THE CHICXULUB IMPACT

The Cretaceous Period ended with a bang. A really loud bang that echoed around the world (seismically at least), followed by widespread firestorms, wildfires and tsunamis that raged for thousands of miles from the point of impact. The vaporized rock and other dust and debris that were hurled into the upper atmosphere caused dramatic cooling of the Earth that lasted for decades.

It was a cataclysm that triggered a global mass extinction event, wiping out 76% of all plant and animal life on the planet, including all of the non-avian dinosaurs, the pterosaurs, and most of the marine reptiles. Some turtles and ancient crocodiles made it through, but aside from those, no four-legged creatures—reptile or mammal—weighing more than about 50 pounds survived. The impact winter stifled photosynthesis, killing plants and 90% of the Earth's plankton, collapsing the food chains on land and sea.

The boundary between the Cretaceous Period and the Paleogene Period is physically delineated by a thin clay layer found in geological strata around the world, and featuring an extremely high concentration of iridium, a common element in meteorites. Below this layer: dinosaur fossils. Above it: no dinosaur fossils. This layer literally separates two different worlds.

Some of the Turning Points I'm planning for future columns may appear obscure at first glance, although I'll be hoping to convince you of their importance. This one? Uncontroversial. When it comes to historical pivot points, they don't get any more dramatic than a giant rock the size of Mount Everest flying in from space to devastate the planet. And since the Chicxulub Impact counts as both science and history I figured I might as well plunge right in—so to speak—and get the Big One out of the way, before wandering off to cover events that have a bit more nuance to them.

Just about everything we know about the Chicxulub Impact has been discovered during my lifetime, but there have been at least three substantial leaps forward in our understanding of the event in just the last couple of years. So it seems like a good time to take another look.

The Cretaceous Period lasted from 145 million to 66 million years ago, and was the era of many of our favorite dinosaurs: Tyrannosaurus Rex, Triceratops, the ankylosaurs, hadrosaurs, and pterosaurs, all of them super cool. Plus a bunch of mammals, though most of them were rabbit-sized or smaller, ratty marsupials and such, so quite a bit less cool. The asteroid that came barreling in to wreak havoc among them and cause what we now term the Cretaceous-Paleogene (K-Pg) extinction event was six to nine miles across, and caused an explosion equivalent to billions of Hiroshimas.

The existence of this life-obliterating asteroid had been postulated since 1979, when Luiz and Walter Alvarez first identified the iridium-rich layer at the K-Pg boundary, but it took until 1991 to identify its impact site and prove its existence beyond reasonable doubt: the Chicxulub impact crater is largely buried beneath the Yucatan Peninsula in Mexico, and is a hundred and ten miles across and twelve miles deep. That was Ground Zero, all right.

Okay, so what's new?

In 2020, we learned just *how* the asteroid probably came into the atmosphere. Turns out that the shape of an impact crater depends strongly on the angle of impact, as well as the speed of the impactor.

Simulations performed by scientists at Imperial College, London (UK) led by Gareth Collins showed that the best matches to the crater data were those where the asteroid hurtles in at 20 km/s (around 45,000 mph) and strikes at an angle sixty degrees from horizontal. And, as it happens, this angle is just perfect for vaporizing as much rock as possible, and efficiently spewing it up into the atmosphere.

In 2021, we found out *where* this asteroid likely came from. The dramatic arrival of such a monster asteroid is a (fortunately) rare event. Scientists Amir Siraj and Avi Loeb used statistical analysis and gravitational simulations to show that one of the family of long-period comets from the Oort Cloud, way off in the outer reaches of our Solar System, could get pulled off course by Jupiter's gravitational field and thrown past the Sun. The tidal disruption from this solar near miss can break up such a comet, increasing the likelihood that a sizeable chunk of it can then come and smack into Planet Earth. Although at first blush this might seem a complex sequence of events, the modeling shows results consistent with the population and usual locations of long period comets, and the implied Earth impact rate (once per 250 to 730 million years). Most crucially, it's consistent with the composition of the asteroid: fragments of long-period comets do have the carbonaceous chondritic content we see in the Chicxulub remains.

And in 2022, we found out *when* the asteroid hit.

Not how long ago: we already knew that with considerable accuracy from radiometric dating: 66.043+0.011 million years ago. (Because science is awesome.) No: we learned the *time of year* when the Big One struck.

It was springtime, in the Northern Hemisphere.

And we found this out far from the Yucatan, in a site discovered by Robert DePalma in the Hell Creek Formation in North Dakota that he named Tanis: an area he quaintly describes as "a carcass assemblage" and "a sudden mass-death accumulation." The fish and other creatures fossilized here were direct casualties of the K-Pg bolide impact: they were killed the *very day* of the asteroid strike. Back then, a river flowed through Tanis, and the shock from the asteroid impact sent huge waves powering up that river to smash into fish, small dinosaurs, and various other creatures, wreaking havoc and death.

These fish had impact spherules embedded in their gills, but not in their stomachs. Tiny (millimeter-sized) glassy beads that had rained extensively across thousands of miles, fused from the extremely hot ejecta from the asteroid impact. At the distance of the Dakotas such beads would have fallen in the first half hour after the impact, and the fish must have died very soon afterward, because none of them ingested any.

But here's the even cooler part (for us, if not the deceased fauna): a team led by Melanie During has revealed that these fossils provide an accurate snapshot of the season. Like many animals, fish have a very seasonal growth cycle, and the pattern of bone growth at the time of their death shows that these were definitely springtime fish. The carbon isotope record confirms this: the plankton that some of the fish likely chowed down on for their last meal were springtime plankton.

So, to review: we now know that the Chicxulub impactor likely came from the outer reaches of the Solar System and arrived by way of Jupiter and a solar approach; that it hit the Earth in almost the "optimum" trajectory to cause maximum damage and devastation to the planet; and that all this made for the crappiest spring ever.

It’s truly impressive that we’ve now gleaned so much about an event that happened 66 million years ago. By combining the discoveries from painstaking work in paleontology and geology with our astronomical knowledge, and new gravitational and dynamical simulations, we now have a rather complete picture of this planet-shaking disaster. We’re able to trace a timeline, almost minute by minute, through a cataclysm that happened on a really bad day, tens of millions of years ago.

And, if not for that event, the mammals would not have risen to prominence as they did. Humanity and human civilization would not have evolved, at least in their current forms, and nor would many of the animals and plants we’re familiar with.

From our human perspective, this must be one of the biggest Turning Points of all.

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