"Climate Catastrophe During the Dark Ages (536-537 AD): Was It Produced by Dust from an Oceanic Impact?"

Earth2Class Workshops for Teachers
Lamont-Doherty Earth Observatory
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- On 8 Nov 2011, an asteroid the size of an aircraft carrier passed Earth closer than the Moon’s distance.
- Although this “near Earth object” missed Earth, at other times our planet has been clonked hard.
Dr. Dallas Abbott has become one of the leading investigators of data from sea floor studies that explore impacts of asteroids, meteorites, and other extraterrestrial objects in recent (historic) times.

Dallas uses evidence from sedimentological and petrologic studies, electron microscopy, and other techniques.

Dallas’s work received special attention when it was featured in the “Science Times” on 14 Nov 2008.
NYS Science Education Standards

Physical Setting: Earth Science 1.2d

Asteroids, comets, and meteors are components of our solar system.

- Impact events have been correlated with mass extinction and global climate change.
- Impact craters can be identified in Earth's crust.
Meteor Crater (Barringer Crater) in Arizona was the first recognized

http://cass.jsc.nasa.gov/images/scraters/scraters_S10.gif
Image taken by MJP while flying westbound to San Diego
Image taken by MJP while flying Eastbound from San Diego to NJ
Impact craters on land have been known and studied for many years. This STS-9 image of the Manicouagan Crater in northern Canada shows the remains of a collision estimated to have taken place 200 million years ago.

Many other craters have subsequently been identified, especially by remote sensing

- Earth’s greater gravitation pull probably means it has been hit more, but water, atmospheric weathering, and plate tectonics have destroyed or hidden many impact sites.
- More than 250 are known.
- Mostly within the stable cratons of North America, Africa, Australia, and Europe.
Methods to identify impact locations include:

- Siderophile (‘Fe-loving’) elements (esp. Ir, Os, and Pt) in “impact melt rocks”
- “Shock metamorphism” in “target rocks” and minerals
- “Shatter cones”
- High-pressure mineral phases, such as stishovite
- “Diaplectic glass” and tektites in “ejecta blankets”
Some important concepts about impact craters

- Form when a meteoroid (asteroid or comet) collides with a solid planet or moon
- Clearly seen on the Moon, Mercury, and Mars, where weathering and erosion are slow
- Often hard to recognize on Earth because of the effects of weathering and erosion
High velocities at which meteoroids collide with Earth explain the great effects from even small objects.

- Velocities range between 11.2 km/sec (escape velocity from Earth) and 72 km/sec (orbital velocity of Earth plus escape velocity of solar system).
- Kinetic Energy released is proportional to square of velocity.
- Meteorite impacts are, gram for gram, more than 100x as powerful as TNT!
Impact Craters are classified as “Simple” or “Complex”

- “Simple Craters” are relatively small, have a smooth bowl shape, and depth:diameter ratios of 1:5 to 1:7
- “Complex Craters” are largely and show the effect of gravitational collapse of the walls to produce a central peak or peak ring
- These are illustrated in the next slide
One Bad Day 65 million years ago...

One of the best studied is the subsurface Chicxulub structure in Mexico, widely accepted at the location of the Cretaceous-Tertiary (K/T) boundary event. Evidence from the sea floor has been collected from the JOIDES Resolution drilling ship. There are major differences in microfossils below and above the event. But this is a story for another E2C workshop.
Not exposed at the surface, it has been identified through geophysical studies of the gravitational field. Located at 21.3°N 89.6°W, the structure has a diameter of ~250-280 km. Its age has been calculated at 64.98 ± 0.05 million years.

http://cass.jsc.nasa.gov/images/scraters/scraters_S37.gif
The Consortium for Ocean Leadership’s Deep Earth Academy has created several learning activities based on cores recovered from this important drill site.

Check out the “Classroom Resources” section for links to these and other activities.
NEAT: Near-Earth Asteroid Tracking

- In recent years, improved instrumentation has enabled scientists to identify and track asteroids in “Near-Earth” orbits.
- NASA’s Jet Propulsion Laboratory provides data through this website.
- Here is a link to one such object that in 2004 was briefly closer to Earth than the Moon orbits.
More NEO Research

- NASA Ames Research Center provided an update to Congress (Apr 2007) describing next-generation NEO surveys and options for diverting a threatening object. Click here for the news article.

- Because this is of international concern, here is an example of a link to a Near-Earth Object Dynamic Site based at the University of Pisa, Italy.
Connections between impacts and mass extinctions provide evidence for the still-unproved theory that such events may be the “metronome that sets the cadence for biological evolution on Earth.” (Koeberl and Sharpton)
NASA’s Jet Propulsion Laboratory provides much more information about impact craters throughout the solar system in their “Welcome to the Planets” web site http://pds.jpl.nasa.gov/planets/
Excellent information and classroom activities have been created by the Hawai'i Space Grant College, Hawai'i Institute of Geophysics and Planetology, University of Hawai'i

http://www.spacegrant.hawaii.edu/class_ac ts/CrateringDoc.html
Selected URLs about Impact Craters

- For more information and some classroom activities:
  - [http://www.solarviews.com/eng/edu/craters.htm](http://www.solarviews.com/eng/edu/craters.htm)
- The Meteor Crater home page:
- A Webquest about impact craters:
  - [http://earthview.sdsu.edu/trees/impact.html](http://earthview.sdsu.edu/trees/impact.html)