SEDIMENTARY ROCKS REIGNITE HEATED DEBATE OVER SNOWBALL EARTH

mong geologists, few debates are as hot as the one over the coldest hypothesis of all: snowball Earth. Proponents of snowball Earth contend that the entire planet was encased in ice during the Cryogenian, between 710 million and 640 million years ago, citing rocks that preserve evidence of glaciation in tropical latitudes from the period. The idea has been mired in controversy since it was proposed in 1992, and now a group of researchers is seeking to disprove the snowballers once and for all.

Ripple marks in rocks dating from the snowball Earth period in places such as Oman suggest at least some areas of ocean remained ice free — evidence that might disprove the snowball Earth hypothesis.

that describes the rocks from Oman. "It's an all or nothing deal." According to the completely frozen snowball hypothesis (as opposed to the "slushball" hypothesis that suggests not everything was completely frozen over), the ice would completely cover the planet "and it would last for a very long time," Allen says. Once the ice reached a certain latitude, it would have reflected most of the sun's incoming radiation, sending Earth into a deep freeze. "The only way to reverse the deep freeze would be for carbon dioxide levels to build up

The researchers have built their case against snowball Earth around sedimentary rocks found in modern Oman dated to the Cryogenian that seem to indicate that at least some areas of the ocean remained ice free during the supposed snowball age. If some areas of open water existed, then the completely frozen snowball Earth hypothesis collapses, says Philip Allen of the Imperial College London in the United Kingdom and lead author of the recent article in Geology

to 300 or 400 times higher than today's levels," he says. "The only way to build up levels that high would be to seal off the oceans under ice so all the carbon dioxide would stay in the atmosphere and not be absorbed by the oceans."

The rocks in Oman, however, show signs of alternating glacial and non-glacial sediments as well as ripple marks that could only have been made by the action of surface waves, Allen says. "Throughout the Fiq Formation in

Oman, we see evidence that the glaciers were advancing and retreating, transporting large volumes of sediment," he says. "It appears that the water cycle did not shut down. It operated normally and vigorously and that is a sure indicator the oceans were open." And although the study focuses primarily on the Oman site, Allen also points to a number of similar deposits in China, Australia, Canada and California that date to the same period. "That's a very large number of oases," Allen says. "And if you have lots and lots of oases, then you effectively have open oceans."

But despite Allen's assertion that his sedimentary study is a solid falsifying test, it hasn't budged pro-snowballers. "This study is not a very comprehensive treatment," says Paul Hoffman of Harvard University in Massachusetts. "It doesn't properly lay out the evidence in favor of the snowball hypothesis, and it criticizes it only from one observational standpoint: the sedimentary evidence of the glacial deposits themselves." The problem with studying glacial deposits, he says, is that, "when ice comes and goes, it works like waves on a beach. When the wave comes in, it wipes out all the previous deposits so the record is incomplete." Hoffman suggests that the rippled rocks must have been left during the retreat of the ice during the final thaw, because earlier deposits would have been wiped out by the glaciers.

"Many arguments have been leveled against snowball Earth, but I don't think any are fatal to the hypothesis," Hoffman says. Observations from around the world, including tropical glacial deposits, iron formations and carbonates left by high carbon dioxide levels, are best explained by the snowball hypothesis, he says. But he notes that there's still a lot of room for discussion. "I'd say 10 percent of geologists accept the snowball theory, 10 percent are opposed to it and about 80 percent are sitting on the fence," he says. "But of the 20 percent that have made up their minds, I don't know a single person who has changed their mind, and I doubt this paper will help one way or the other."