Tibet Reveals Its Squishy Underbelly

Known as the Roof of the World, the vast Tibetan plateau soars so high above the steppes of Asia that for much of history it repelled many would-be invaders. Yet this lofty fortress rests on something quite insubstantial, according to new research.

An international team of investigators has discovered a layer of partially molten rock hiding beneath Tibet—an arrangement that makes the plateau the geologic equivalent of a jelly sandwich.

Geoscientists are seeking to understand Tibet and its flanking mountain ranges because these features represent the best available lesson on what happens when one continental plate rams into another, an event that has recurred countless times in Earth's past (SN: 7/14/90, p. 24).

"Continental collisions play a very big part in shaping the continental crust, and the collision between India and Asia is *the* example of this process going on today," says K. Douglas Nelson, a geologist at Syracuse (N.Y.) University and a participant in a large-scale collaboration between U.S., Chinese, German, and Canadian researchers.

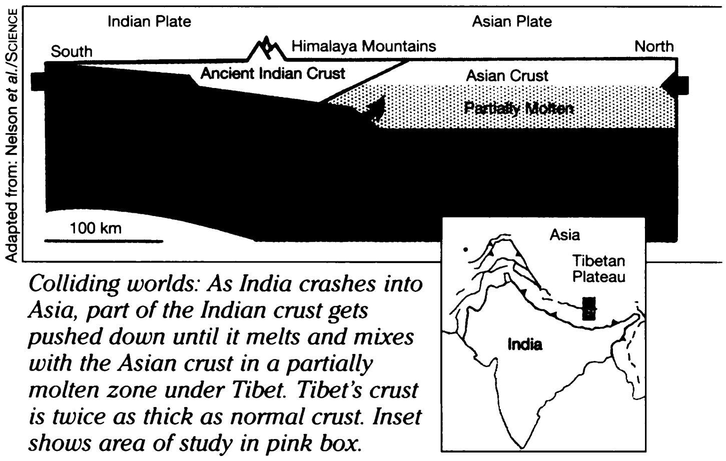
Members of the project, called INDEPTH, report their findings in five separate reports in the Dec. 6 SCIENCE.

The multinational team spent three summers probing deep beneath the surface of south-central Tibet using a variety of geophysical techniques. Small explosions set off in boreholes sent out volleys of seismic waves that reflected off buried structures in the crust and underlying mantle. Measurements of magnetic and electric fields at the surface provided insights into the electric properties of buried rocks. By timing the speed of vibrations arriving from distant earthquakes, scientists gauged the stiffness of rock beneath the plateau.

All of the geophysical data point to the existence in the crust of a liquid-rich zone that extends from about 15 kilometers below the surface to an unknown depth, says Nelson. The INDEPTH scientists surmise that the liquid is partially molten rock in a layer underlying much of the Tibetan plateau.

If these conclusions are correct, they would help resolve a major debate about what is happening to the crust of India as it slams into Asia. Some scientists hold that the Indian plate, including its crust and mantle, is sliding beneath the Asian plate. Others have proposed that the two plates are meeting like cars in a head-on crash, with both getting squashed in the process. The new results suggest, however, that the collision is creating a melting pot where the lines between India and Asia blur.

"You don't have an identifiable Indian crust or Asian crust beneath Tibet. It's all been mixed together. This is a new paradigm for a continent-continent collision," says INDEPTH participant Alan G. Jones of the Geological Survey of Canada in Ottawa.



Colliding worlds: As India crashes into Asia, part of the Indian crust gets pushed down until it melts and mixes with the Asian crust in a partially molten zone under Tibet. Tibet's crust is twice as thick as normal crust. Inset shows area of study in pink box.

The partially molten layer formed, the scientists believe, during the last 40 million years as the viselike continental collision squeezed the Indian and Asian plates from the north and south. The mangled crust at the meeting point spread vertically into a plateau and went downward, where it grew warm enough to melt. This molten rock then migrated up to form a layer of liquid-rich rock in the upper crust.

The INDEPTH study represents an important achievement because "it's the first systematic view of what the Tibetan crust looks like," says B. Clark Burchfiel of the Massachusetts Institute of Technology. Yet the conclusions drawn from the study remain controversial because INDEPTH scientists investigated only a small part of the southern plateau and cannot tell how far the partially molten layer extends.

Nelson, Jones, and their colleagues plan to return to Tibet next summer to examine the crust farther north. If the mushy zone does underlie much of the Tibetan plateau, it would help solve a number of puzzles about the region. In particular, geologists have wondered why a plateau ringed by mountains is so flat. A soft underlying layer could not support any large mountains, thus explaining the lack of relief, says Nelson.

Lessons learned from Tibet can provide insights into much earlier continental collisions, such as the one 300 million years ago between North America and Africa, which constructed the Appalachian Mountains. — *R. Monastersky*

Pollution helps weeds take over prairies

Acid rain and agricultural pollution both spew nitrogen into the air. Though plants need nitrogen to grow, a new study finds that even small additions of this fertilizing pollutant can perturb the landscape.

In plots of Minnesota prairie to which ecologists applied nitrogen for 12 years, native grasses showed a dramatically impaired ability to compete against weeds that had immigrated from Europe centuries ago.

The nitrogen treatment triggered the terrestrial equivalent of eutrophication—algal blooms that result when aquatic systems are overfed, argues David A. Wedin of the University of Toronto. Just as unchecked algal growth can choke out native aquatic species, so overfertilized weeds began choking out native tallgrass prairie plants.

Like trees and shrubs, the interloping weeds belong to a class of plants, known as C3, that employs a slightly different scheme for using carbon dioxide than the native C4 prairie grasses. Overall, C3

Adding nitrogen to prairie remnants (like those in the foreground, left) fostered the invasion of quack grass, a European weed, and its rise to dominance (right).

plants dominate in North America.

Parsimonious in their use of nitrogen, prairie grasses can thrive where access to this nutrient is limited, Wedin observes. Adding this nutrient gave the C3 weeds—nitrogen hogs by nature—the toehold they needed to begin invading prairie plots, he and David Tilman of the University of Minnesota in St. Paul report in the Dec. 6 SCIENCE.

As the weedy immigrants died, their considerable nitrogen stores spurred the growth of nitrogen-starved soil microbes that break down plant matter. These microbes, in turn, rapidly released much of the weeds' building blocks into the environment, permitting nitrogen to run off as water pollution and carbon to reenter the air.

The naturally slow decomposition of prairie plants, in contrast, ensures that most of their constituents become stored in the earth. Indeed, this is how prairies built the U.S. farm belt's rich soils.

The rapid decomposition of weeds should dampen the spirits of energy policy analysts, says plant ecologist Ernst-Detlef Schulze of Bayreuth University in Germany. These "technocrats" had argued that by spurring plant growth, the nitrogen in acid rain would help industrialized nations sop up more of the carbon that their fossil-fuel burning is emitting as carbon dioxide, he says. Such carbon releases threaten to trigger a global warming.

The new study now shows the fallacy in that reasoning, Schulze says.

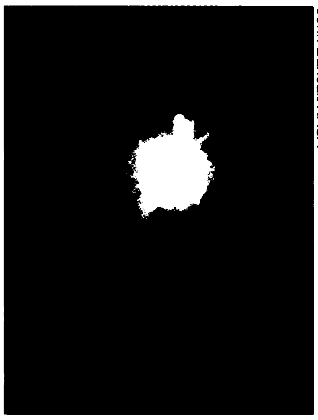
He notes that the loss of prairie species provoked by adding nitrogen "in many cases caused carbon storage to be more than halved."

Adds Tim Seastedt of the University of Colorado at Boulder, "this is a beautiful example of an ecosystem feedback," where pollution can "induce changes in species composition that alter the ecosystem to guarantee the new species will persist." Globally, however, other human activities may compensate for these changes, Seastedt notes. For instance, some Mexican C3 shrub lands are now being converted to C4 grasslands.

— J. Raloff

Radio search finds few distant quasars

They lie far away and can reveal what the universe looked like long ago, yet the stars of distant galaxies are often too faint to be seen. In contrast, quasars, the brilliant searchlights that reside at the heart of some galaxies, stand out prominently. So for several decades, astronomers have sought to map the distribution of galaxies by tracking distant quasars.



John Bahcall/NASA

Visible-light image of a nearby, radio-wave-emitting quasar.

As astronomers have used quasars to probe further back in time, they have found that these powerhouses are increasingly scarce beyond a certain distance, referred to as a redshift of 3. This distance corresponds to a time when the universe was about one-fourth its current age and may mark a significant epoch in galaxy formation or development, many astronomers speculate.

Other researchers find that reasoning flawed. Visible light emitted even by the brightest quasars, if they are extremely remote, can be quenched by dust lying between those bright bodies and Earth. These researchers argue that a large, unseen population of distant quasars may exist behind intergalactic dust.

Now, Peter A. Shaver of the European Southern Observatory in Garching, Germany, and his international team of colleagues say they have closed that loophole. By observing quasars at radio wavelengths, a part of the electromagnetic spectrum unaffected by dust, they have confirmed previous findings that the number of quasars starts dwindling beyond a redshift of 3.

In particular, although they identified 25 radio-emitting quasars corresponding to the time when the universe was about 20 percent of its current age, they found none representing the period when the universe was half as old.

Fewer than 10 percent of all known quasars are strong radio emitters, but Shaver believes they may be representative of the total quasar population. He and his colleagues report the results of their 4-year study in the Dec. 5 NATURE.

"It seems that the decline is real, and we are seeing the epoch when quasar activity began," comments Patrick S. Osmer of Ohio State University in Columbus.

The significance of the finding is still open to interpretation, notes Shaver. The era when quasars first began forming may indicate the time when most galaxies began making stars and had concentrated enough matter at their cores to produce quasars. However, if quasars are primarily the product of galactic collisions (SN: 11/23/96, p. 326), then their debut may signal the onset of a later stage of cosmic evolution, when fully formed galaxies began to gather into clusters and merge.

— R. Cowen

Smallest frog leaps into the limelight

While hunting for a rare woodpecker in the Cuban rain forest, a team of biologists halted to listen to an unfamiliar chirping coming from the forest floor. Although their avian quarry eluded them, they returned with a member of what they now report is the smallest frog species in the Northern Hemisphere. Shown here at 3.5 times life size, the frog rests on a Cuban coin the size of a U.S. nickel.

"We got down on our hands and knees to find them," says S. Blair Hedges of Pennsylvania State University in State College. Hedges credits his colleague Alberto R. Estrada of the Institute of Forest Investigations in Havana with finding the first of the new species, which they informally call the eleuth frog after its genus, **Eleutherodactylus.** *The scientists will give the species a formal Latin name in an upcoming issue of* COPEIA.

"This frog is probably at the limit of how small they can get," says Hedges. Less than 10 millimeters long, it shares the title of world's smallest frog with a distantly related Brazilian cousin.

The eleuth frog shows many traits typical of miniaturized species, says James Hanken of the University of Colorado at Boulder. For example, it produces only one egg at a time. Moreover, it lays its eggs out of the water and they hatch into developed frogs instead of tadpoles. "This allows tiny species to avoid predation in ponds and streams as larvae," he says.

Hedges plans to return to Cuba this summer. The island sports many other tiny species, including a bee hummingbird, the smallest bird.

— D. Vergano

M. Lammertink/COPEIA