Earth Sciences

Richard Monastersky reports from San Francisco at the fall meeting of the American Geophysical Union

Cracks in 3-D

For engineers constructing earthquake-resistant buildings, subsurface nuclear waste repositories and other important structures, it's important to know how and why the building materials collapse under force. Now, in an effort to better understand this process, scientists have for the first time developed and tested a method for observing microcracks in three dimensions. Previously, researchers have been able to study the fractures in rocks in only two dimensions.

Neville Cook and Ziqiong Zheng of the University of California at Berkeley added the next dimension by creating a 3-D cast of the cracks. They start by immersing a column of limestone in liquid metal, and then applying up to 10,000 pounds per square inch of force to the ends of the limestone. As the microcracks develop in the rock, the metal seeps into the crack space, and hardens in place when the rock is cooled. The researchers then cut thin sections of the column and apply acid to the surface of the section. The acid etches away the the limestone, but leaves a metal skeleton that represents the actual planes of the cracks. Through a scanning electron microscope, Cook and Zheng have taken stereo 3-D pictures of these metal crack planes and have been able to confirm several theories about crack formation.

Arguments over air in amber

Amber, the fossilized resin of trees, has long been prized for its color and sheen. But for scientists, amber may not be as valuable as recent reports have claimed. Two months ago, Robert Berner of Yale University and Gary Landis of the U. S. Geological Survey in Denver announced that bubbles of gas trapped in 80-million-year-old amber may actually be samples of air from the age of the dinosaurs (SN: 11/7/87, p. 293). But Harmon Craig and Yoshio Horibe of the Scripps Institution of Oceanography in La Jolla, Calif., now report that their own analyses of gas trapped in amber show otherwise.

According to Craig, the ratio of nitrogen to argon in the gas was not the same ratio normally found in air. Rather, this ratio was characteristic of gases dissolved in water. Craig thinks the gases were originally dissolved in the sap of the ancient trees, which is a substance different from the tree resin. When the trees were injured, says Craig, sap and resin leaked out and the gases from the sap created bubbles in the resin. This idea contradicts Berner and Landis's claim that the resin actually trapped air as it was exuded from the tree.

Berner and Landis reported that the concentrations of different gases within the bubbles enabled them to calculate that the oxygen level in the ancient atmosphere was 1½ times today's amount. But Craig says that the contents of the bubbles represent nothing other than the concentrations of gases dissolved in the sap, which are far different from their concentrations in air. Berner, however, believes that because Craig is pulverizing the area surrounding the bubbles – rather than gently crushing it, as Berner does – he is causing the release of other gases in addition to those in the amber. Hence, he says, Craig is actually analyzing a different sample of gas. In the future, the two groups hope to exchange samples in an effort to air their differences.

Fixing nitrogen: The flash-fry way

Nitrogen accounts for roughly 78 percent of the air that we breathe. But this nitrogen is useless to the living cells of almost all plants and animals, which rely on a select group of organisms – most notably blue-green algae and the bacteria on the roots of alfalfa and peanuts – that can "fix" nitrogen, or combine it with other elements into a biologically useful form. Traditionally, atmospheric scientists have thought that these organisms were the major source of fixed nitrogen (other significant sources include industrially produced fertilizers and auto pollution). But one group of researchers has found that lightning may be doing as much as half of the job.

As the strokes of electrical energy jump from cloud to ground and cloud to cloud, they ionize the air, producing nitrogen oxide (NO) in the process. Then ozone (O_3) reacts with the NO, generating NO_2 and molecular oxygen. Previous studies had estimated that these reactions accounted for around 3 percent of the fixed nitrogen in the atmosphere, says Edward Franzblau of the New Mexico Institute of Mining and Technology in Socorro.

However, he and his colleagues measured the nitrogen compounds produced by lightning and found that each lightning flash fixed more nitrogen than had been previously predicted. And by multiplying the molecules fixed per flash by the average number of lightning flashes on earth – approximately 100 per second – they calculated that lightning produces about half the store of fixed atmospheric nitrogen.

The measurements are difficult and even dangerous. On one occasion, Franzblau had to grab his instrument and run for cover when a storm veered toward his mountaintop position. Because these measurements are unconfirmed and contradict airborne measurements of nitrogen compounds produced by lightning, some scientists question the new conclusions. But others believe the findings warrant attention. If they are confirmed, says Ralph Cicerone of the National Center for Atmospheric Research in Boulder, Colo., "it's going to force us to take a much more realistic look at lightning."

Catching subduction in the act

As the Pacific plate inches northwest, its leading edge dives into the mantle of the earth, forming some of the deepest trenches in all of the world's oceans. This recycling process, called subduction, has been going on for tens of millions of years at these sites. Now, in another part of the Pacific, some earth scientists think they are beginning to see the earliest stages in the birth of a subduction zone that will eventually form a trench to the north and west of New Guinea.

Researchers from the University of Hawaii first proposed this idea two years ago when they noticed that a supposedly quiet area of the Pacific was actually experiencing major earthquakes (SN: 1/11/86,p.25). The earthquakes seemed to be clustered in a line that ran through Micronesia, and they were originating at shallow depths in the crust. These observations led the Hawaii scientists to postulate that this band of earthquakes was signaling the initial stages of subduction.

The bathymetry of the area is not detailed enough to tell if there is, in fact, a trench along this line. But other researchers from Hawaii, the University of South Carolina at Columbia and the Air Force Geophysical Lab in Hanscom, Mass., have recently used satellite data to look at the gravity near small sections of the proposed subduction zone. They found that over the proposed trench, gravity was lower than normal, which is the expected reading over a trench. They also detected a bulge in the ocean surface to the south of the proposed trench, meaning that there is some excess matter beneath the bulge attracting the water to that spot. Since there are no underwater mountains in that area, this excess mass must be below the oceanic crust and could be the edge of a slab of crust that is beginning to be thrust down into the earth.

While such findings are consistent with the existence of the proposed subduction zone, scientists have examined only a tiny portion of the zone. Still, they have some time to do further work on this area. If subduction is really starting, scientists believe it will be 5 million to 10 million years before this process really gets going.