the core data. Students will then reflect upon the science process they participated in by using the Science Flow Chart and discuss common aspects of how science is done.

Grades 6-10

Connections to the Next Generation Science Standards

Disciplinary Core Ideas

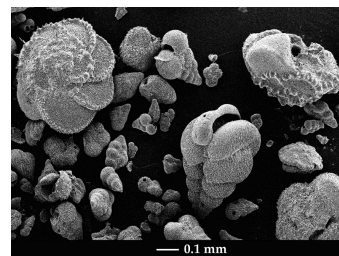
- MS/HS-ESS1C The history of planet Earth
- MS/HS-ESS2 Earth materials and systems
- MS-LS4A Evidence of common ancestry and diversity

Science & Engineering Practices

- Asking questions and defining problems
- Analyzing and interpreting data
- Constructing explanations and designing solutions
- Engaging in argument from evidence

Crosscutting Concepts

- Patterns
- Cause and effect
- Scale, proportion and quantity
- System and System Models
- Stability and Change



Materials

- Images from Cretaceous Impact Kit at: joidesresolution.org/node/3306
 - Lab Book: Core Description Card
 - Maps – Drill Site and Changing Continents
 - Microscopic Images – Cretaceous & Tertiary Forams, Microtektite
 - Ocean Images – Cretaceous and Present Day
 - Extinction Event – Meteorite, Acid Rain and Dead Dino!
- Cretaceous Impact core model or print out (see above link)
- Simple Science Flow Chart at appropriate grade level (1 per student) See below or visit: <http://undsci.berkeley.edu/teaching/teachingtools.php>

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Background Information See below and visit joidesresolution.org/node/3306

Directions

1. Pass out the Cretaceous Impact (171B) core model, photograph, or mock core to each group.
2. Explain to students that this is a sediment core from the ocean and it holds evidence of past events on earth. Their job is to analyze the core to make inferences that explain what they observe.
3. Give students time to make individual and group observations, recording them in a way that can be shared with the class. Discuss what it means to make scientific observations (http://undsci.berkeley.edu/article/0_0_0/howscienceworks_05) and how observations are used to make inferences that can be tested. Undoubtedly, students will include inference statements in their initial observations of the core. Have them identify these and discuss why they are not observations. Then students can revisit their observations and enhance them with more detail using their different senses and available tools (e.g. ruler).
4. Discuss the patterns students see in the core. For example, they should notice very abrupt transitions between layers and that the top and the bottom layers look similar in color and texture.
5. Ask students to generate ideas to explain the patterns they see. Their ability to do this should be limited since important information has not been provided.
6. Have students identify missing information that they need to proceed.

Examples of information students should identify as important

- *Which end of the core is up?*
- *Which end is most recent?*
- *What is the age of the different core layers?*
- *Where was the core drilled?*
- *What is each layer made of?*
- *What else was happening on earth during that time?*
- *Where were the continents located during that time?*

Note: Students can also record who, what, when, where, why, and how questions about scientific ocean drilling and the people and processes behind core retrieval. www.joidesresolution.org contains useful information for addressing such questions.

7. Invite students to request the information that they need. Respond to these requests using materials from the Cretaceous-Impact kit or other sources. Distribution of the information can be either piece-meal as requests are made or together as a packet.

8. As a whole class or in small groups, students should begin to connect what they see in the core with the extinction event that killed the dinosaurs. Give them an opportunity to construct an argument from their evidence that they can share in written or oral format.

Important observations and inferences to discuss:

- There was a loss of diversity and size in the microfossils after the meteor impact.
- Though the size of the different layers is similar, the time they represent is very different. The middle, dark layer (ejecta and fireball layers) were deposited very quickly, in a matter of days or months, compared to approximately 100,000 years it took to deposit the microfossil layers.
- The size of the ejecta layer in cores from this time period, decreases with distance from the impact size.

9. Have students reflect back on and list all of the aspects of science they participated in e.g. gathered information, made inferences, made observations, talked to each other, etc.
10. Pass out the simple Science Flow Chart. Have students analyze the model and explain what it shows about how science is done.

Key elements of the Science Flow Chart as a model:

- Science is non-linear.
- Investigations can start in any number of places and go in many directions.
- Testing ideas is central to science, but there are other important aspects such as benefits and outcomes.
- Science does not have an ending point.
- Collaboration and community is an important aspect of science.

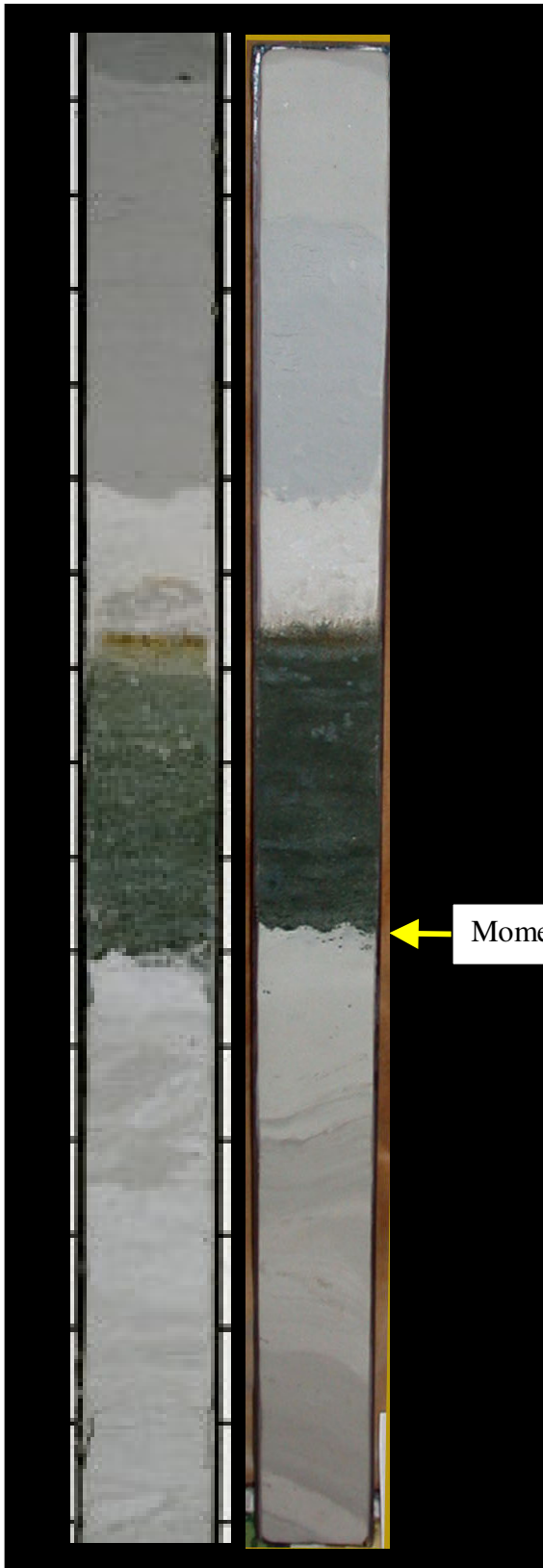
More information can be found at: undsci.berkeley.edu.

11. Have students plot the science actions they participated in from their list onto the Science Flow Chart where they think they most belong, then reveal the more complex age appropriate flow chart.
12. Discuss any similarities and differences between what they plotted and what is found on the model. It is OK if students have differences. This is a model and models can be adapted, but encourage students to talk about their choices.
13. Using the Science Flow Chart: Have students trace the pathway they took during their investigation including connections to what they would want to do next in the process.

EXTENSION: Have students use additional resources to explore alternative hypotheses and/or different lines of evidence about the extinction event that took place 65 million years ago.

Cretaceous/Tertiary Boundary Core Replica

Integrated Ocean Drilling Program - Leg 171B-1049A-17X-2



This replica of a sediment core recovered by the Ocean Drilling Program records the cataclysmic event that changed life on Earth 65 million years ago. The drill ship JOIDES Resolution obtained this core 350 miles east of Florida at a depth of 427 ft (128 meters) below the ocean floor. On that day, an asteroid nearly 10km wide slammed into what is now Mexico's Yucatan Peninsula and blasted debris into the atmosphere. When the dust cloud settled, a 177km wide crater scarred the Earth. A large number of marine and terrestrial creatures became extinct.

The following description is printed on the backside of the replica:

1. After the Impact: Sediment is laminated and slightly bioturbated. Only tiny, less ornate foraminifera microfossils are found in this layer; a few new species have evolved.
2. Fireball Layer: This layer is stained orange due to oxidization of the upper part of the spherule layer. Contains dust and ash fallout from the asteroid impact.
3. Tektite Layer: Ejecta, including tektites – glassy spherules condensed from the hot vapor cloud produced by the asteroid impact – are found in this layer of the core. Debris thrown into the atmosphere by the impact rained down on the Earth for days to months after the event. The impact and ensuing global climatic changes devastated life. In the ocean, 95 percent of the free-floating foraminifera died out. Grades from coarser to finer particles from the bottom to top of layer.
4. Moment of Impact: The irregular surface is the K/T (Cretaceous/Tertiary) Boundary.
5. Before the Impact: The sequence immediately below the K/T unconformity displays microfaults and slump. This layer contains microfossils of the large and ornate foraminifera that flourished in the oceans during the time of the dinosaurs.

Above wording taken from the ODP (Ocean Drilling Program) and JOI (Joint Oceanographic Institutions) sponsored poster on the Leg 171B (1049A-17X-2) core now on display at the Smithsonian Institution, Washington, D.C., USA. This core is part of the ODP/Bremen Core Repository collection, University of Bremen, Germany.

Comparison of real core (left) and replica (right).

RECORDS OF THE APOCALYPSE: ODP DRILLS THE K/T BOUNDARY

Richard D. Norris, Woods Hole Oceanographic Institution
and the ODP Leg 171B Scientific Party

ODP results from the Atlantic Ocean, 300 miles off northeastern Florida, provide dramatic support for the long-standing theory that a large extraterrestrial object slammed into Earth about 65 million years ago at the Cretaceous-Tertiary (K/T) boundary. This event caused widespread extinctions of perhaps 70 percent of all species, including the dinosaurs. By drilling multiple holes at Site 1049 in 1997, ODP Leg 171B recovered three cores containing sedimentary layers that reveal — in beautiful detail — a cataclysmic story of destruction and biotic upheaval (see photograph). The lowermost impact layer contains a graded bed (6 to 17 cm thick) of green, silica-rich globules produced by the large meteorite impact. This spherule layer, which contains Cretaceous planktic foraminifera, forms a sharp contact with underlying nanofossil ooze (soft, microfossil-rich sediment) that was deposited before the catastrophe. The spherule layer also contains mineral grains and rock debris from the Chicxulub crater on Mexico's Yucatan Peninsula, the site of the presumed meteorite impact, over 1500 km away from Site 1049. The thin, rusty brown layer and the dark gray layer of bioturbated nanofossil ooze above it passes upwards into white nanofossil ooze of early Tertiary age, when survivors of the fireball repopulated the oceans. Notably, the dark gray ooze atop the rusty horizon contains only a few species of minute Cretaceous planktonic foraminifera suggesting that the spherule bed, and the bolide impact that produced it, were associated with a massive collapse of the oceanic ecosystem. Spherules were not observed at the K/T boundary at nearby Sites 1050 and 1052, although rocks from both the earliest Tertiary and the latest Cretaceous were recovered. The impact debris at these sites may have slumped into deeper water shortly after the impact debris fell from the sky, settled through the ocean, and arrived on the seafloor. These new ODP cores hold great research potential because unlike most K/T layers, those from Leg 171B are soft, unlithified, and the microfossils are extremely well preserved. This will enable scientists to conduct high-quality geochemical and paleontological studies of the post-apocalyptic repopulation of the ocean.

Cretaceous/Tertiary Boundary meteorite impact ODP Leg 171B, Site 1049, Core 1049A, Section 17X-2

