

Researchers consider whether supernovae killed off large ocean animals at dawn of Pleistocene

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Muons showering Earth may have spelled curtains for Megalodon, a school-bus-sized shark, 2.6 million years ago. Credit: Wikimedia Commons.

About 2.6 million years ago, an oddly bright light arrived in the prehistoric sky and lingered there for weeks or months. It was a supernova some 150 light years away from Earth. Within a few hundred years, long after the strange light in the sky had dwindled, a tsunami of cosmic energy from that same shattering star explosion could have reached our planet and pummeled the atmosphere, touching off climate change and triggering mass extinctions of large ocean animals, including

a shark species that was the size of a school bus.

The effects of such a supernova—and possibly more than one—on large ocean life are detailed in a paper just published in *Astrobiology*.

"I've been doing research like this for about 15 years, and always in the past it's been based on what we know generally about the universe—that these supernovae should have affected Earth at some time or another," said lead author Adrian Melott, professor emeritus of physics & astronomy at the University of Kansas. "This time, it's different. We have evidence of nearby events at a specific time. We know about how far away they were, so we can actually compute how that would have affected the Earth and compare it to what we know about what happened at that time—it's much more specific."

Melott said recent papers revealing ancient seabed deposits of iron-60 isotopes provided the "slam-dunk" evidence of the timing and distance of supernovae.

"As far back as the mid-1990s, people said, 'Hey, look for iron-60. It's a telltale because there's no other way for it to get to Earth but from a supernova.' Because iron-60 is radioactive, if it was formed with the Earth it would be long gone by now. So, it had to have been rained down on us. There's some debate about whether there was only one supernova really nearby or a whole chain of them. I kind of favor a combo of the two—a big chain with one that was unusually powerful and close. If you look at iron-60 residue, there's a huge spike 2.6 million years ago, but there's excess scattered clear back 10 million years."

Melott's co-authors were Franciole Marinho of Universidade Federal de Sa?o Carlos in Brazil and Laura Paulucci of Universidade Federal do ABC, also in Brazil.

According to the team, other evidence for a series of supernovae is found in the very architecture of the local universe.

"We have the Local Bubble in the interstellar medium," Melott said. "We're right on its edge. It's a giant region about 300 [light years](#) long. It's basically very hot, very low-density gas—nearly all the gas clouds have been swept out of it. The best way to manufacture a bubble like that is a whole bunch of supernovae blows it bigger and bigger, and that seems to fit well with idea of a chain. When we do calculations, they're based on the idea that one supernova that goes off, and its energy sweeps by Earth, and it's over. But with the Local Bubble, the [cosmic rays](#) kind of bounce off the sides, and the cosmic-ray bath would last 10,000 to 100,000 years. This way, you could imagine a whole series of these things feeding more and more cosmic rays into the Local Bubble and giving us cosmic rays for millions of years."

Whether or not there was one supernova or a series of them, the supernova energy that spread layers of iron-60 all over the world also caused penetrating particles called muons to shower Earth, causing cancers and mutations—especially to larger animals.

"The best description of a muon would be a very heavy electron—but a [muon](#) is a couple hundred times more massive than an electron," Melott said. "They're very penetrating. Even normally, there are lots of them passing through us. Nearly all of them pass through harmlessly, yet about one-fifth of our radiation dose comes by muons. But when this wave of cosmic rays hits, multiply those muons by a few hundred. Only a small fraction of them will interact in any way, but when the number is so large and their energy so high, you get increased mutations and cancer—these would be the main biological effects. We estimated the cancer rate would go up about 50 percent for something the size of a human—and the bigger you are, the worse it is. For an elephant or a whale, the radiation dose goes way up."

A supernova 2.6 million years ago may be related to a marine megafaunal extinction at the Pliocene-Pleistocene boundary where 36 percent of the genera were estimated to become extinct. The extinction was concentrated in [coastal waters](#), where larger organisms would catch a greater radiation dose from the muons.

According to the authors of the new paper, damage from muons would extend down hundreds of yards into ocean waters, becoming less severe at greater depths: "High energy muons can reach deeper in the oceans being the more relevant agent of biological damage as depth increases," they write.

Indeed, a famously large and fierce marine animal inhabiting shallower waters may have been doomed by the supernova radiation.

"One of the extinctions that happened 2.6 million years ago was Megalodon," Melott said. "Imagine the Great White Shark in 'Jaws,' which was enormous—and that's Megalodon, but it was about the size of a school bus. They just disappeared about that time. So, we can speculate it might have something to do with the muons. Basically, the bigger the creature is the bigger the increase in radiation would have been."

The KU researcher said the evidence of a [supernova](#), or series of them, is "another puzzle piece" to clarify the possible reasons for the Pliocene-Pleistocene boundary extinction.

"There really hasn't been any good explanation for the marine megafaunal extinction," Melott said. "This could be one. It's this paradigm change—we know something happened and when it happened, so for the first time we can really dig in and look for things in a definite way. We now can get really definite about what the effects of radiation would be in a way that wasn't possible before."

More information: Adrian L. Melott et al, Hypothesis: Muon Radiation Dose and Marine Megafaunal Extinction at the End-Pliocene Supernova, *Astrobiology* (2018). [DOI: 10.1089/ast.2018.1902](https://doi.org/10.1089/ast.2018.1902)

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