Workshop on the Costa Rica-Nicaragua seismogenic zone

contributed by Eli Silver

Workshop Report

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The seismogenic zone of convergent margins generates Earth's greatest earthquakes. Geological processes within this zone affect geochemical and mass cycling and significantly impact margin volcanism. The hazard implications are profound for the inhabitants in these areas.

Marino Protti, Universidad Nacional, Heridia, and Eli Silver, University of California, Santa Cruz, convened a workshop to review the Costa Rica-Nicaragua Seismogenic Zone (CRiNiSEIZE) in San Francisco on December 7, 1997. The workshop was sponsored by JOI/USSSP, NSF International programs, and MARGINS, and was attended by 55 experts representing a variety of scientific disciplines. The meeting was built upon three previous international workshops which stressed the importance of understanding the mechanics of the seismogenic zone in subduction environments. One meeting, the Seismogenic Zone Experiment (SEIZE), identified the Costa Rica-Nicaragua seismogenic zone as one of the two highest priority regions for focused studies.

Specific CRiNiSEIZE workshop goals were: to better define the nature of the seismogenic zone, to prioritize potential scientific studies, and to organize international teams to focus on different aspects of the zone's structure and behavior. These teams are expected to generate research proposals that ultimately lead to drilling in the active seismogenic zone. The workshop produced a multidisciplinary strategy to prepare for riser drilling on the Central American margin. As a first step, the workshop participants proposed passive seismic experiments to map and define the seismogenic zone. A plan was developed to deploy about 30 three-component ocean bottom seismometers (OBS) and 20 land recorders. The well studied Nicoya seismic gap (Costa Rica) was identified as the prime site for investigation.

Workshop participants also proposed regional multichannel seismic and OBS refraction studies of the Nicaragua margin to obtain crustal structure information compatible with existing data for Costa Rica. The first studies would involve 2D seismic reflection, although any site recommended for riser drilling would likely require 3D work as well. 3D seismic data is currently available for Costa Rica. Because riser drilling to the seismogenic zone is costly and time consuming, only the most effective imaging tools should be used. These may involve experiments using 4D seismics—that is, time variability in reflectivity characteristics associated with fluid flow and mechanical changes.

Heat flow data are also required from the Nicaragua margin, for comparison with the Costa Rican data. One cruise to swath map and collect heat flow data may be sufficient to characterize structural changes along the margin. Additional submersible observations would provide a time-series understanding of the intensity and chemistry of fluid venting along faults and mud volcanoes.

As part of the overall strategy, the workshop also recommended four to six locations off the Nicoya peninsula for marine geodesy studies. Expansion and densification of the Nicoya and surrounding Global Positioning System (GPS) arrays, expansion of GPS studies into Nicaragua, and the addition of more continuous stations were recommended. Other offshore geophysical experiments could monitor long-term vertical motions.

ODP non-riser drilling is an important way to characterize the incoming crust. A desirable goal would be to penetrate the Tsunamigenic zone off Nicaragua and monitor fluid pressure and flow over time. CORK holes through the Costa Rica décollement could monitor fluid variations and chemical behavior associated with forearc strain and seismicity. Finally, by using drill-in casing ODP may be able to penetrate the deformed Costa Rica prism. Data from ODP Leg 170 suggest this prism is related to onshore geology, not to incoming Cocos plate material. A program that monitors fluid and chemical behavior should be carried out simultaneously at several active flow horizons within a hole.

Geochemical studies of the arc volcanoes may reveal the degree to which materials flow through the seismogenic zone. Furthermore, modeling and laboratory studies should be included in the planning and synthesis stages of all components. An integrated program to study the Central American margin promises a fuller understanding of the seismogenic process, and joint efforts will minimize the cost/benefit ratio of conducting a large scientific endeavor.