Earth Sciences

Stefi Weisburd reports from San Francisco at the joint meeting of the American Geophysical Union and the American Society of Limnology and Oceanography

Forests made the world frigid?

It's easy to imagine how ice ages may have affected life as it evolved. But some scientists are beginning to suspect that, conversely, changes in the distribution and diversity of species may also have changed the climate.

James C. G. Walker at the University of Michigan in Ann Arbor and Andrew H. Knoll at Harvard University have concluded on the basis of biogeochemical modeling that one glacial episode 290 million years ago was triggered by the spread of forests onto land, as adaptations enabled plants to live and reproduce without the constant presence of water. The researchers reason that the earth cooled because the forests removed atmospheric carbon dioxide — a "greenhouse" gas that helps prevent the earth's heat from escaping to space. The plants converted the carbon to organic matter, which was then buried in sediments.

"The notion that glacial epochs could be due to changes in CO_2 is an old idea," says Walker. "Only recently have we begun to have enough information on global geochemical cycles to figure out what might cause CO_2 concentrations to change." Scientists think continental configurations influence ice ages as well. Having a lot of land near the poles, for example, might allow a buildup of glacial snow and ice.

Walker and Knoll's model indicates that the burial of carbon was also key to the onset of two other glacial epochs, one at 700 million years ago and the other at about 2 million years ago. But Walker thinks these ice ages were triggered by tectonics and not biology. Strontium isotope levels in rocks suggest that volcanic activity or seafloor spreading was enhanced during those epochs. These processes, he proposes, drew oxygen out of the oceans and atmosphere so that more organic carbon was preserved in sediments and not returned to the atmosphere by respiring organisms.

Opening doors to the core, and more

Advances in the tracking and analysis of underground earthquake waves are enabling seismologists to focus on the planet's innards as never before. Recently researchers made the first maps of the earth's core, showing that it is not a uniform, smooth body (SN: 7/5/86, p. 10).

This picture of a bumpy core is supported by a new study done at Caltech in Pasadena. Olafur Gudmundsson and his colleagues conclude that the radius of the outer core varies with latitude and longitude, so that the core-mantle boundary is made up of mountains and valleys extending as much as 10 kilometers above or below the boundary. The researchers think there are highs under eastern Australia, Central America, south central Asia, the North Atlantic Ocean and the Northeast Pacific Ocean, and lows under the Southwest Pacific Ocean, the East Indies, Europe and Mexico. They suspect that this topography is caused by the circulation patterns of the mantle.

But seismic evidence is not the only information scientists have about the inner earth. Caltech's Bradford Hager, Mary Ann Speith at the Jet Propulsion Laboratory in Pasadena and their colleagues have examined two other variables: changes in the day length and in the earth's magnetic field. Scientists have long known that the earth's rotation rate, which determines the length of day, can be sped up or slowed down by winds blowing on mountains. Similarly, "winds," or flow patterns of the earth's liquid outer core, can change the rotation rate by pushing on whatever bumps may be on the core-mantle boundary; the bigger the bump, the greater the effect.

Using the flow patterns determined by other researchers from changes in the magnetic field (which is generated by core flow), Speith's group indeed found that the topography of the core-mantle boundary could be affecting the length of day. But in order to be consistent with the length-of-day data, says Hager, the relief at the boundary must be 10 to 100 times smaller than that proposed by Gudmundsson's group.

To reconcile all three data sets, Hager prefers instead a model in which there are continent-like structures at the base of the mantle made up of a material less viscous than, and perhaps chemically different from, the overlying mantle. These structures would not extend very far into the core, satisfying the length-of-day constraints, and because they would slow down seismic waves passing through them, they could also account for variations in seismic speeds at the core-mantle boundary seen by seismologists.

Going even deeper into the core, Harvard researchers using two types of seismic data have found that seismic waves traveling parallel to the earth's rotation axis go faster than those moving in the earth's equatorial plane. "This means that the crystals inside the [solid] inner core are aligned nonrandomly, in a way that is related to the direction of rotation," says John H. Woodhouse, who works with Adam M. Dziewonski, Domenico Giardini, Xiang-Dong Li and Andrea Morelli. Perhaps as the inner core crystallizes from the liquid outer core, the crystals are mechanically aligned by the fluid flow in some preferred direction, he says. Alternatively, material could be steadily circulating in the inner core in a way that aligns the crystals.

All these studies are just scratching the surface of the inner earth. What excites many scientists is that different branches of geosciences are coming together to address some fundamental, longstanding questions about the planet, such as its structure and how the flow patterns in the core generate the magnetic field.

Washout at the GPS Shootout?

In the misty, early morning, a group in the park across from San Francisco's Civic Center huddled around two sets of strange-looking objects. The objects were radio wave antennas receiving satellite signals, and the people were scientists participating in the GPS Shootout: a competition among four companies developing receivers for the Global Positioning System (GPS). The GPS is the Department of Defense's multibillion-dollar navigation system, which for a few million dollars more will enable civilian scientists to measure distances of several kilometers to within less than a centimeter.

Because it measures distances between two ground stations by comparing the times it takes for radio signals to arrive from a satellite, the GPS is not limited, as are most other surveying and navigation methods, by the curvature of the earth. "GPS has turned the surveying world inside out," says John D. Bossler, director of the Center for Mapping at Ohio State University in Columbus. Scientists studying the movement of the plates and the deformation of the crust say GPS will be less expensive, faster and provide more information about height differences of ground stations than existing methods.

Still, there are problems to be worked out, such as getting precise locations for the satellite orbits and taking the distorting effects of atmospheric water vapor into account. At the GPS Shootout, one company's antenna was radiating at frequencies that interfered with the other systems, preventing one group from getting results. Of the remaining three, one system measured the 30.471-meter baseline across the park exactly, one was 1 millimeter off and the other missed the mark by 7 millimeters.

The researchers involved said they learned much from the experiment, although some don't think the results are conclusive. Joked Lloyd Penland of Wild Heerbrugg Instruments, Inc., in Atlanta, "We learned not to put the instruments so close together and that we should have GPS Shootouts at other times of the year [when the satellites can be contacted later in the day] so we don't have to get up so early."