Fragile Forests Implied by Pleistocene Pollen

Biologists who seek signs of the American tropical forests of the Pleistocene usually find arid savannahs instead

Recent analysis of pollen profiles in sediment cores taken from two lakes in northern Guatemala provide the first convincing data on vegetation change—and therefore climate change—from Central America at the Pleistocene/Holocene transition, 10,000 years ago. These data, reported by Barbara Leyden of the University of Florida, Gainesville, indicate that where today there stands a lush, tropical forest, in the late Pleistocene was a cool and arid scrub savannah landscape (*1*). This conclusion is important not only in terms of enlarging the climatic history of the American neotropics but also in sharpening the appreciation of tropical forests as dynamic, unstable and short-lived entities.

Climatological ideas about the tropics and neotropics during the Pleistocene glacial periods has undergone a revolution in the past decade or so. Instead of experiencing moister conditions while the rest of the globe froze during glacial advances, landmasses near the equator were for the most part cool and dry. This, at least, seemed to be the clear message coming from analysis of oxygen isotope and planktonic data in deep sea cores, specifically those of the CLIMAP project (*2*).

More direct data, such as pollen profiles from continental sediments have however, been slower in coming, particularly from tropical America. "The acid test of the climatic predictions is the paleobotanical data," comments Alan Graham of Kent State University. "So far there have been very few sites available to give an answer." Paul Colinvaux of Ohio State University comments, "The postulate of an arid Pleistocene in South and Central America is widely accepted but little tested from a paleobotanical point of view."

The information from Leyden's laboratory joins just a handful of data points from other regions of the American neotropics, such as Lake Valencia in Venezuela (*3*), that essentially confirm the picture derived from the deep sea cores.

Although the entrapment of pollen in lake sediments inevitably reflects local vegetation cover to some extent, careful analysis can distill quite general information. The more usual problem for paleobotanists is finding a lake that has experienced unbroken accumulation of sediments, particularly across dramatic climatic transitions, which are likely to disrupt continuity.

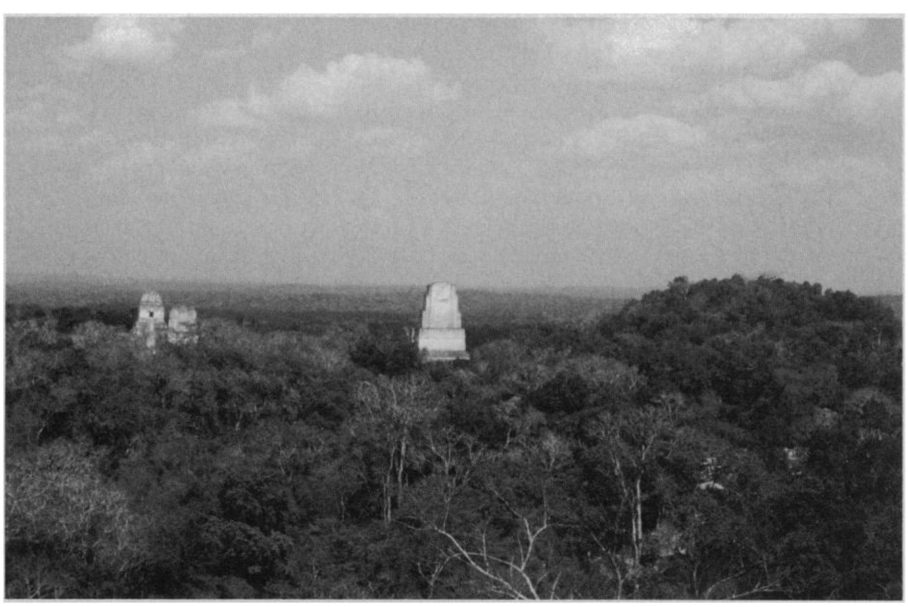
Edward Deevey, also of the University of Florida, has had a long interest in climatic history of Central America, not least because of the rich record of Mayan occupation there. He describes the Guatemala lowlands as a poor bet for finding lake deposits that record the vegetational changes at the end of the last glaciation. "It is flat lying limestone terrain, honeycombed by solution caverns, disappearing rivers, and sinkholes. It is so porous hydrologically that, when sea levels fall, as they do with glacial advances, the water table drops and the lakes disappear." Nevertheless, he found two, Lakes Quexil and Salpeten, in the Department of Peten, which yielded the cores that Leyden has been working with.

The pollen data indicate that around 11,000 years ago, before the ice age came to a rapid end, the Salpeten Basin was covered by amaranths and composites, which imply a marsh environment. Lake Quexil, just 20 km to the southwest, had more persistent standing water, with pondweeds and sedges present. Although there is evidence of juniper scrub in the area, which today grows only at high, cool elevations, there is no sign of the lush, moisture-loving, semievergreen seasonal forest that now carpets the lowlands. The Peten during the late Pleistocene was apparently only thinly vegetated in the lowlands and received considerably less rainfall than today.

The transition from the open countryside of the last glaciation to the rich diversity of today's tropical forest was initially through a brief vegetational period of pine, oak and temperate hardwoods, such as elm, which implies cooler, wetter conditions than prevail today.

The speed with which the highly diverse and age-old looking modern forest has established itself since the ice retreated is impressive enough. Locally, this is even more so, because between 3000 years ago and the sixteenth century, the Mayan people leveled large areas of the forest.

In the larger context of ecological theory, Leyden notes that the Peten has been considered by some to have been a Pleistocene forest refuge. This designation relates to an idea first proposed in the late 1960's, which held that moist tropical forests shrank during cooler glacial times of the Pleistocene and persisted in protected localities—refugia—where the climate remained congenial (*4*). With the return of warmer climes, the forest would spread out of its restricted refuges and reestablish continuous cover.



Young lush tropical forest

Inspite of having been leveled by the Maya until just a few centuries ago, the forest of northern Guatemala has returned with thick, luxuriant growth, giving the look of ages.

The problem with this attractive notion is that, with the possible exception of one site in Brazil, every paleobotanical test of putative refugia in tropical America has shown the forest to be absent in the late Pleistocene. A leading theorist on forest refugia, Ghillean Prance of the New York Botanical Garden, says that with pressure from data such as Leyden's and "more time to think about the problem" the basic ideas are changing. "During the past few years there has been a shift to thinking about a repeated resynthesis of the tropical forests from their various components, which were scattered during glacial periods" (*5*).

This repeated reassembly, as opposed to repeated regrowth of pristine communities, forces one to view the tropical forest as less of a cohesive, natural unit than previous theory implied. Drawing on her work on temperate forests of North America, Margaret Davis of the University of Minnesota suggests that the forests formed during each interglacial might be quite distinct, depending on how different component species responded to the glaciation and how migration routes developed as the temperature rose. Graham's work in the mid-1970's on vegetation shifts of the Mexican lowlands throughout the Pleistocene forced him to view tropical forests as dynamic and ephemeral rather than stable and ancient. Others are following his lead. "There has been a complete turn around of opinion among ecologists, and data such as those from the Peten lake cores are helping it on its way."

The tremendous diversity of both plant and animal species of tropical forests has long dazzled inquiring naturalists. Pondering on the origin of this diversity, ecologists have doubtless been impressed by the apparent agelessness of the forests, and so diversity came to be associated with environmental stability. The emerging realization that tropical forests are mere biological youths, constantly suffering dynamic turnover, is helping to overthrow this intuitively appealing equation. High diversity through instability, not stability, is how the equation now reads, which brings the forests in line with other avenues of biological inference (*6*).—**Roger Lewin**

References

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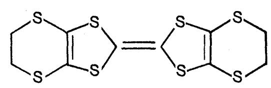
New Organic Superconductor

The first sulfur-based organic compound that is a superconductor at ambient pressure has recently been reported by two research groups, I. F. Shchegelov and his colleagues at the Institute of Chemical Physics in Moscow and Jack Williams and his associates at Argonne National Laboratory.* The compound, a triiodide salt of bis(ethylenedithiolo)tetrathiafulvalene or BEDT-TTF, is the first of a new family of compounds, one of which



is superconducting at a temperature three times higher than any previous ambient-pressure, organic superconductor.

The search for ambient-pressure superconductors that operate at readily achievable temperatures has been frustrating. When the so-called critical temperature apparently hit a plateau at 23.2 K for metal-based superconductors in 1973 (with Nb_3Ge) attention switched to organic compounds. The first candidates here were based on a selenium compound, tetramethyltetraselenafulvalene or TMTSF. For the most part, salts of TMTSF require high pressures, on the order of 10,000 atmospheres, to be superconducting. One derivative that did not, $(TMTSF)_2ClO_4$, has a very low critical temperature, 1.3 K.

Researchers feared for some time that these TMTSF materials, known as Bechgaard salts, might turn out to be the only superconducting organics. That fear was allayed last year when a team at IBM San Jose Research Laboratory reported superconductivity in a perrhenate salt of BEDT-TTF (*Science*, 11 November 1983, p. 606). Unfortunately, this compound, $(BEDT\text{-}TTF)_4(ReO_4)_2$, is superconducting only under 4000 atmospheres and has a critical temperature of 2 K.

Williams developed the most recent BEDT-TTF-based superconductors following a theoretical consideration of the molecular structure required for superconductivity. The organic molecules in superconducting salts stack one over the other like pancakes: electrons can thus pass between adjacent π-electron systems while counterions occupy the spaces between the stacks. Based on x-ray crystallography studies, the Argonne group had suggested that the selenium-selenium (or sulfur-sulfur) distance between the stacks is the major factor in determining whether material will be superconducting. He inferred that high pressures compress the stacks to the appropriate distance and angles. He then calculated that small counterions should combine with BEDT-TTF to produce the correct interstack distance and angles for superconductivity.

Williams's prediction turned out to be correct, but he was beaten to press by the Soviet group. Shchegelov and his colleagues reported that $(BEDT\text{-}TTF)_2I_3$ superconducts at ambient pressure with a critical temperature of about 1.4 to 1.5 K, and the Argonne group confirmed this. Both groups also found that the salt occurs in several different crystal structures, only one of which is superconducting.

More recently the Argonne group has gone on to develop a family of salts with the general formula $(BEDT\text{-}TTF)_xI_yBr_z$, which are superconducting at ambient pressure. The precise identities of these materials remain to be established, but one of them, probably $(BEDT\text{-}TTF)_2IBr_2$, has been shown to have a critical temperature of 4.2 K. This is the highest critical temperature recorded so far for any organic superconductor. Encouraging though it is, there is still some way to go before the apparent critical temperature plateau of metallic superconductors is reached.

—**Thomas H. Maugh II**

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