Earthquakes to the core -- Researchers drill down at the epicenter

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"What do I remember about an earthquake? I was in the 7th grade. All of a sudden the floor just started shaking. Desks were falling over. Kids were falling on the ground. It was so scary. It happened so quickly!"

For people like Tony Zurnick, part of growing up in California was getting caught off guard by the sudden rumbles of earthquakes. Anyone who has lived through a major earthquake will tell you they'd certainly like to get advance warning next time.

In an attempt to better understand earthquakes and with the goal of one day being able to predict them, an international team of scientists and engineers headed to the heart of where earthquakes happen. The team is involved in a project called The San Andreas Fault Observatory at Depth (SAFOD). A massive undertaking, they drilled a mile and a half into the earth at a test site in Parkfield, Calif., to study what happens at the epicenter of an earthquake. Parkfield is a town located along the San Andreas Fault where a number of minor earthquakes occur each year.

"There's roughly a dozen major plates that the Earth's surface is broken up into and this is one of the first times we've ever been able to drill into one of those boundaries between the tectonic plates," says geologist Chris Marone, a professor at Pennsylvania State University. "We know very little of what's within these fault zones."

Marone and his colleagues, geologist Brett Carpenter and hydrogeologist Demian Saffer, are research collaborators. With support from the

National Science Foundation (NSF), they took advantage of the SAFOD drilling and set to work to study those boundaries called fault zones--where plates shift, pressure builds and earthquakes happen.

"One of the main goals that interests me is to recover material from the fault," says Carpenter. So, with samples from SAFOD in hand, Carpenter went to work.

First, he prepared samples to place in a pressure chamber at their lab. "We'll take a piece of the fault and shear it under a constant normal stress; under conditions that try to mimic what it was like along the fault at depth. At that point, we try to measure the strength and behavior of the sample," explains Carpenter.

Saffer, the hydrogeologist, wants to know how fluids, particularly water, might impact the wear and tear of rocks at the fault zone as it flows through the earth's crust. "We're measuring the rock property called permeability," explains Saffer. "It's basically the ability of water to flow through the rocks. We have a core sample from the San Andreas Fault [which we] trimmed into something we can put in our apparatus. We basically try to push water through the one-inch diameter core sample and measure how resistant it is to water flowing through it."

Were samples from the SAFOD site permeable? "No," he replies. "Most of the material from the San Andreas Fault that we've tested is what we call an aquitard. [The material has] very low permeability. It's very difficult for water to flow through, so this means it would be very effective as a seal or in trapping fluids either in the long-term or in the short-term during an earthquake."

The next challenge is to understand how these findings impact the severity of earthquakes at that site and apply it to other fault zones.

Marone and his collaborators say an area between two plates at the Parkfield site is filled with rubble and clay. When the plates shift at this location, they move in a slow steady creep, causing minor earthquakes hardly felt on the surface. That's very different from other fault zones where harder rocks like granite can lock together. Eventually, overwhelming pressure builds, releasing in a violent tremor, and often wreaking havoc above.

"So, one of the biggest questions is to better understand earthquake physics and mechanics," continues Saffer. "We see these different behaviors on plate boundary faults. Sometimes, in some places, they creep along peacefully. In other places, we have small earthquakes. In other places, we have some slow earthquakes. In other places, we have normal earthquakes, the kind that we think about when we think about mass destruction and geologic hazards. What we don't know is why we have those different behaviors."

Marone says this research is giving them a taste to know more. "The work that's happening on the SAFOD core right now is generating a lot of interest in going back, re-instrumenting the bore hole and maybe doing more coring and drilling in the future because we don't know everything that we could know from that place."

Better understanding of the basic mechanics of a tremor is the key to the ultimate goal of forecasting a quake. "There're a lot of people in California and a lot of people all over the world that live on active fault lines," notes Carpenter.

"It would be great to know when an earthquake is going to happen," agrees Zurnick, who can't forget the trauma of being caught off guard in the 7th grade. "Look what happened in Japan. I still can't believe so many people died. Getting advanced notice could save lives. I have children. I want to make sure they're safe."

It's about figuring out what happens at the core of the quake--drilling down on the problem of how to predict when and where an earthquake will happen before the shaking starts.

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