# Earth Sciences

## Pollen provides ancient weather report

For allergy sufferers, pollen seems to exist for the sole purpose of making people miserable. But palynologists, who study pollen and spores, say the plant grains are nothing to sneeze at. Since pollen can survive in sediments and rock for thousands and even millions of years, it gives scientists a portrait of the plants that once covered an area. At the forefront of pollen science, a new study shows these tiny reproductive elements can provide a detailed record of climate fluctuations during the last Ice Age cycle.

Researchers from the Laboratory of Historical Botany and Palynology in Marseilles, France, report in the March 23 NATURE that they have compiled a 140,000-year-long climate history for eastern France based on pollen records for that region. They collected the fossil pollen from sediments that have built up over the last 140,000 years in a lake and a swamp.

The scientists created the climate history through a complex translation process involving several stages and mathematical techniques. First they gathered modern pollen samples from a variety of locales in Europe, North Africa and Siberia. Then, based on the different kinds of vegetation found in each sample, they defined a mathematical relationship between the pollen and the climate conditions for that particular area. Finally they matched the fossil pollen samples against the most similar modern ones. This process gives a continuous measure of temperature and precipitation conditions reaching back in time through the last Ice Age and into the previous interglacial period, which occurred roughly 130,000 to 115,000 years ago.

This type of record will aid researchers trying to understand why Earth has swung back and forth between cold and warm periods over the last several hundred thousand years. In the past, investigators have relied mainly on long climate records from deep-sea sediments and more recently from cores of the Antarctic and Greenland ice caps. The continents have provided far less long-term information.

Vera Markgraf, a palynologist from the Institute of Arctic and Alpine Research of the University of Colorado in Boulder, says the French study is important because "it shows that there are other records besides the deep-sea record that can help us understand how the clime has changed."

Palynologists have drawn climate information from pollen for a long time, but this is one of the most detailed continuous records ever made. Still, Markgraf and others caution that the methods used in the new study are so complex they could be problematic. "It becomes acrobatics and a little bit dubious after a while," she says, "because you're going through too many steps."

## Dinosaur tragedy yields birth clues

Picture a pregnant dinosaur, tramping through the marshes of Utah during the late Jurassic period about 150 million years ago. Although long overdue, the animal cannot lay one its eggs, perhaps because it is sick or some predator has disturbed it. Whatever the reason, the mother dinosaur is forced to hold the egg in its oviduct for an abnormally long time, causing a suffocating second shell to develop around the egg.

While the enclosed baby dinosaur never reached the land of the living, the egg itself survived the eons in the form of a fossil. Paleontologists who recently discovered this misformed egg are using it to glean clues about dinosaurs' reproductive systems, they report in the March 31 SCIENCE.

Found in 1987, the egg comes from the Cleveland-Lloyd Dinosaur Quarry in Utah, a site that has yielded thousands of dinosaur bones. It is split in two pieces connected by a thin folded area of shell, says Karl F. Hirsch from the University of Colorado Museum in Boulder, James H. Madsen Jr. from Salt Lake City and Kenneth L. Stadtman and Wade E. Miller from Brigham Young University in Provo, Utah.

Since bones survive as fossils more often than do soft body parts, paleontologists know quite a lot about dinosaur skeletons and relatively little about dinosaur organs and tissues. Yet the unusual double-shelled egg can offer information about processes at work in the oviducts of these animals, says Hirsch.

## Wherefore the world's wobble?

A triumphant team of explorers reaches the precise South Pole (the rotational pole) and plants a flag into the ice. Seven months later, a second group arrives at the pole and sets its own flag. Will the two banners touch?

No. Because of a puzzling phenomenon called the Chandler wobble, they will probably sit about 10 meters apart. A study using supercomputer simulations is now raising some tantalizing ideas about the force that powers this wobble.

The term Chandler wobble refers to Earth's motion around its axis of rotation. If this axis were visible, a person standing near the South Pole would observe that the pole actually moves around, forming a spiral-like pattern with a period of 14.2 months. Among other things, this motion means that a city's latitude is always changing ever so slightly with respect to the axis of rotation.

Scientists say they can explain at least one aspect of the Chandler wobble. Mathematicians have proposed for centuries that because of Earth's squashed shape, the planet naturally tends to wobble. But friction from both the oceans and the elastic inner earth should grind this motion to a halt relatively quickly. The real problem, say scientists, is identifying the force behind the wobble.

The usual lineup of suspects includes earthquakes, motion in the fluid outer core of the planet and some sort of source in the atmosphere. While previous research has shown that the atmosphere could produce a small part of the wobble, Sultan Hameed and Robert G. Currie from the State University of New York at Stony Brook suggest in the March GEOPHYSICAL RESEARCH LETTERS that the atmosphere plays the dominant role in powering the motion. As evidence, they present the results of a supercomputer experiment with a global climate model. This climate program uses laws of atmospheric physics to simulate the behavior of global air temperatures, pressures and other variables.

While examining the changes in simulated air pressure over 23 years, Hameed and Currie detected a cycle with a period of 14.7 months, which is very close to the period of the Chandler wobble. According to the researchers, the cycle is significant because the climate model simulates only the atmosphere and oceans. The equations in the model include no mention of any activity in the solid earth. "It follows that neither earthquakes nor the motions of the core fluid are needed to explain the [Chandler] wobble of the solid earth; instead it appears it is produced by atmospheric excitation," the researchers say. This means the atmosphere might drive the wobble by sloshing back and forth across the globe.

Other scientists, however, remain unconvinced. Meteorologist Richard Rosen from Atmospheric and Environmental Research Inc., in Cambridge, Mass., calls the results interesting but says the cause of the 14-month-cycle in the model remains mysterious. He wonders whether the cycle, if it exists in nature, has enough power to drive the wobble.

Thomas A. Herring of the Harvard-Smithsonian Center for Astrophysics, also in Cambridge, says an interesting test on the Chandler wobble will come during the next earthquake above magnitude 8 or so. Measuring techniques may be accurate enough now to resolve whether a quake can affect the wobble, he says.