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Detailed Data Available for Recent Costa Rica Earthquake

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On 5 September 2012 a magnitude 7.6 earthquake occurred beneath the Nicoya Peninsula of northwestern Costa Rica, rupturing the subduction zone between the Cocos and Caribbean plates. In most subduction zones the locus of seismic slip lies far offshore, making it difficult to infer interface seismogenic processes from on-shore observations. In contrast, the Nicoya Peninsula lies close to the trench (within 70 kilometers), allowing observations directly over the earthquake rupture zone.

Because of its favorable location, the frequency and apparent regularity of large earthquakes, and timing (late in the earthquake cycle), the Nicoya Peninsula was a focus site for the Seismogenic Zone Experiment (SEIZE) beginning in 1997. This project was funded by the U.S. National Science Foundation's (NSF) MARGINS program, which investigated the geological evolution of continental margins. Since then, the region has seen numerous studies of seismicity, velocity structure, heat and fluid flux, bathymetry, geodesy, coastal geomorphology, and paleoseismology, addressing fundamental questions about subduction zone processes.

The September 2012 Nicoya earthquake is a fitting capstone for the SEIZE initiative and also presents an important opportunity to address new science objectives central to the MARGINS successor program, Geodynamic Processes at Rifting and Subducting Margins (GeoPRISMS). These objectives span a spectrum of fault slip behavior from seconds (earthquakes) to months (slow slip events) to decades or longer (seismic cycle strain and net crustal deformation).

Seismic Setting and Observation Campaigns

The Nicoya region produces frequent large (M>7) earthquakes, including similar events in 1853, 1900, and 1950 (M 7.7) [*Protti et al.*, 1995]. Prior geodetic studies mapped the Nicoya segment as a locked zone, with parts of the subduction interface accumulating strain at essentially the rate of motion between the plates, about 8 centimeters per year [*Dixon*, 1993; *Lundgren et al.*, 1999; *Norabuena et al.*, 2004; *Feng et al.*, 2012]. Geomorphic data are also consistent with these rates of strain accumulation [*Marshall and Anderson*, 1995]. The history of frequent large earthquakes, combined with geodetic and geomorphic data consistent with locking on the plate interface and accumulating seismic strain, meant that the 2012 event was expected [*Nishenko*, 1989; *Protti et al.*, 1995].

Smaller (M~7) events in 1978 and 1990 also occurred in the region, and at least five slow slip and tremor events have been recognized here in the last decade

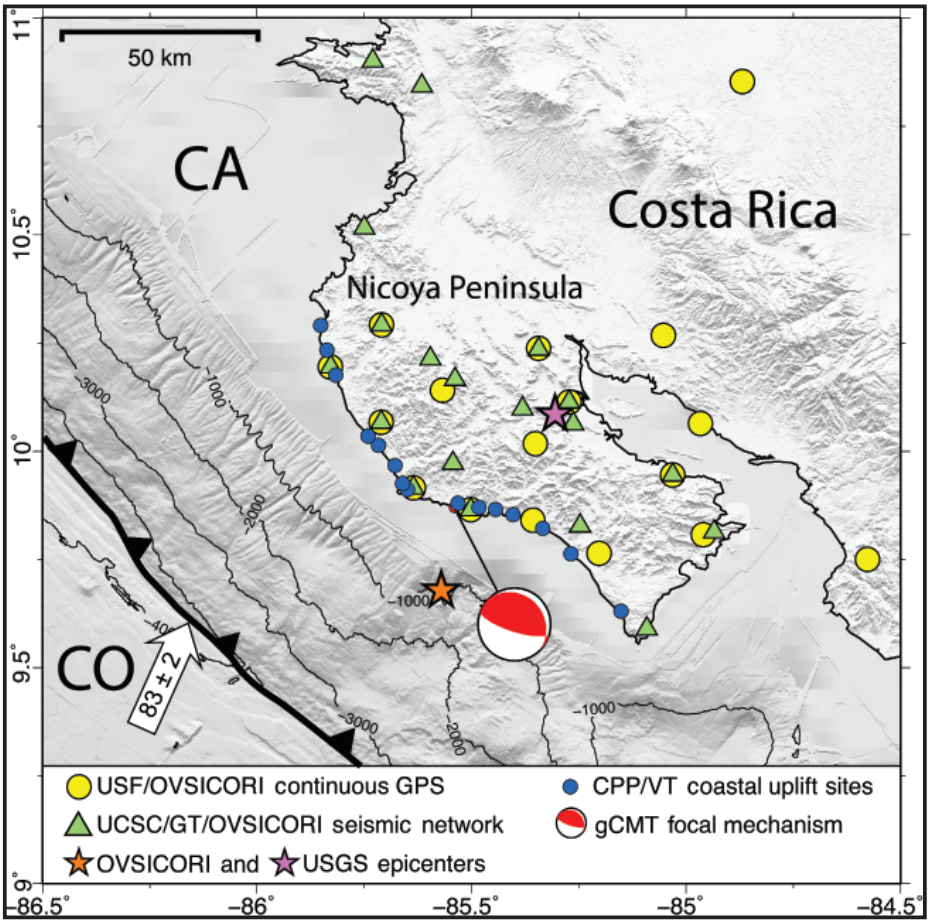

Fig. 1. Scientific observation stations at the Nicola Peninsula in Costa Rica, where the Cocosplate (CO) is subducting under the Caribbean plate (CA). Institutions involved with study are the University of South Florida (USF); University of California, Santa Cruz; Georgia Institute of Technology (GT); Observatorio Vulcanológico y Sismológico de Costa Rica, Universidad Nacional (OVSICORI-UNA); California State Polytechnic Institute, Pomona (Cal Poly Pomona, CPP); and the Virginia Polytechnic Institute and State University (Virginia Tech, VT). Global Centroid Moment Tensor solution (gCMT) for the 5 September 2012 earthquake is shown along with epicenter estimates from the U.S. Geological Survey (USGS) and OVSICORI-UNA. Arrow shows rate (in millimeters per year) and direction of convergence of CO relative to CA. Depth contoursare in meters.

[*Outerbridge et al.*, 2010; *Walter et al.*, 2011; *Jiang et al.*, 2012]. Nonetheless, prior to the earthquake on 5 September 2012, significant seismic strain had accumulated.

The University of South Florida; University of California, Santa Cruz; Georgia Institute of Technology; and Observatorio Vulcanológico y Sismológico de Costa Rica, Universidad Nacional (OVSICORI-UNA), one of Costa Rica's main institutes for earthquake and volcano research, operate a network of high-precision, continuously recording GPS receivers and broadband seismometers on the Nicoya Peninsula (Figure 1). The network started in 2002 through a collaboration between OVSICORI-UNA, Tokyo University, and the Japan International Cooperation Agency. Since 2005, support has come from NSF's Instrumentation and Facilities, MARGINS, and CAREER programs, the latter of which is designed to support early-career development for young scientists. Installation, maintenance, and data archiving are facilitated by UNAVCO and the Incorporated Research Institutions for Seismology (IRIS). This network recorded data several years before, during, and after the 2012 earthquake. MARGINS-funded geomorphic and paleoseismic studies by the California State Polytechnic Institute, Pomona (Cal Poly Pomona), and the Virginia Polytechnic Institute and State University (Virginia Tech) provide additional constraints on seismic cycle deformation along the Nicoya coast.

Data Freely Available

In the wake of the 2012 earthquake the NSF Geophysics and GeoPRISMS programs funded rapid response fieldwork to collect real-time geophysical and geomorphic data from the Nicoya Peninsula. These data provide an unprecedented image of the temporal and spatial distribution of slip during and after the earthquake, along with a significant community research opportunity.

Geodetic data from the continuous GPS network (including 5-hertz GPS data for selected stations) are archived and publicly available on the UNAVCO Web site (http://www.unavco.org/voce/viewforum.php?f=56). The seismic and geomorphic data from the recent surveys are being processed and will be archived and available through IRIS and UNAVCO in early 2013. Anyone with an interest in seismic processes and hazards is encouraged to exploit these new data.

References

Dixon, T. H. (1993), GPS measurement of relative motion of the Cocos and Caribbean plates and strain accumulation across the Middle America Trench, *Geophys. Res. Lett., 20*, 2167–2170.

Feng, L., A. V. Newman, M. Protti, V. Gonzalez, Y. Jiang, and T. H. Dixon (2012), Active deformation near the Nicoya Peninsula, northwestern Costa Rica, between 1996 and 2010: Interseismic megathrust coupling, *J. Geophys. Res., 117*, B06407, doi:10.1029/2012JB009230.

Jiang, Y., S. Wdowinski, T. H. Dixon, M. Hackl, M. Protti, and V. Gonzalez (2012), Slow slip events in Costa Rica detected by continuous GPS observations, 2002–2011, *Geochem. Geophys. Geosyst., 13*, Q04006, doi:10.1029/2012GC004058.

Lundgren, P., M. Protti, A. Donnellan, M. Heflin, E. Hernandez, and D. Jefferson (1999), Seismic cycle and plate margin deformation in Costa Rica: GPS observations from 1994 to 1997, *J. Geophys. Res., 104*, 28,915–28,928.

Marshall, J. S., and R. S. Anderson (1995), Quaternary uplift and seismic cycle deformation, Península de Nicoya, Costa Rica, *Geol. Soc. Am. Bull., 107*, 463–473.

Nishenko, S. P. (1989), Circum-Pacific seismic potential, 1989–1999, *U.S. Geol. Surv. Open File Rep., 89–86*.

Norabuena, E., et al. (2004), Geodetic and seismic constraints on some seismogenic zone processes in Costa Rica, J. Geophys. *Res., 109*, B11403, doi:10.1029/2003JB002931.

Outerbridge, K., et al. (2010), A slow slip and tremor event in May 2007, Costa Rica margin, *J. Geophys. Res., 115*, B10408, doi:10.1029/2009JB006845.

Protti, M., et al. (1995), The March 25, 1990 (Mw=7.0, ML=6.8), earthquake at the entrance of the Nicoya Gulf, Costa Rica: Its prior activity, foreshocks, aftershocks, and triggered seismicity, *J. Geophys. Res., 100, 20*,345–20,358, doi:10.1029/94JB03099.

Walter, J. I., S. Y. Schwartz, M. Protti, and V. Gonzalez (2011), Persistent tremor within the northern Costa Rica seismogenic zone, *Geophys. Res. Lett., 38*, L01307, doi:10.1029/2010GL045586.

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