Listening for SILENT Earthquakes

By Tim Stephens

Costa Rica's Nicoya Peninsula is known for good surf and beautiful beaches. Among seismologists, however, it is better known for earthquakes. The peninsula lies directly over an active fault zone that generated major earthquakes in 1853, 1900, and 1950. The next big one could hit any day.

Or not.

Susan Schwartz, director of the Keck Seismological Laboratory at UC Santa Cruz, and her collaborators have detected a different kind of movement on the Nicoya Peninsula—a slipping of the fault that doesn't generate seismic energy. It's the same fault motion as an earthquake, but it happens so slowly that no ground-shaking occurs.

Known as a "silent earthquake" or "slow slip event," this phenomenon was first observed in Japan and off the coast of Washington and southern Canada. It can only be detected with networks of modern instruments that use the Global Positioning System (GPS) to obtain highly accurate measurements of movements of the Earth's crust over time.

A slow slip event may reduce the risk of a major earthquake by relieving stress on a fault, or it may increase the risk by adding stress to an adjacent fault segment that remains locked up. It all depends on the details of what's going on deep beneath the surface of the Earth.

"Most subduction zones with good networks of modern instrumentation have now observed this slow slip mode, but we don't really understand it at all yet," says Schwartz, a professor of Earth and planetary sciences. "We need to know a lot more about where it's happening in order to understand its implications for earthquake hazards."

JIM MACKENZIE

Prior to transport, professor of Earth and planetary sciences Susan Schwartz and colleague Dan Sampson inspect and pack the GPS and seismographic monitoring instruments they will be installing in Costa Rica.

Schwartz's team detected the Costa Rican event in data from a limited array of three GPS stations installed several years ago by Japanese researchers. Now, with funding from the National Science Foundation, Schwartz and her collaborators are determined to learn more about what's going on beneath the Nicoya Peninsula. She is working with Timothy Dixon of the University of Miami, Costa Rican scientists Marino Protti and Victor Gonzales, and UCSC instrument specialist Dan Sampson to establish an extensive network of seismic and GPS monitoring stations in the area.

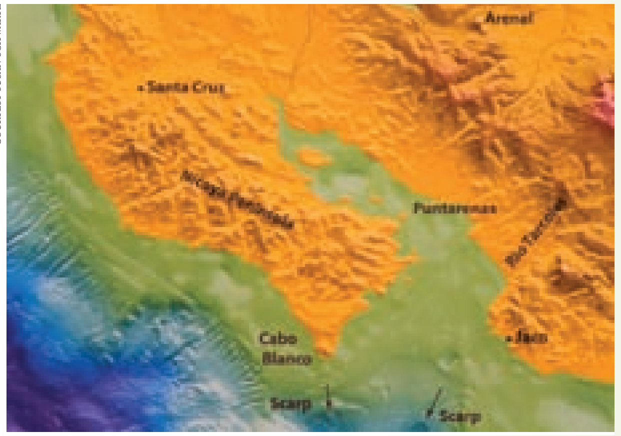
With this project, Schwartz is continuing a long tradition of UCSC involvement in earthquake and volcano research in Costa Rica. Protti, who earned his Ph.D. at UCSC, is one of three alumni affiliated with the country's geophysical observatory, Observatorio Vulcanológico y Sismológico de Costa Rica, Universidad Nacional (OVSICORI-UNA).

Karen McNally, professor emerita of Earth and planetary sciences, led the team that helped establish OVSICORI-UNA in the 1980s and worked to develop the country's program for the reduction of earthquake hazards. In 2004, she received the University Medal from Universidad Nacional for her contributions, and she continues to work with Costa Rican researchers to expand and improve the country's seismographic network.

Schwartz, who has been working in Costa Rica since 1991, says McNally's efforts laid the groundwork for ongoing research by herself and other UCSC faculty and students. "Costa Rica has tremendous earthquake hazards, and UCSC's involvement in the area is pretty impressive," she says.

Flanked by active tectonic margins on both the Pacific and Caribbean coasts, Costa Rica is one of the most earthquake-prone and volcanically active countries in the world. Just off the west coast is the Middle America Trench, where a section of the seafloor called the Cocos Plate dives beneath Central America, generating powerful earthquakes and feeding a string of active volcanoes. This type of boundary between two converging plates of the Earth's crust is called a subduction zone—and such zones are notorious for generating the most powerful and destructive earthquakes.

COURTESY SUSAN SCHWARTZ



The seismogenic zone Schwartz is studying runs beneath the Nicoya Peninsula, on Costa Rica's west coast.

The Cocos Plate and the Caribbean Plate that overrides it are converging steadily at about three inches per year, but the subducted slab of the Cocos does not go down smoothly. It scrapes against the overriding plate, catching and locking up, pulling the edge of the Caribbean Plate down with it. When the fault finally breaks, the upper plate springs back up. In an earthquake, this takes place in seconds to minutes, whereas a slow slip event takes place over days or weeks.

At most subduction zones, the part of the plate boundary where earthquakes originate—the seismogenic zone—lies beneath the ocean. But in Costa Rica, the seismogenic zone runs right beneath the Nicoya Peninsula.

"It's a perfect opportunity to study the seismogenic zone using a network of land-based instruments," Schwartz says.

Installing the instruments is a major undertaking, however, especially in a region where access is limited. Most of the roads on the Nicoya Peninsula are impassable during the summer rainy season. And the instruments have to be anchored in solid bedrock, which means a lot of digging. Starting last year, Schwartz and her team have been making regular trips to the region, scouting locations and carefully installing GPS and seismic stations.

At the same time, they have been trying to educate the population of Nicoya about earthquake hazards. Protti, who has written a book about the peninsula, feels strongly that the area is overdue for a major earthquake. Nicoya is now being heavily developed for tourism, however, and not everyone is receptive to his message, Schwartz says.

"He is really trying to raise awareness of the risks, but it's not something people like to hear about," she says.

Ultimately, the information the researchers gather from their network of monitoring stations will lead to better assessments of the region's earthquake hazards, as well as a better understanding of subduction zones in general.

"We've known for a long time that when you look at how fast the plates are moving with respect to each other, versus how much slip occurs in earthquakes, it doesn't match up. There's a very large slip deficit," Schwartz says. "But if we find that there are a lot of these slow slip events, it may mean the next earthquake is farther off than we had thought."