EarthDate

Surviving the Asteroid

Plankton repopulate the Chicxulub crater in the first years after the impact of the asteroid that caused the end-Cretaceous mass extinction.

Credit: John Maisano (UT Austin)

On previous *EarthDates*, we talked about the asteroid that wiped out the dinosaurs—and 75 percent of *all* species on Earth. But what survived? And how?

In the first years after impact, dust and aerosols blocked the sun's light and heat, which slowed photosynthesis.

Plants died, along with most things that depended on them, as the food web collapsed.

Most types of plankton in surface ocean waters also died, and rained down through the water column, where bottom-dwelling scavenger species had a field day.

Large organisms with fast metabolisms and higher food needs starved, while some species of less than 50 lbs with slower metabolisms hung tough.

Specialized species suffered worst. Generalists that could more easily adapt fared better.

Early mammals and birds—avian dinosaurs—quickly began to fill the environmental niches left empty by extinct larger species.

Within 300,000 years, a blink of an eye in evolutionary terms, there were productive ecosystems across Earth.

Strangely, one of the places productivity recovered fastest was within the asteroid crater. Scientists are studying why.

It would be another 10 million years before evolution filled all empty environmental niches and the diversity of life equaled what it was before the impact.

The resulting mix looked very different than before and allowed the rise of mammals and birds and, eventually, humans.

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Background: Surviving the Asteroid

Synopsis: Sixty-six million years ago, the Chicxulub asteroid killed off 75 percent of species on Earth in a planetary catastrophe. Proving that life is tenacious, surviving organisms took advantage of both the special ecosystems in the crater and the environmental niches that opened up because of the extinctions of larger species.

- Precise dating of spherules places the impact around 66 million years ago—the boundary between the end of the Mesozoic Era (Cretaceous period) and the beginning of the Cenozoic Era (Paleogene period).
  - The initial impact may have killed locally, but the subsequent darkness caused the global extinctions. A few months of near total darkness and up to 2 years of twilight occurred because of dust and aerosols in the stratosphere.
    - The dust and aerosols caused major global climate change, called an *impact winter*, as well as a drastic drop in photosynthesis, resulting in the collapse of food webs and the well-documented simultaneous extinction of organisms from both land and sea.
  - With less sunlight for photosynthesis, the number and size of photosynthetic microfossils—which record the history of ocean-water chemistry—sinking through the water column decreased. Since these *pelagic* (living in open ocean) calcifers built their tiny shells principally out of calcium compounds, less calcium was cycled out of surface waters to the deep ocean, resulting in an increase in surface-water alkalinity.
    - The increase in alkalinity is the opposite of previous extinctions, when volcanic CO_2 caused the oceans to become more acidic.
  - The darkness resulting from the Chicxulub impact killed from the ocean's surface downward; however, scavenging *benthic* life (living on the seafloor) survived as the tiny corpses of their floating pelagic food sources rained down on them.
    - It takes about 1,000 years for the ocean to mix from top to bottom, so the extinction event must have been shorter than 1,000 years to leave benthic life on the ocean bottom unaffected.
    - Previous global extinction events lasted long enough (>1,000 years) for impacted surface waters to mix deep into the water column, causing depletion of oxygen and acidification on the seafloor that suffocated bottom-dwelling life first. Surface-dwelling plankton tended to survive these events because surface waters were constantly oxygenated by wave motion.
- It takes time for life to return after such a catastrophic event. How do we define recovery of life?
  - Productivity is a measure of energy produced and consumed, even if just by a few survivor species or even a single extremophile population. The productivity of marine ecosystems in the North Atlantic took about 300,000 years to be restored.
    - In the immediate area of the crater, however, life returned more quickly. Within the crater itself, marine organisms rebounded in less than 6 years. In fact, only minutes after the crater formed, seawater with living organisms flowed into it! And productivity in the area of the crater returned to normal in about 30,000 years—clearly showing scientists that distance from the crater was not a factor in recovery.
    - Productivity increased as twilight turned to partial sunlight in just 3 years and full sunlight in a few decades. Photosynthetic phytoplankton provided more and more food for zooplankton and other larger organisms as the sun's light returned to normal intensity.

References: Surviving the Asteroid

Rapid Recovery of Life at Ground Zero of the End-Cretaceous Mass Extinction I Nature
Life Recovered Rapidly at Impact Site of Dino-Killing Asteroid I ScienceDaily
Dinosaur-Killing Asteroid Cast a 2-Year Shroud of Darkness Over Earth I LiveScience
How Long Did It Take for Life to Rebound after the Death of the Dinosaurs? I Washington Post
"Surprisingly Fast" Recovery of Life at Dinosaur-Killing Asteroid Impact Site I Science & Technology Research News

Contributors: Dr. Chris Lowery (UT Austin Institute for Geophysics), Juli Hennings, Harry Lynch

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        - While highly specialized species suffered, generalist survivor species thrived because they were flexible enough to deal with changing ecosystems.
        - Even macrofauna made it through the catastrophe. Animals with low weights (less than 25 kg, or 55 lbs) and low metabolic rates survived the starvation suffered by larger organisms.
    - Diversity, a measure of the number of species in an ecosystem, is often equated with ecosystem health.
        - Although their populations changed somewhat, benthic microorganisms survived with all of their diversity intact because enough organic matter fell through the water column to provide them with sustenance.
        - Diversity of most surviving species recovered in about 10 million years, a time frame typical of extinction events.
- The Cretaceous–Paleogene extinction that ended the Mesozoic Era left many vacant environmental niches, which were filled by the descendants of species that survived—like mammals (ultimately, humans) and avian dinosaurs (ultimately, birds).

A map showing the location of the Chicxulub crater.

Credit: UT Austin Jackson School of Geosciences News

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