Global warming today mirrors conditions leading to Earth's largest extinction event, study says

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More than two-thirds of life on Earth died off some 252 million years ago, in the largest mass extinction event in Earth's history.

Researchers have long suspected that volcanic eruptions triggered "the Great Dying," as the end of the Permian geologic period is sometimes called, but exactly how so many creatures died has been something of a mystery.

Now scientists at the University of Washington and Stanford believe their models reveal how so many animals were killed, and they see frightening parallels in the path our planet is on today.

Models of the effects of volcanic greenhouse gas releases showed the Earth warming dramatically and oxygen disappearing from its oceans, leaving many marine animals unable to breathe, according to a study published Thursday in the peer-reviewed journal *Science*. By the time temperatures peaked, about 80 percent of the oceans' oxygen, on average, had been depleted. Most marine animals went extinct.

The researchers tested the model's results against fossil-record patterns from the time of the extinction and found they correlated closely. Although other factors, like ocean acidification, might have contributed some to the Permian extinction, warming and oxygen loss account for the pattern of the dying, according to the research.

By this century's end, if emissions continue at their current pace, humans will have warmed the ocean about 20 percent as much as during the extinction event, the researchers say. By 2300, that figure could be as high as 50 percent.

"The ultimate, driving change that led to the mass extinction is the same driving change that humans are doing today, which is injecting greenhouse gases into the atmosphere," said Justin Penn, a UW doctoral student in oceanography and the study's lead author.

Curtis Deutsch, a UW associate professor of oceanography and an author of the research, said if society continues to pump greenhouse gases at our current rate, "we have no reason to think it wouldn't cause a similar type of extinction."

The Earth 252 million years ago was a much different place. The continents as we know them today were still mostly one landmass, named Pangea, which looks like a chunky letter "C" on a map.

The climate, however, resembled Earth's now, and researchers believe animals would have adapted many traits, like metabolism, that were similar to creatures today. Nearly every part of the Permian Ocean, before the extinction, was filled with sea life.

"Less than 1 percent of the Permian Ocean was a dead zone—quite similar to today's ocean," Deutsch said.

The series of volcanic events in Siberia that many scientists believe set off the mass extinction "makes super volcanoes look like the head of a pin," said Seth Burgess, a geologist and volcanologist with the United States Geological Survey.

"We're talking about enough lava erupted onto the surface and intruded

into the crust to cover the area of the United States that if you looked at the U.S. from above was maybe a kilometer deep in lava," he said.

Burgess, who has researched the Siberian Traps volcanic events but did not work on the new Science paper, said scientists believe magma rising from the earth released some extinction-causing greenhouse gases.

In addition, sills of magma still inside the earth heated massive deposits of coal, peat and carbonate minerals, among others, which vented even more carbon and methane into the atmosphere.

"That's how you drive the Permian mass extinction, by intruding massive volumes of magma into a basin rich in carbon-bearing sediments," he said.

The UW and Stanford research "takes the next step in figuring out why things died at the end of the Permian," Burgess said. "It couples what we think was happening in the climate with the fossil record, and it does it elegantly."

It took a supercomputer more than six months to simulate all the changes the volcanic eruptions are suspected of causing during the Permian period. The computer models go into remarkable detail—simulating things like clouds, ocean currents and marine plant life—in describing what temperatures and conditions were like on Earth.

The researchers knew that surface temperatures rose about 10 degrees Celsius in the tropics because of previous scientific analysis of the fossilized teeth of eel-like creatures called conodonts.

To run their model, researchers pumped volcanic greenhouse gases into their simulation to match temperature conditions at the end of the Permian period.

As temperatures climbed toward the 10-degree mark, the model's oceans became depleted of oxygen, a trend scientists are evaluating in today's oceans, too.

To measure how rising temperatures and less oxygen would affect animal species of the Permian period, the researchers used 61 modern creatures—crustaceans, fish, shellfish, corals and sharks. The researchers believe these animals would have similar temperature and oxygen sensitivities to Permian species because the animals adapted to live in similar climates.

Warming's effects were twofold on the creatures, the researchers found. In warmer waters, animals need more oxygen to perform bodily functions. But warm waters can't contain as much dissolved oxygen, which means less was available to them.

In other words, as animals' bodies demanded more oxygen, the ocean's supply dropped.

In their model, the researchers were able to quantify the loss of habitat as species faced increasingly challenging ocean conditions. Surface-temperature rise and oxygen loss were more substantial in areas farther from the equator. Extinction rates also increased at higher latitudes.

Animals in the tropics were already accustomed to warmer temperatures and lower oxygen levels before the volcanic eruptions shifted the climate, according to the research. As the world warmed, they could move along with their habitat.

Marine creatures that favored cold waters and high oxygen levels fared worse: They had nowhere to go.

"The high latitudes where it's cold and oxygen is high—if you're an

organism that needs those kind of conditions to survive, those conditions completely disappear from Earth," Deutsch said.

In modern oceans, warming and oxygen loss have also been more pronounced near the poles, researchers said, drawing another analogue between the shift in climate some 252 million years ago and what's happening today.

"The study tells us what's at the end of the road if we let climate (change) keep going. The further we go, the more species we're likely to lose," Deutsch said. "That's frightening. The loss of species is irreversible."