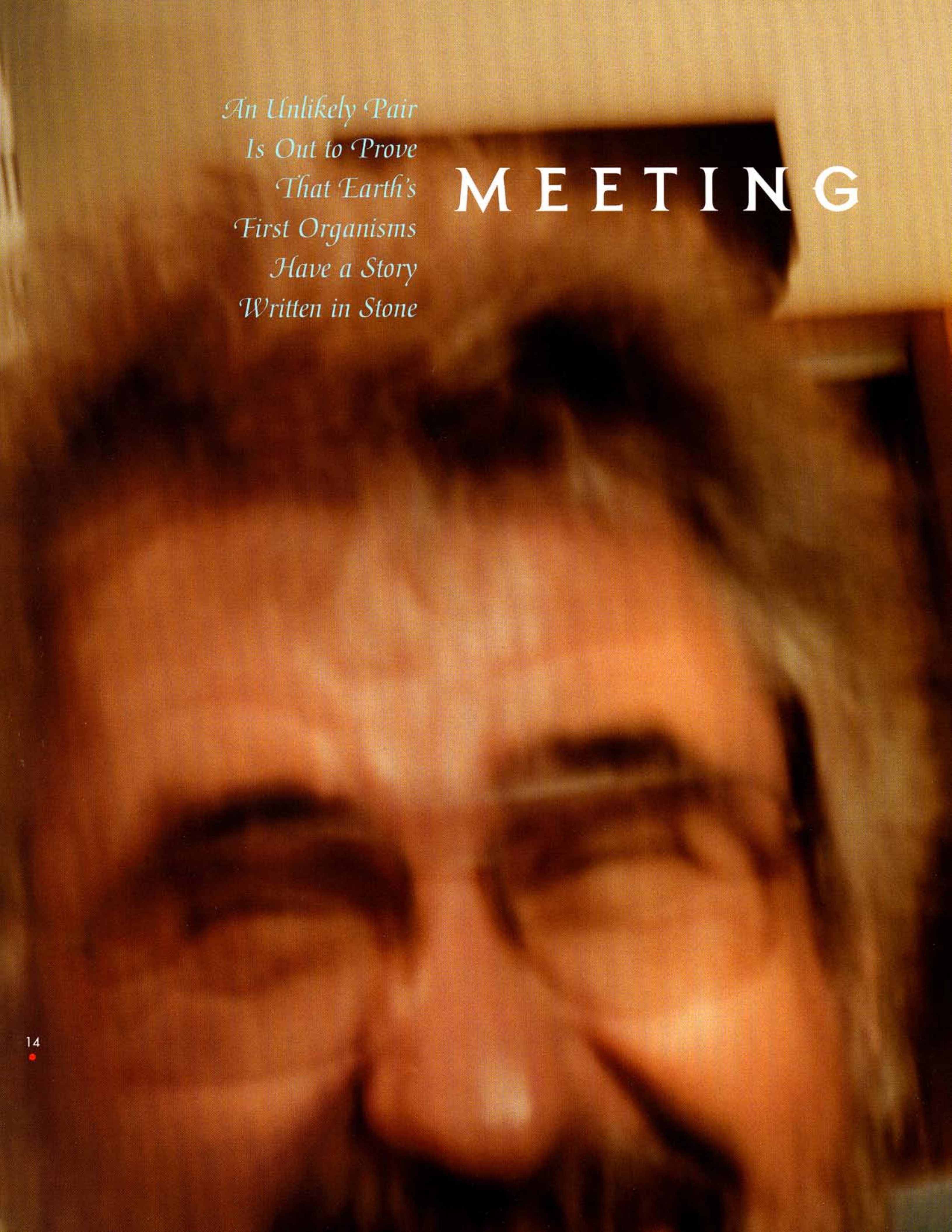


MEETING

An Unlikely Pair Is Out to Prove That Earth's First Organisms Have a Story Written in Stone

OF THE MINDS

BY ROBERT MONROE

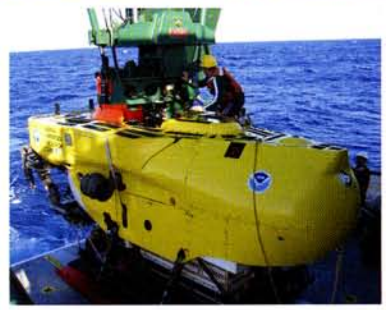
SCIENCE LOVES AN INDEPENDENT SPIRIT, though that's not necessarily a good thing.

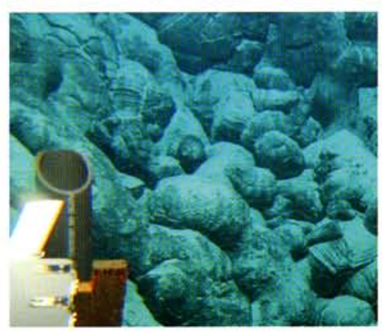
The demands of their calling require many scientists to spend big chunks of their careers working in virtual solitude or within the confines of their small research cliques. Scripps microbiologist Brad Tebo, for instance, acknowledges that he is more likely to see other researchers in his department at far-flung conferences or seminars than in the corridors of his own office building.

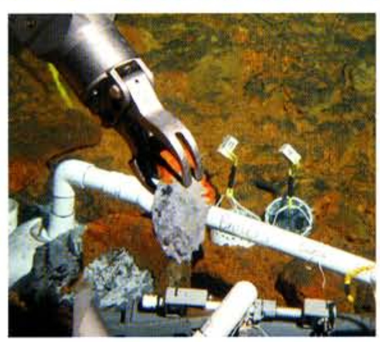
That's why his recent work with Scripps's Hubert Staudigel—a geologist of all things—makes the two a veritable odd couple of research. Staudigel has enlisted Tebo's help to verify a discovery that could provide direct evidence that life existed on Earth at least 3.5 billion years ago. Rocks dug up by Staudigel in South Africa two years ago contain microscopic boreholes that he and others believe were drilled by bacteria that lived less than a billion years after the formation of the planet.

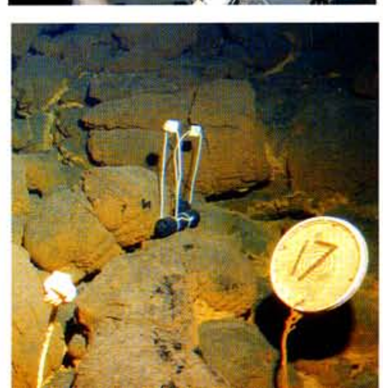
The result of the collaboration could also provide techniques for finding traces of even older life on Earth or evidence of life beyond our planet.

"These techniques provide a completely new tool for searching for life, and are independent of anything that's ever been done before," said Gustaf Arrhenius, a Scripps geochemist who has conducted his own studies of early life.









Opposite page, *Geologist Hubert Staudigel (left) and biologist Brad Tebo, with iron-oxidizing bacteria in hand, put diverse talents together to track life on Earth.* **Top,** *Traces of the life-form that started it all. Scientists believe this titanite-filled cavity found in present-day South Africa was bored by bacteria 3.5 billion years ago.* **Left, top to bottom,** *Research submersible* Pisces *and pillow basalts at the Loihi Seamount in Hawaii where similar microbial processes are taking place.*

TWO ROADS DIVERGED

Neither Tebo nor Staudigel considered origin of life research among his main interests before their collaboration began. Tebo studies bacteria that can feed on iron, manganese, and other metals. His primary research has focused on the development of bacteria as a bioremediation tool, identifying microbes that can eat toxic substances and render them benign (see "Bacteria to the Rescue," *Explorations* Spring 1998). He is interested in the genetic coding and adaptations that allow microbes to subsist on pure metals and in the mechanisms by which microbes oxidize metals, turning iron, for instance, into rust.

Throughout his 26-year career as a geologist, Staudigel has concentrated on geochemical cycling, petrology, and volcanism, considering living organisms merely one of several factors involved in the geological processes that formed the earth.

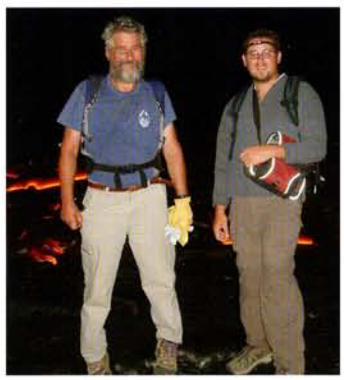
In the early 1990s, Staudigel became interested in the work of Ingunn Thorseth, a Norwegian researcher who had a novel way of explaining the degradation of volcanic glass. "People saw these funny little holes for a long time, but no one imagined that a little microbe could substantially change the pH and dissolve the rock," Staudigel said.

Thorseth was a student of Harald Furnes, a University of Bergen researcher who eventually came to Scripps. Furnes approached Staudigel about testing Thorseth's theory on some of the world's best-preserved early rock formations.

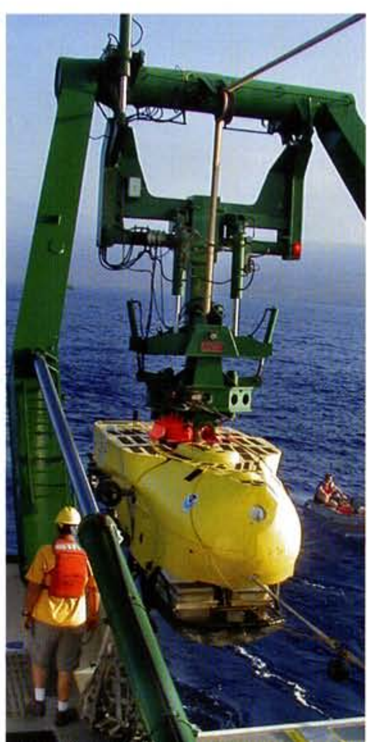
The Barberton Greenstone Belt is a field of volcanic rock located 480 kilometers (300 miles) east of Johannesburg, South Africa. Today the formation is 1,000 meters (3,300 feet) above sea level in the middle of a wildlife preserve. But 3.5 billion years ago, the rock was created by submarine lava flow, creating a rock formation that would provide shelter from the meteorite bombardments that took place during the earliest part of Earth's history.

Currently active island volcanoes like Hawaii's Mauna Loa and the emerging Loihi Seamount nearby produce similar flows. As the lava flows, a portion of the molten rock interacts with cold ocean water prior to becoming volcanic glass. The quick chill prevents the lava from crystallizing and turning into rock. Organisms and organic materials in the water that come into contact with the hot lava stick to it, and the microbes start growing, forming a glaze called "biofilm."

The Barberton lavas that time has squeezed to Earth's surface are made of this same volcanic glass. As the seawater cooled the lava, it formed tubelike structures, which eroded over time into the cross sections that give these distinctive formations their name—pillow lavas.



Far Left, *Drill holes mark the location of the South African find.* **Left, top to bottom,** *Hubert Staudigel with graduate student Brad Bailey; weathered basaltic glass bears evidence of microbial action; and the research submersible* Pisces *is deployed.*



After collecting rock samples during his 2003 expedition with Staudigel and other colleagues, Furnes took the rocks back to his lab for analysis. What he found made a convert out of Staudigel, who thought they wouldn't find anything in the rock that could withstand billions of years of assault by the elements.

Above left, *Hubert Staudigel harvests 1,250° C (2,000° F) Hawaiian lava.* **Above,** *Staudigel boards* Pisces.

"I was just blown away," Staudigel said. "Those rocks have been sitting around for billions of years—enduring the weathering of three-quarters of Earth's history. To find hair-sized etchings still there is just amazing."

There could be no doubt that however the holes got there, they got there 3.5 billion years ago. A layer of metamorphic titanite, itself dating back to that time period, had filled the cavities the way gold fills teeth, essentially sealing off the rock and making it impenetrable to future invaders.

A FRIEND IN NEED

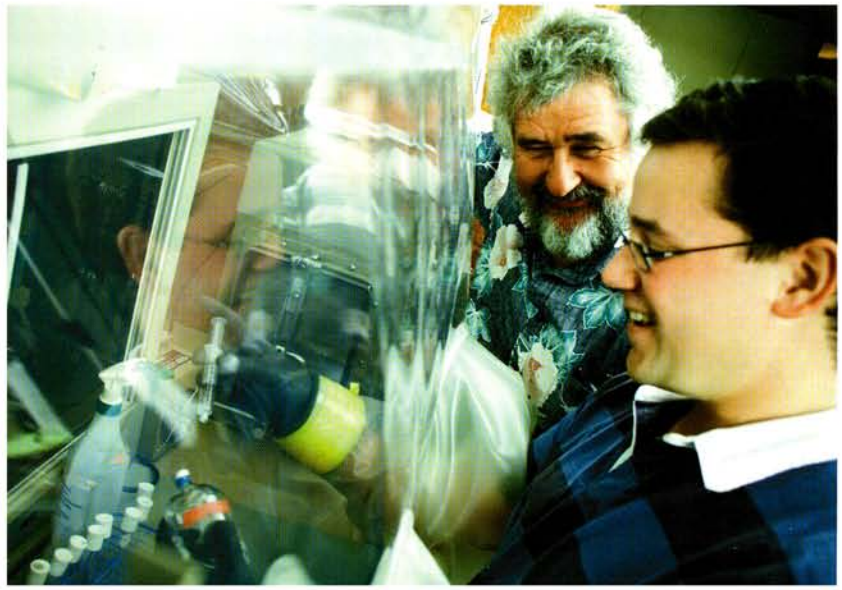
Staudigel says one would be hard-pressed to explain how the holes got there by nonbiological means. But as he is not a biologist, his ability to give an alternative explanation is limited.

He first approached Tebo in 2000, after being told that Tebo specialized in the world's most improbable organisms.

To confirm Furnes and Staudigel's find, Tebo and Staudigel are examining modern-day microbes—bacteria of the genera *Pseudoalteromonas*, *Marinobacter*, and *Sulfitobacter* among others—known to thrive on the basaltic glass. These microbes can be found in places like the Loihi Seamount, where the events of 3.5 billion years ago are currently being repeated. In 2004, Tebo and Staudigel made excursions to Loihi in the submersible *Pisces*, collecting samples of "finger chimneys," delicate structures the size and shape of hollowed-out pencils that are found in freshly cooled flows on the slopes of the undersea mountaintop. They are coated by the rust created when bacteria oxidize the iron that they contain.

Some of the work is taking place in a controlled laboratory setting at Scripps, where the team works not only with bacteria collected in the field but also with lava. To collect the lava, Staudigel had to approach 1,250° C (2,000° F) lava fields. "If you smell the burning rubber of your soles, you move," he said. The lava is then cooled, remelted, and refashioned into "designer" volcanic glass.

The researchers' goal is to watch the bacteria in action, determine how they colonize and alter volcanic glass, and observe how quickly this process occurs. They want to know whether the microbes prefer an oxygen-rich oxidizing environment or a reducing environment. What they hope to find is a particular chemical or genetic signature that is common to both recently formed and ancient volcanic glass samples. That signature could verify that bacteria existed at the time the etchings in the South African rock were made.



Top, *In a specialized chamber, Hubert Staudigel and Brad Bailey culture anaerobic organisms.* **Bottom,** *Brad Tebo and Staudigel flank student Lisa Hauck in the lab.*

IS LIFE EVEN OLDER?

Observers hope to see these same analyses performed on even older samples. Sedimentary rocks in Greenland are believed to bear traces of 3.8 billion-year-old lifeforms. The evidence is indirect, however, and is being studied even further by Arrhenius and his team. The fact that typical pillow lavas are found in the same formation and that tough titanite fills the cavities of the volcanic glass give them hope that evidence in the 3.8 billion-year-old lava rocks from Greenland might also be preserved.

The collaboration between Tebo and Staudigel officially runs through 2009, but it could take much longer for Tebo to detail the chemical mechanisms by which bacteria—now and in the distant past—can break down volcanic glass.

Hubert Staudigel and Brad Tebo view a model of the Vailulu'u Seamount in Samoa to which they will travel in June to further study glass-eating bacteria. Tebo predicts a lifetime of work ahead.

"It's not easy work. It's slow going because of the kinds of processes that we're studying," Tebo said. "It's probably going to take the rest of our lives to get a really good body of data."

Despite the long research road ahead of them, they count milestones in ways not reflected in research papers. While it was once uncommon for a biologist and a geologist to participate in such a joint venture, both say that they now see more interdisciplinary work being done at Scripps and other academic centers.

"We discovered that it takes many of us to design really good experiments," Staudigel said. "Working together, we learned we must be tolerant of each other's shortcomings and be free to throw out ideas and also to reject them if necessary."

That détente means Tebo doesn't even mind if his geologist colleague can't keep the bacteria at the center of his research straight. Well, maybe a little.

"They all look alike," Staudigel admitted in Tebo's office.

"Yeah, your kids all look alike too," Tebo retorted with a laugh.