PRESS RELEASE

Rocks at Asteroid Impact Site Record First Day of Dinosaur Extinction

An international scientific team led by The University of Texas at Austin and the participation of Centro de Astrobiología (CAB, CSIC-INTA) has analyzed rocks from the central area of Chicxulub crater in the Gulf of Mexico. The analyses have allowed scientists to rebuild the first 24 hours after the impact of the asteroid that ended the Age of Dinosaurs.

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There are today about 200 known impact craters on Earth. Some are very well preserved, even clearly visible like the 1,200-meter-wide Meteor Crater in Arizona, others are detected only by the trained eyes of specialist geologists and geophysicists. The most important of them all is the Chicxulub impact crater. It is located at the Yucatán peninsula in México. However, despite its tremendous size (200 km) it offers no spectacular views for a visitor. The crater is buried below hundreds of meters of sediments that have accumulated through the millions of years that have passed since it was formed. There have been many large impacts over the course of the Earth´s history, but Chicxulub is the only impact event so far known to have caused one of the five big mass-extinctions of life. When the asteroid slammed into the planet, the impact set wildfires, triggered tsunamis and blasted so much sulfur into the atmosphere that it blocked the sun, which caused the global cooling that ultimately doomed the dinosaurs.

A new study led by researchers at the University of Texas Institut of Geophysics (UTIG) and with the participation of the Centro de Astrobiología has confirmed the scenario that scientists have hypothesized. Rock samples extracted from the central area of the crater have been analyzed and hard evidence has been found in the tens of meters of rocks that filled the impact crater in the first 24 hours after impact.

"The evidence includes bits of charcoal, jumbles of rock brought in by the tsunami's backflow and conspicuously absent sulfur. They are all part of a rock record that offers the most detailed look yet into the aftermath of the catastrophe that ended the Age of Dinosaurs", said Sean Gulick, the research professor at the University of Texas Institute for Geophysics (UTIG) leading author of the study.

"It's an expanded record of events that we were able to recover from within ground zero", said Gulick, who also co-led the 2016 International Ocean Discovery Program scientific drilling mission that retrieved the rocks from the impact site offshore of the Yucatan Peninsula. "It tells us about impact processes from an eyewitness location", he adds.

The research is published today in the Proceedings of the National Academy of Sciences (PNAS) and builds on earlier work that described how the crater formed and how life quickly recovered at the impact site.

Most of the material that filled the crater within hours of impact was produced at the impact site or was swept in by seawater pouring back into the crater from the surrounding Gulf of Mexico. Just one day deposited about 130 meters of material, a rate that's among the highest ever encountered in the geologic record. This breakneck rate of accumulation means that the rocks record what was happening in the environment within and around the crater in the minutes and hours after impact and give clues about the longer-lasting effects of the impact that wiped out 75% of life on the planet.

Gulick described it as a short-lived inferno at the regional level, followed by a long period of global cooling. "We fried them and then we froze them. Not all the dinosaurs died that day, but many dinosaurs did", concludes Gulick.

As an expert on impact-related sedimentation in craters formed in marine environments, Jens Ormö, researcher at Centro de Astrobiología and coauthor of the study analyzed the samples looking at relative variations in factors like type of rock, size of fragment or roundness of the fragment, in order to know the way the material has been transported and deposited, and sometimes also from where in the target it came from. As Ormö points out, "this part of the study was essential for understanding the amount of water that flowed into the crater and the processes that occurred when the crater was filling up. The sediments reveal tremendous transport energies that are much bigger than any other catastrophic flooding known on the planet. Dense, debris-filled water moved with velocities equaling the windspeed of hurricanes".

Researchers estimate the asteroid hit with the equivalent power of 10 billion atomic bombs of the size used in World War II. The blast ignited trees and plants that were thousands of miles away and triggered a massive tsunami that reached as far inland as Illinois, more than 2,000 km away. Inside the crater, researchers found charcoal and a chemical biomarker associated with soil fungi within or just above layers of sand that shows signs of being deposited by resurging waters. This suggests that the charred landscape was pulled into the crater with the receding waters of the tsunami.

However, one of the most important takeaways from the research is what was missing from the core samples. The area surrounding the impact crater is full of sulfur-rich rocks. But there was no sulfur in the core. That finding supports a theory that the asteroid impact vaporized the sulfur-bearing minerals present at the impact site and released it into the atmosphere, where it wreaked havoc on the Earth's climate, reflecting sunlight away from the planet and causing global cooling. Researchers estimate that at least 325 billion metric tons would have been released by the impact. To put that in perspective, that's about four orders of magnitude greater than the sulfur that was spewed during the 1883 eruption of Krakatoa, which cooled the Earth's climate by an average of 2.2 degrees Celsius for five years.

Although the asteroid impact created mass destruction at the regional level, it was this global climate change that caused a mass extinction, killing off the dinosaurs along with most other life on the planet at the time. “The real killer has got to be atmospheric”, Gulick said. “The only way you get a global mass extinction like this is an atmospheric effect”, he concludes.

“All that can be read from the sediments laid down during those first moments lets us know how it was on the first day of the Cenozoic, the first day of a new age dominated by mammals and eventually by our own species. A species that now by, among other things, massive pollution of oceans and atmosphere has initiated the sixth and latest of the mass-extinctions. Maybe there is still time to learn something from the previous event”, concludes Ormö.

About the CAB

The Center for Astrobiology (CAB) is a Joint Research Center of the Spanish National Research Council (CSIC) and the National Institute of Aerospace Technology (INTA). Created in 1999, it was the first Research Center of the world specifically devoted to astrobiological interdisciplinary research. In April 2000, CAB became the first Associate Member to NASA Astrobiology Institute (NAI). Its main objective is to study the origin, presence and influence of life in the universe. In addition to the understanding of the phenomenon of life as we know it (emergence, development, adaptability to extreme environments, etc.), it also involves the search for life beyond Earth (Exobiology) and Planetary Exploration and Habitability. Finally, the development of Advanced Space Technology and Instrumentation is also one of its main objectives.

CAB is a truly multi-disciplinary institute, hosting scientists specializing in a very wide range of topics as Biology, Chemistry, Geology, Physics, Genetics, Ecology, Astrophysics, Planetology, Engineering, Mathematics, Computer Science, etc., and has also several Support Units, such as an Education & Public Outreach Office, an Administrative Unit, and an extensive scientific Library.

Nowadays, CAB is hosting more than 120 researchers and technicians working on National and International Scientific Projects and participating in several European Networks. The CAB has developed the Rover Environmental Monitoring Station (REMS) for the mission Mars Science Laboratory (MSL), an environmental station on board NASA’s Curiosity rover, operating on Mars since 2012. Also, CAB has developed TWINS, Temperature and Wind Sensors for NASA’s InSight mission, on Mars since November 2018. In addition, the CAB is involved in the development of two more instruments that will travel to Mars in 2020: MEDA , an instrument for NASA’s Mars 2020 mission and RLS instrument for ESA’s ExoMars 2020 mission. Finally, CAB also participates in different missions and instruments of great relevance such as CARMENES, CHEOPS, PLATO, the Space Telescope James Webb (JWST) with the instruments MIRI and NIRSPEC or BepiColombo ESA’s mission.

The CAB received in 2017 the “Unit of Excellence Maria de Maeztu” Award, within the subprogramme of Institutional Strengthening of the State Plan for Scientific and Technical Research and Innovation, aimed at funding and acknowledging public research centres that perform cutting-edge research, and have demonstrated scientific leadership and impact at global level, as well as an active collaboration in their social and business environment.

More information

<u>Figures</u>

Fig. 1: Core sample. A portion of the drilled cores from the rocks that filled the crater left by the asteroid impact that wiped out the dinosaurs. Scientists found melted and broken rocks such as sandstone, limestone and granite – but no sulfur-bearing minerals, despite the area's high concentration of sulfur containing rocks. This finding suggests that the impact vaporized these rocks forming sulfate aerosols in the atmosphere, causing cooling on the global scale. ©International Ocean Discovery Program

Fig. 2: Asteroid impact. An artist's interpretation of the asteroid impact. The asteroid in the artwork appears much larger than the six-mile rock that scientists hypothesize actually struck the Earth 66 million years ago. Nevertheless, the image nicely illuminates the heat generated as the asteroid rapidly compresses upon impact and the vacuum in its wake. ©NASA/Don Davis.

Fig. 3: Researchers: Sean Gulick, a research professor at The University of Texas at Austin Jackson School of Geosciences and lead author of this study, with co-author Joanna Morgan, a professor at Imperial College London, on the International Ocean Discovery Program research expedition that retrieved cores from the submerged and buried impact crater. Gulick and Morgan co-led the expedition in 2016. ©The University of Texas at Austin Jackson School of Geosciences.

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The First Day of the Cenozoic, by S.P.S. Gulick, T. Bralower, J. Ormö, B. Hall, K. Grice, B. Schaefer, S. Lyons, K.H. Freeman, J. Morgan, N. Artemieva, P. Kaskes, S.J. de Graaff, M. Whalen, G. Collins, S.M. Tikoo, C. Verhagen, G.L. Christeson, P. Claeys, M. Coolen, S. Goderis, K. Goto, R. Grieve, N. McCall, G. Osinski, A. Rae, U. Riller, J. Smit, V. Vajda, A. Wittmann and the Expedition 364 Scientists.

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