SBU Researchers at the NSLS Discover Properties of Perovskite, Explain Why No Earthquakes Start in Earth's Lower Mantle

Recent research at the NSLS, reported in the October 24, 2002 issue of *Nature* by Stony Brook University (SBU) scientists, illustrates for the first time why earthquakes do not start in the Earth's lower mantle, the lower part of the roughly 1,400-mile-thick portion surrounding Earth's core.

Using bright, hard x-rays from the superconductor wiggler beamline X17, Jiuhua Chen of SBU's Mineral Physics Institute led research in measuring the strength of $Mg_{0.9}Fe_{0.1}SiO_3$ perovskite, a dominant mineral of the lower mantle, at high pressure and temperature. Collaborators in this research, which is funded by the National Science Foundation, are Donald Weidner and Michael Vaughan, both of SBU.

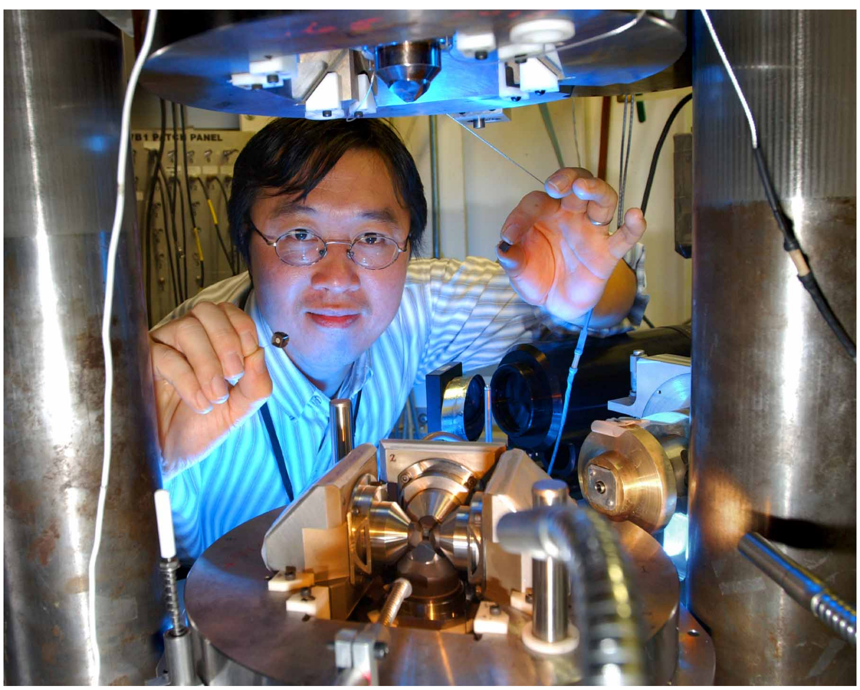
"We found that the perovskite not only is stronger than other minerals at high pressure and temperature, but also has a temperature-insensitive plastic-flow character," said Chen. "The result revises the existing prediction of the rheological property — which is the flow of a material under stress — of Earth's lower mantle and thus supplies the first experimental evidence for understanding why earthquakes do not start in the lower mantle.

"This result also sheds light on many other of Earth's dynamics," added Chen.

He explained that, from surface to center, Earth's structure is made up of the crust; the upper mantle; the transition zone; the lower mantle; the outer core, which is liquid; and the inner core. Earth's crust is divided into areas called tectonic plates which move separately and rub against each other. Some earthquakes occur when adjacent plates "catch" and then suddenly release the pressure that has built up over time. These are called near-surface or shallow earthquakes.

When two plates collide, the thinner, denser plate is forced under the thicker, lighter plate and sinks deep into the mantle. This process is called subduction.

Earthquakes can also start along the subducting slab. These earthquakes are called deep earthquakes.



Jiuhua Chen is at beamline X17B at the NSLS, where a Stony Brook University team has developed equipment that can simulate temperature and pressure conditions needed for studying Earth's structure and dynamics.

"Our result helps in understanding more about the deflection of the subducting slab at the top of the lower mantle, because the strong perovskite may create a mechanical barrier to the subduction," said Chen. "We can now also predict a viscosity jump at the boundary between the transition zone — the portion of Earth that is between 250 and 410 miles deep — and the lower mantle, which is very important information for modeling convection processes in Earth."

Chen explained that the mechanism of deep earthquakes has been a long-standing question. Geophysicists know that seismic observations show no earthquakes starting in the lower mantle, but until the SBU study of perovskite, the reason was unclear.

"We have studied the rheological properties of many mantle minerals," Chen said. "Our results indicate that, among many possible mechanisms, plastic instability may be responsible for the earthquakes."

Investigating the properties of perovskite is difficult because this mineral, unlike others, is unstable under ambient conditions.

"However, with the experimental instrumentation that we developed at the NSLS, we could finally challenge the problem," said Chen. "Our goal is to gain a full understanding of Earth's structure and dynamics. With the NSLS right on our doorstep, we are approaching this goal."

-Liz Seubert

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