Modeling India's drive into Eurasia

If you lay a sheet of paper on a flat surface, place your index finger perpendicular to the lower left hand edge and exert a gentle, steady upward motion, the paper rotates slowly to the right. In a grossly simplified way, this exercise duplicates an experiment that some researchers suggest explains the movement of land masses in eastern Asia in response to the advance of India.

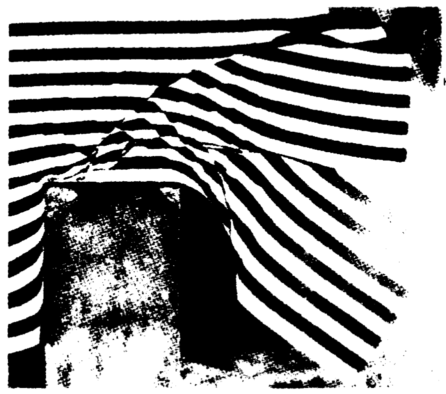
The model, presented at the recent meeting of the American Geophysical Union, is one attempt to answer one of the great questions in earth science. Forty or 50 million years ago, India collided with Asia and is still moving at a rate of about 5 centimeters per year. Some effects of this impact, such as the buckling of the Himalayan mountains, are apparent. But the formation of other features — the world's longest faults and the huge elevated zone known as the Tibetan Plateau —must somehow be related to the inexorable motion of the Indian plate. How?

Paul Tapponnier, Gilles Peltzer and colleagues at the Institute of Earth Physics in Paris performed simple experiments in which an unbending indentor penetrates into a layered sheet of more deformable plasticine (see photo). The results are an analogy of what happens in Asia in response to pressure from the unbending indentor, India.

When the experiment is performed with unmovable boundaries on the east and west, a symmetrical pattern of alternate faults occurs on the right and left sides as the indentor advances. However, when the east has a free margin — analogous to the subduction zone that trends along the China coast — faults form assymetrically in the plasticine, and propagate to the boundary. As the indentor moves north, the fault migrates further into the plasticine, and a nearly rigid block of the material moves along the fault, rotating about 25 degrees. Eventually another fault develops, and another block of plasticine, now north of the indentor, begins to rotate, pushing the first block until it has rotated about 40 degrees from its starting point.

The model results bear a striking similarity to major features apparent in Asia today. The researchers suggest that in the first 20 to 30 million years of the collision, Indochina rotated to the southeast along the Red River fault. As Indochina turned, the crust split, opening the South China Sea. When India overtook the Red River fault, the Altyn Tagh fault began to form and South China began its slow move "hundreds of kilometers" to the east and the Andaman Sea began to open.

"I think we can model the entire collision with this simple idea," says Tapponnier. If India keeps going, he says, a third major fault will propagate toward the Sea of Okhotsk, "connecting faults in the Tien Shan, Mongolia and Baikal." As it forms, another block of east Asia will begin its clockwise rotation, pushing South China out of the way.



Tapponnier

When a rigid indentor (India) pushes into deformable plasticine (Asia), faults form analagous to major faults in Asia. As the indentor pushes north, it displaces a slab (South China, top right), which rotates along fault lines and pushes another slab (Indochina, lower right).

The hypothesis is appealing and, in Tapponnier's word, "bold." The researchers suggest that "faulting may be the dominant mode of deformation of the continental lithosphere," and that rifts and ocean basins may form as "purely collisional effects" without driving action by mantle material immediately underneath — another proposed driving force for movement of continents. One way to test the model is to study paleomagnetism in South China and Indochina to learn where the blocks of Asia were at given times.

At the meeting, other geophysicists expressed both intense interest in the model's results, and also some reservations. One drawback of the research, which grew out of a cooperative project between France and China, is that it considers only horizontal movement and does not address the reasons for the high crustal elevations in Asia. The Tibetan Plateau, for instance, covers about two million square kilometers and is nearly five kilometers above sea level.

While the Himalayas, at altitudes as high as eight kilometers, probably have been thrust up as the Indian Plate drives beneath Eurasia, the Tibetan Plateau probably has been "squeezed up like an accordion," says Harvard's Greg Houseman. Using numerical calculations, he and Philip England, also of Harvard, allowed the crust to thicken as a rigid indentor advanced. "When we push that into the middle of the thin layer, what you see is a plateau of crustal thickness about twice its normal size," he says. The model showed a more gentle slope in crustal thickness to the north, while real topography reveals a rapid drop in elevation between the Tibetan Plateau and northwest China.

Houseman says he questions the use of layers in the plasticine model. He believes the easy separation of the blocks along the layers is an "artifact of the system" and would like to see what would happen in a uniform plasticine slab. He believes the region does not deform primarily by faulting. Instead, he says, the faults represent the "deformation of a thick crustal layer that is moving in response to what is happening underneath in a more viscous layer" at depths from 30 to 100 kilometers.

— C. Simon

Hypersuperduper galaxy cluster

How big can an astronomical system be? Two astronomers, Riccardo Giovanelli of the Arecibo Ionospheric Observatory in Puerto Rico and Martha P. Haynes of the National Radio Astronomy Observatory in Green Bank, W.Va., suggest that there exists a huge supercluster of galaxies that stretches across the sky from horizon to horizon. They propose that two previously known superclusters, the Lynx-Ursa Major distribution and Pisces-Perseus one, are joined to each other by a string of galaxies running across the so-called zone of avoidance, the part of the sky where visible light is obscured by the dust in the plane of our own Milky Way galaxy. If they are right, the finding raises serious cosmological questions.

The way to determine that galaxies belong to a cluster is to show that they appear to be associated with each other as we see them on the sky and also that their redshifts are very nearly the same. Giovanelli and Haynes were studying the redshifts of galaxies in the Lynx-Ursa Major distribution. They noticed that the Lynx-Ursa Major cluster, which is a long stringy pattern, seemed to be continued on the other side of the zone of avoidance by the Pisces-Perseus cluster. Furthermore, the redshifts of the two groups fall in the same narrow range. Giovanelli and Haynes looked for a bridge through the zone of avoidance by studying 21-centimeter radio emissions, which penetrate the dust. They found evidence for one, and in the October ASTRONOMICAL JOURNAL, they published the suggestion that the two clusters are really one, "which stretches over three radians" — that is, nearly halfway around the circle of the sky or 700 million light-years at the distance (200 million light-years) calculated from the average redshift.

The cosmological question arises from cosmologists' habit of assuming that the universe is homogeneous. Homogeneity is known to be violated on the small scale by such things as galaxies and ordinary clusters, but cosmologists held out for a large-scale, over-all homogeneity. Now if a supercluster can extend halfway around the sky, there doesn't seem too much room left to look for homogeneity.

—D. E. Thomsen