Study Casts Doubt On 'Snowball Earth' Theory

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A study that applied innovative techniques to previously unexamined rock formations has turned up strong evidence on the "Slushball Earth" side of a decades-long scientific argument.

The study appears in the Sept. 29 Science Express. The lead author is Alison Olcott, a Ph.D. student of earth sciences in the USC College of Letters, Arts and Sciences.

Geologists agree that prehistoric Earth was locked in a deep freeze during Precambrian times, about 750 to 600 million years ago. They disagree over the severity of the glaciation.

"Snowball Earth" proponents, who say that Earth's oceans were covered by thick ice, explain the survival of life by hypothesizing the existence of small warm spots, or refugia.

On the other side are supporters of a "Slushball Earth" that would have included large areas of thin ice or open ocean, particularly around the equator.

The debate has tended to revolve around the same rock samples and analytical techniques, Olcott said. So she and her team focused on a drill core of little-known black shale deposits from southeastern Brazil and applied lipid biomarker techniques to identify prehistoric organisms based on the fatty remains of their cell membranes.

The team, which included scientists from USC, Caltech, the University of Maryland and a Brazilian mining company, identified "a complex and productive microbial ecosystem," including photosynthesizing organisms that could not have existed under a thick layer of ice.

"If there was ice, it had to have been thin enough that organisms could photosynthesize below it or within it," Olcott said.

Frank Corsetti of the USC College, one of Olcott's advisers and a co-author on the paper, said: "What she has provided is the first real evidence that substantial photosynthesis occurred in the Earth's oceans during the extreme ice age 700 million years ago, which is a challenge for the snowball theory."

The evidence from the drill core does not prove that large parts of the ocean remained free of sheet ice during the pre-Cambrian glaciation. It is statistically unlikely but possible, Olcott said, that the drill core found one of the tiny "refugia" for marine life whose existence is allowed under the "Snowball Earth" hypothesis.

But, she said, "finding the one anomalous spot would be quite unlikely," adding that the drill core came from an extensive formation of rocks with similar characteristics.

"At what point does an enormous refugium become open ocean?" she asked.

Skeptics also may argue that the rocks do not necessarily date to a glacial era, Olcott said. But her team found evidence of glacial activity in the samples, such as dropstones (continental rocks dropped by melting glaciers into marine deposits) and glendonites (minerals that only form in near-freezing water).

Objections aside, the paper's main contribution may be the application of new techniques to an old chestnut.

"Geologists don't necessarily think of looking for traces of microbes left in the rocks. This is the first direct look at the ecosystem during this time period," said Olcott, who credited USC's geobiology program, one of a handful in the country, with influencing her thinking.

"They really try to synthesize between geology and biology. It was a new way to attack the problem."

Corsetti agrees. "The climate of collaboration between geologists and biologists," he said, "is unusually good at USC ... it was this way of thinking that provided the impetus for the project in the first place."