Earth Science

When glaciers covered the entire Earth

Climate scientists get a chill when they think of an ice age blanketing the entire globe. Once totally frozen, a planet should, in theory, remain trapped in ice forever because its blinding white surface would reflect almost all incoming sunlight. Evidence from the distant past, however, suggests that Earth has somehow managed to thaw itself from global ice ages.

A team of geologists studying rocks from South Africa has discovered signs that ice reached all the way from the poles to the tropics 2.2 billion years ago, during Earth's Proterozoic era. This globe-girdling glacier was far larger than the ones in the recent geologic past, which extended only as far south as the Ohio River valley in North America and the Black Sea in Europe.

David A. Evans of the California Institute of Technology in Pasadena and his colleagues determined the extent of the ancient ice ages by studying glacial deposits in South Africa. Directly above those rocks are lava flows that erupted during the ice age or immediately thereafter. From the orientation of magnetic grains in the lava, the scientists could tell that this region sat close to the equator, at about 11° latitude, during the Proterozoic ice age. "This would be the equivalent of finding glaciers in Panama today," says Evans, whose team reported its findings in the March 20 NATURE.

The South African rocks are not the first known indications of tropical ice sheets. Geologists have discovered signs of glacial deposits even closer to the equator in rocks roughly 700 million years old. The new evidence deepens the climatic enigma, says Evans, because it shows that Earth has escaped from global ice ages at least twice. He calls these episodes "snowball Earths."

Alan J. Kaufman of Harvard University says that a lack of carbon dioxide may have pushed Earth into such deep freezes. If the atmospheric concentration of this greenhouse gas dropped, the surface temperature might have plummeted enough to permit a global ice age.

Only a truly catastrophic event could have thawed the planet from such a frosty state, he speculates. Some possibilities are a huge volcanic eruption, a comet impact, or the sudden release of frozen methane deposits in the ocean floor (SN: 11/9/96, p. 298; 3/22/97, p. 181). Such kicks to the planet would have flooded the atmosphere with heat-trapping carbon dioxide, thereby warming Earth's surface enough to end the ice ages, Kaufman hypothesizes. *—R.M.*

Searching for life in fire and ice

Leaving no stone unturned, scientists are gearing up to conduct an all-out search for life hiding in rocks, glaciers, boiling springs, and other unusual places. A number of federal programs are mounting projects in this vein, and researchers discussed their plans at a press conference in Washington, D.C., last week.

The National Science Foundation has solicited proposals for a new initiative, Life in Extreme Environments, which will fund $6 million in studies in 1998. "The goal is to gain the knowledge to provide the basis for understanding how life originated and developed on Earth and how life may thrive today or [have thrived] in the past on other planets," says Mike Purdy of NSF.

Other projects are investigating life beneath the ocean floor, specifically the 50,000-kilometer-long volcanic ridge that winds its way around the world. Recent studies have shown that volcanic eruptions from this midocean ridge release huge numbers of bacteria that apparently thrive under the ocean floor, says S. Kim Juniper of the University of Quebec in Montreal. Along with studies of life existing within continental rock (see p. 192), these marine investigations are expanding the envelope of the known biosphere. *—R.M.*

Physics

From a meeting in Kansas City, Mo., of the American Physical Society

Particle tracking and liquid flow

Measuring the rate at which a falling bead moves through a liquid can provide useful information about the liquid's thickness and flow characteristics. The tiny volume of a biological cell, however, precludes the use of such macroscopic techniques for determining the flow properties of its internal fluids.

Now, chemical engineer Thomas G. Mason and his coworkers at Johns Hopkins University in Baltimore have developed a new method for measuring viscosity and related characteristics when only a minuscule sample of liquid is available. Called "laser deflection particle tracking," the technique offers the possibility of probing on a microscopic scale liquids laced with tangles of DNA or other biomolecules.

The idea is to suspend a microscopic polystyrene sphere, less than 1 micrometer in diameter, in the liquid. Jostled by the molecules of the liquid and any other molecules present in the mixture, the sphere would follow an erratic path. By focusing a laser beam on the sphere and monitoring the deflected light, researchers can track the sphere's motion in two dimensions. From the data, they can calculate the mixture's viscosity and other flow characteristics.

Mason and his colleagues have tested the method on water containing a tangled network of polyethylene oxide chains and on a salt solution packed with DNA molecules. "We believe the technique would work in many types of environments," Mason says. "The huge advantage is the small sample volume required."

Ultimately, it may be possible to eschew the use of microspheres and track the motion of mobile particles already present inside a cell, yielding a noninvasive method of determining the flow behavior of complex cellular fluids. *—I.P.*

Cooking up carbon doughnuts

First, there were buckyballs—molecules made up of carbon atoms arranged into closed spheres. Then came buckytubes—buckyballs with elongated waists forming cylindrical carbon tubes sealed at both ends. Buckytubes, in turn, could line up side by side to form bundles, or ropes.

Daniel T. Colbert of Rice University in Houston and his coworkers have now found, amid the tangled mass of buckytubes and ropes typically produced from carbon vapor, doughnut-shaped rings of carbon atoms. Such rings apparently result when the ends of a growing nanotube meet and fuse.

Carbon doughnuts show up regularly in electron micrographs and scanning force microscope images of laser-grown carbon nanotube material. "We see these perfect circles nearly every time we look," says Rice's Richard E. Smalley. Ring diameters typically range from 300 to 500 nanometers. *—I.P.*

Probing atomic migration in thin wires

When a high electric current flows through a narrow wire connecting components of a microelectronic device, some atoms can get swept along with the current. As a result, gaps may form in areas of the wire where more atoms are carried away than brought in, causing the device to fail. In other locations, pressure can build up where atoms accumulate, eventually producing cracks in the insulating layers separating wires from other components.

Now, researchers can take advantage of intense X rays generated by a particle accelerator (SN: 3/22/97, p. 172) to measure forces caused by current-induced atomic rearrangements in microcircuit wiring. G. Slade Cargill III of Columbia University and his coworkers have used an X-ray microbeam, focused to a diameter of 10 micrometers (μm), to monitor continuously changes in the separation of atoms as current flowed for 70 hours along an aluminum wire 0.5 μm thick and 200 μm long. The experiments provide direct, real-time evidence of stress buildup during electromigration, Cargill says. *—I.P.*