*This sequence of photographs shows how the stress pattern in a sample of stretched polyvinylbutyrate changes as the material relaxes over a period of roughly 5 minutes.*

different amorphous and crystalline forms. Under an applied load, the material tries to rearrange itself to redistribute and minimize stresses. Under those conditions, silk molecules relax by unwinding and changing the hydrogen bonding along their backbones. In a glass fiber, the mobile defects correspond to imperfections in the distorted, tetrahedral network of oxygen and silicon atoms.

"It's these mobile units of structure that cause something to happen under a load," Bendler says. "The material isn't just sitting there. There's a mechanical reorganization."

Although ceramicists, engineers and artisans have long recognized the peculiar behavior of glasses, polymers and ceramics and have taken these properties into account when working with the materials, until recently researchers made little progress in understanding relaxation phenomena because the mathematics used to describe such processes seemed so complicated and difficult, Bendler says. Now, the new concepts of mobile defects and fractal-time motion appear to provide a self-consistent picture of viscoelastic and thermodynamic behavior in supercooled liquids and glassy solids.

"One of the chief merits of the theory is that it's so simple mathematically," Bendler says. "We're able to use defect-diffusion mathematics – the mathematics of intermittent pausing – to model the kind of behavior displayed by almost all amorphous materials. It gives us a nice, satisfying picture." □

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# Earliest evidence for plate tectonics

Earth scientists are still trying to piece together the plate-tectonics puzzle. What exactly pushes the vast fragments of the Earth's outer shell around the surface, and when did the crustal plates first break up and start sliding around, warping, tearing and burying each other as they collide?

The Earth's surface provides solid evidence that the crustal plates have been moving for 600 million years. Less direct evidence supports plate tectonics back to 1.9 billion years ago. Now, four researchers say they have found the earliest geologic evidence yet for plate tectonics – in a formation in India where two plates apparently crashed together 2.5 billion years ago, when the Earth was less than half its present age.

These data challenge previous models in which some scientists envisioned the Earth's crust as lacking plate tectonics until fairly recent geological time. "Our findings show that plate tectonic processes in the very early Earth were much like those of the last 600 million years," says Eirik J. Krogstad of the State University of New York, Stony Brook.

Krogstad and co-worker Gilbert N. Hanson, along with S. Balakrishnan and V. Rajamani of Jawaharlal Nehru University and D. K. Mukhopadhyay of Roorkee University, both in India, describe the new findings in the March 10 SCIENCE. They gathered their evidence for early tectonics from a narrow, north-south-trending strip called the Kolar schist belt, where rocks of various ages and origins lie juxtaposed. Krogstad says two pieces of continental crust crunched together from the east and west, squeezing up a band of seafloor between them. This former seafloor, or oceanic crust, makes up the belt, and differs in composition and density from the surrounding two continental crusts.

The continental crust on the west side contains much older rocks than the east side. By measuring how much uranium has decayed to lead and comparing other radioactive-isotope ratios, the researchers estimate the oldest material on the west side at about 3.2 billion years old. Krogstad calls the estimated 2.5-billion-year-old rocks on the east side "juvenile." He thinks the age difference indicates these two continents formed in different places and times before colliding.

According to Krogstad, when the two plates moved together they consumed most of the seafloor separating them, leaving just the narrow belt. Lying side by side in the belt are slivers of fairly ordinary ocean crust and of ancient oceanic crust. Moreover, slivers on the east side of the belt of ocean crust contain more light rare-earth elements than those on the west. Because the levels of these elements are thought to vary from place to place within the mantle, the researchers reason that these oceanic crustal slivers with different ingredients had different sources in the mantle. They conclude that the oceanic crust here formed in different times and places, and crunched together as solid plates.

The researchers were able to estimate the time of the cataclysmic event because the collision introduced into the rock new radioactive material that started decaying at that time – approximately 2.5 billion years ago. In addition to radioactive elements, the tectonic crunch allowed gold to filter up, making the Kolar belt more than just a gold mine of knowledge. According to Krogstad, it's also the world's richest gold mine. His team plans to spend more time exploring the area, hoping to turn up more evidence of early tectonics. And perhaps, he says, they'll stumble across more gold. *– F. Flam*