An asteroid collision 466 million years ago created meteorites that still fall to Earth.

PLANETARY SCIENCE

Dust from asteroid breakup veiled and cooled Earth

Ancient event may have led to a boom in animal life

By **Joshua Sokol**

Faced with a dangerously warming world, would-be geoengineers have dreamed up ways to quickly turn down the heat. One proposed technique: spreading a veil of dust that would sit in space or Earth's atmosphere and reflect sunlight. Researchers say they have now found evidence for a similar experiment that played out naturally, 466 million years ago, when an asteroid out in space exploded into bits. Dust from the breakup blanketed the planet, says Birger Schmitz, a geologist at Lund University in Sweden, plunging it into an ice age that was soon followed by an explosion in animal life.

The ancient episode offers both encouragement and caution for geoengineers. If Schmitz is right, it dramatically demonstrates how dust can cool the planet. But the deep freeze is a lesson in potential unintended consequences. "Maybe our study will trigger a big academic controversy," says Schmitz, who leads a study published this week in *Science Advances*.

All over the world, the ratio of decaying isotopes in a common meteorite type suggests the space rocks formed in a singular shock event 466 million years ago. Models based on how long they took to cool suggest they came from a 150-kilometer-wide parent body, which broke up in a collision in the asteroid belt beyond Mars, sending a stream of fragments into the inner solar system. Bits from the breakup still fall to Earth today.

Schmitz's team has found a rich source of the debris: a limestone quarry in southern Sweden. Since the 1990s, it has yielded more than 100 fossil meteorites, found in rock layers that date to soon after the asteroid breakup. "The flux had to be enormous at this time," says Bill Bottke, a planetary scientist at the Southwest Research Institute in Boulder, Colorado, who has studied the breakup.

The meteorites fell about the time early animal life boomed. Major animal groups had already evolved, but during this Great Ordovician Biodiversification Event (GOBE), ocean animals doubled or even tripled in biodiversity. Reefs built by microbes gave way to some of the first coral reefs, trilobites grew larger, and tentacled predators such as nautiloids diversified and swarmed the mostly fishless seas. In 2008, Schmitz argued that the asteroid breakup might be responsible. Perhaps, he and colleagues proposed, large fragments striking Earth spurred the GOBE by shaking up ecosystems, clearing out ecological niches for new species to evolve into.

But the idea didn't catch on, in part because there was no sign of large impact craters from just after the collision. Instead, some paleontologists offered a different trigger for the GOBE: a succession of ice ages that took place at the same time. Colder water can hold more dissolved oxygen, fueling life. And as water froze into glaciers, sea levels dropped, isolating shallow seas and creating niches for speciation.

Schmitz's team now thinks the asteroid breakup brought on those ice ages, by creating a cloud of dust that hung in space and in the atmosphere, reflecting sunlight away from Earth and allowing the ice to build up. In layers of limestone spanning just a few million years, from the original quarry and other sites in Sweden and Russia, the team found a surge in both small extraterrestrial grains and in chemical isotopes that trace even finer extraterrestrial dust. "All this dust floated in, just when the sea level fall started," Schmitz says. "Suddenly it clicked."

Rebecca Freeman, a paleontologist at the University of Kentucky in Lexington, says the timing is "perfect." "It isn't necessarily the answer to every question, but it certainly ties together a lot of observations," she says.

Peter Reiners, a geochemist at the University of Arizona in Tucson, argues that the falling asteroid dust would have also delivered iron to the world's oceans, chilling the climate a different way. The dust would have nourished photosynthetic microbes at the sea surface, drawing carbon dioxide out of the atmosphere. When they died and sank, much of the carbon they absorbed would be buried with them, further cooling the planet.

The ancient events are eerily similar to modern-day geoengineering schemes. A study in 2012 evaluated the idea of towing an asteroid to a gravitationally stable point between Earth and the sun, and grinding off dust that would remain in space and shade Earth. Researchers found that a 32-kilometer-wide near-Earth asteroid called 1036 Ganymed could make a dust cloud big enough to remain in place and block 6.6% of the sun's light, well over the 1.7% reduction the authors say could offset 2°C of expected warming. Fertilizing the ocean with iron has also been proposed to combat climate change.

Seth Finnegan, a paleontologist at the University of California, Berkeley, is not yet convinced about the ancient geoengineering event. He wants to see global evidence for extraterrestrial dust, alongside signals for cooling and biodiversification. He also urges researchers to model how much dust the asteroid breakup would have made, and how it would have affected climate. Schmitz says he's searching for dust at a third site in central China.

If it turns out that a powdered asteroid really did have such a profound effect on the Ordovician, Finnegan adds, then the episode also delivers a warning: It "shows that the consequences of messing around in that way could be pretty severe." ■

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IMAGE: NASA/JPL-CALTECH

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