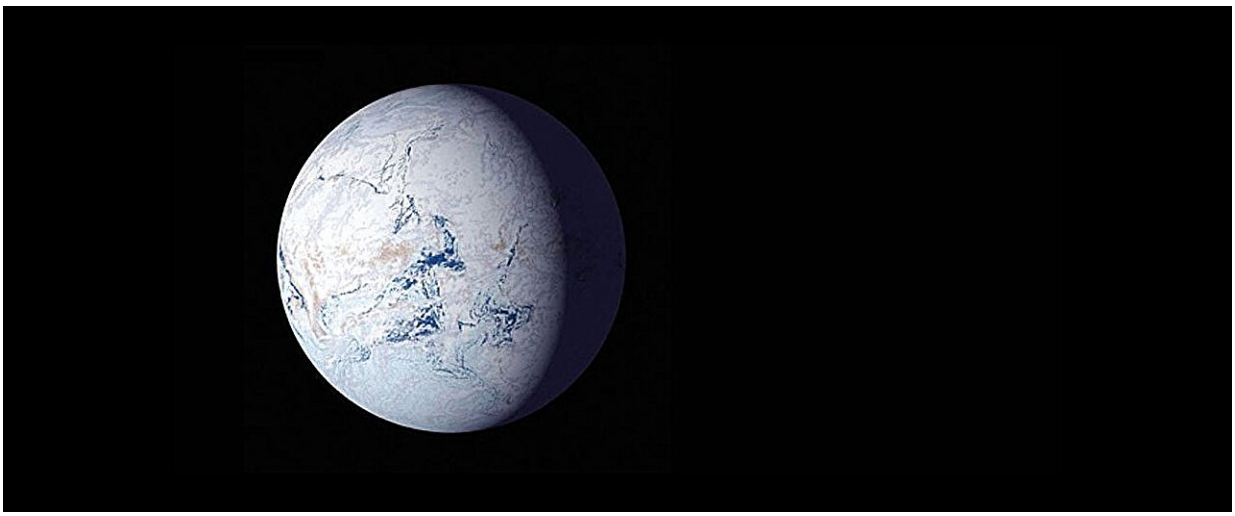
What turned Earth into a giant snowball 700 million years ago? Scientists now have an answer

February 8 2024



Artists impression of 'Snowball Earth'. Credit: NASA

Australian geologists have used plate tectonic modeling to determine what most likely caused an extreme ice-age climate in Earth's history, more than 700 million years ago.

The study, published in *Geology*, helps our understanding of the functioning of the Earth's built-in thermostat that prevents the Earth from getting stuck in overheating mode. It also shows how sensitive global climate is to atmospheric carbon concentration.

"Imagine the Earth almost completely frozen over," said the study's lead author, ARC Future Fellow Dr. Adriana Dutkiewicz. "That's just what happened about 700 million years ago; the planet was blanketed in ice from poles to equator and temperatures plunged. However, just what caused this has been an open question.

"We now think we have cracked the mystery: historically low volcanic carbon dioxide emissions, aided by weathering of a large pile of volcanic rocks in what is now Canada; a process that absorbs atmospheric carbon dioxide."

The project was inspired by the glacial debris left by the ancient glaciation from this period that can be spectacularly observed in the Flinders Ranges in South Australia.

A recent geological field trip to the Ranges, led by co-author Professor Alan Collins from the University of Adelaide, prompted the team to use the University of Sydney EarthByte computer models to investigate the cause and the exceptionally long duration of this ice age.

The extended ice age, also called the Sturtian glaciation after the 19th-century European colonial explorer of central Australia, Charles Sturt, stretched from 717 to 660 million years ago, a period well before the dinosaurs and complex plant life on land existed.

Dr. Dutkiewicz said, "Various causes have been proposed for the trigger and the end of this extreme ice age, but the most mysterious aspect is why it lasted for 57 million years—a time span hard for us humans to imagine."

The team went back to a plate tectonic model that shows the evolution of continents and ocean basins at a time after the breakup of the ancient supercontinent Rodinia. They connected it to a computer model that

calculates CO_2 degassing of underwater volcanoes along mid-ocean ridges—the sites where plates diverge and new ocean crust is born.

Sturt Formation glacial deposits from the Sturtian Glaciation circa 717–664 million years ago in the northern Flinders Ranges, Australia, close to the Arkaroola Wilderness Sanctuary. Research lead author Dr. Adriana Dutkiewicz from the School of Geosciences, the University of Sydney, pointing to a thick bed of glacial deposits. Credit: Professor Dietmar Müller/University of Sydney

They soon realized that the start of the Sturtian ice age precisely correlates with an all-time low in volcanic CO_2 emissions. In addition, the CO_2 outflux remained relatively low for the entire duration of the ice age.

Dr. Dutkiewicz said, "At this time, there were no multicellular animals or land plants on Earth. The greenhouse gas concentration of the atmosphere was almost entirely dictated by CO_2 out-gassing from volcanoes and by silicate rock weathering processes, which consume CO_2."

Co-author Professor Dietmar Müller from the University of Sydney said, "Geology ruled climate at this time. We think the Sturtian ice age kicked in due to a double whammy: a plate tectonic reorganization brought volcanic degassing to a minimum, while simultaneously a continental volcanic province in Canada started eroding away, consuming atmospheric CO_2.

"The result was that atmospheric CO_2 fell to a level where glaciation kicks in—which we estimate to be below 200 parts per million, less than half today's level."

View towards the Arkaroola Wilderness Sanctuary, Flinders Ranges, with the

Sturt Formation glacial deposits from the Sturtian Glaciation circa 717–664 million years ago forming a prominent ridge in the middle of the photo on the left. Credit: Professor Dietmar Müller/University of Sydney

Dr. Adriana Dutkiewicz from the School of Geosciences at the University of Sydney in the Flinders Ranges, South Australia. Credit: The University of Sydney

The team's work raises intriguing questions about Earth's long-term future. A recent theory proposed that over the next 250 million years, Earth would evolve towards Pangea Ultima, a supercontinent so hot that mammals might become extinct.

However, the Earth is also currently on a trajectory of lower volcanic CO_2 emissions, as continental collisions increase and the plates slow down. So, perhaps Pangea Ultima will turn into a snowball again.

Dr. Dutkiewicz said, "Whatever the future holds, it is important to note that geological climate change, of the type studied here, happens extremely slowly. According to NASA, human-induced climate change is happening at a pace 10 times faster than we have seen before."

More information: Adriana Dutkiewicz et al, Duration of Sturtian "Snowball Earth" glaciation linked to exceptionally low mid-ocean ridge outgassing, *Geology* (2024). DOI: 10.1130/G51669.1

Provided by University of Sydney