UC SANTA BARBARA

THE Current

August 8, 2025

Sonia Fernandez

Destructive cosmic airbursts likely more common than previously believed

Touchdown airbursts — a type of cosmic impact that may be more common than the crater-forming, dinosaur-killing kind — remain somewhat less understood. UC Santa Barbara Earth Science Emeritus Professor James Kennett and collaborators continue to make the case that these high-energy events deserve closer attention.

“Touchdown events can cause extreme damage through very high temperatures and pressures,” Kennett said. “And yet they don’t necessarily form a crater, or they form ephemeral surface disturbances, but they’re not the classic major craters that come from direct impacts.”

In four recently published papers, Kennett and co-authors presented evidence for several cosmic airbursts of different ages — events in which the impactor, such as a comet, explodes above ground, sending heat and shockwaves to the Earth’s surface. From the North Atlantic deep-sea floor to a site of an ancient desert civilization, these papers present a bevy of new evidence in support of the extremely high temperatures and pressures associated with these events. The so-called impact proxies include rare elements and minerals derived from the comet itself, molten glass and spherules formed from terrestrial materials at high temperatures, and shocked quartz, which displays patterns of cracks in this very hard material.

New evidence in the marine record

In a study published in the journal PLOS ONE, the research team reports, for the first time, the discovery of impact proxies in ocean sediments associated with the Younger Dryas Impact Hypothesis (YDIH). These records are described in several deep-sea cores in Baffin Bay, located off the western coast of Greenland.

“Baffin Bay is very significant because it’s the first time we’ve found evidence for the Younger Dryas cosmic impact event in the marine record,” Kennett said. According to this hypothesis, a fragmented comet exploded above Earth some 12,800 years ago, triggering an anomalous global cooling period called the Younger Dryas, the extinction of many large animals, and human population and cultural changes. Because the comet was fragmented, the impacts of several bodies resulted in areas of widespread burning evidenced in a “black mat” carbon-rich sediment layer.

The layer, which has been found mostly in the Northern Hemisphere at sites across the Americas and Europe, also contains peak abundances of platinum and iridium, as well as metallic melt spherules, shocked quartz, and minerals fused together forming meltglass.

“They’re preserved in marine sediments as deep as about 2,000 meters,” Kennett said. The presence of these proxies doesn’t say anything in particular about the actual shocks, he explained, but rather illustrate their force, reach and allude to the event’s subsequent climatological impacts. “The material was thrown up into the atmosphere, and was globally transported and deposited in a broadly distributed layer that we earlier have described.”

Potentially the first known crater of Younger Dryas Boundary (YDB) Age

Impacts with Earth by extraterrestrial material vary in magnitude from the daily bombardment of Earth by tons of fine extraterrestrial dust to the dinosaur killers that occur on a timescale of tens of millions of years. Because the more extreme events leave their marks on Earth in the form of craters, much of the “gold standard” evidence of cosmic impacts is aligned with these structures and the character of associated material. As a result, proving the occurrence of a touchdown airburst becomes a challenge, given that there are typically no deformations in the

landscape. This makes it very difficult to prove such an occurrence in the same way that the Chicxulub crater off Mexico's Yucatán Peninsula has been linked to the massive impact that led to the extinction of dinosaurs.

"Previously, there has been no evidence for the Younger Dryas boundary (YDB) event of any crater or possible crater," said Kennett. "So these events are more difficult to detect, especially when they are older than a few thousand years and after being buried, leave little or no superficial evidence."

However, a shallow seasonal lake near Perkins in southeast Louisiana could be the first known such crater formed during the YDB. Reporting in the ScienceOpen journal Airbursts and Cratering Impacts, the research team followed up on a speculation first made in 1938 by the property owner that the seasonal lake could be an impact crater based on its shape and a "crater-like rim raised about 1 meter above the surrounding terrain." It wasn't until 2006 that the sediments in and around the shallow depression began to be examined for impact proxies; from then until 2024, the team also examined sediment from several lake cores, finding spherules, meltglass and shocked quartz, which they determined by radiocarbon dating to support the Younger Dryas impact event. Nevertheless, the researchers said that "further research would be beneficial for testing the hypothesis that the lake/depression resulted from a cosmic impact."

Tunguska and Tall el-Hammam revisited

Shocked quartz — grains of quartz that show fractures and cracks that could only have been produced by high temperatures and pressures — have long been considered evidence for impact. However, this line of reasoning has typically been reserved for the larger crater-forming impacts, which tend to form parallel fractures in this hard material. In a pair of papers in Airbursts and Cratering Impacts, the researchers continue to bolster their argument for a range of fracture patterns that could be indicative of airbursts. To do so, they examined sediments from the site of the Tunguska event — an airburst that occurred over Siberia in 1908, and revisited evidence from Tall el-Hammam, the site of a major ancient city in the Levant that is thought to have experienced a similar-sized event about 3,600 years ago.

"The interesting thing about Tunguska is that it is the only recorded historical touchdown event," Kennett said, and indeed, there are documented eyewitness

reports of a fireball in the sky, and photographs of flattened trees. However, for all the studies of the fallen trees and the soils at the impact site, there had up until now been little effort in search of cosmic impact proxies. This study is the first comprehensive evidence of airburst/impact proxies at Tunguska.

The researchers' analysis of Tunguska revealed shocked quartz grains with the telltale planar deformations and fractures, some filled with meltglass. In addition, they found impact-produced spherules and melted metal and carbon. The high energies related to this impact may also have produced small ground depressions, now existing as swamps and lakes.

Meanwhile, they also expanded their evidence for a proposed Middle Bronze Age-era airburst over Tall el-Hammam in the southern Jordan Valley. In addition to previous reporting of the usual suspects of spherules, carbon, meltglass and rare minerals, the researchers have described shocked quartz with a variety of fracture patterns similar to those in Tunguska sediments, including the classical parallel cracks, but also web-like, curved and sub-planar fissures, indicative of a range of high pressures and directionality resulting from the blast.

Taken together, these papers point to the idea that cosmic impacts, and in particular touchdown airbursts, may occur more often than previously thought.

"They're far more common, but also possess much more destructive potential than the more localized, classic crater-forming asteroidal impacts." said Kennett. "The destruction from touchdown events can be much more widespread. And yet they haven't been very well studied, so these should be of interest to humanity."

Media Contact
Sonia Fernandez
Senior Science Writer
(805) 893-4765
sonia.fernandez@ucsb.edu

About UC Santa Barbara

The University of California, Santa Barbara is a leading research institution that also provides a comprehensive liberal arts learning experience. Our academic community

of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. All of this takes place within a living and learning environment like no other, as we draw inspiration from the beauty and resources of our extraordinary location at the edge of the Pacific Ocean.