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IODP-INVEST
WHITE PAPER

NICOYA, COSTA RICA: AN IODP TARGET WHERE THE SEISMOGENIC ZONE OF LARGE EARTHQUAKES CAN BE DRILLED AND INSTRUMENTED

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ABSTRACT

The Nicoya segment of Middle America Trench has generated large earthquakes in 1883, 1900 and 1950. Since the Nicoya peninsula sits right over the seismogenic zone, it has proved to be a unique site for near field monitoring of interplate interactions. Recent crustal deformation data indicates that locking on this plate boundary starts as close as 30 km from the trench where the plate interface is around 6 km deep. These results make this subduction segment an attractive target for drilling the plate interface and seismogenic zone at several different depths in a margin where collected data suggests is close to rupture. This temporal proximity to failure gives also a chance to monitor several parameters (such as fluid flow, geochemistry, strain, temperature, tilt, among others) in holes at several distances from the trench prior to rupture, possibly during rupture and most of the changes induced by postseismic slip.

This area is part of the target region of both, the Seismogenic Zone Experiment (SEIZE) and the Subduction Factory (SUBFAC) initiatives of MARGINS and it has been studied for many years with different techniques (high resolution marine seismics, refraction profiles, broad band land and ocean seismic stations, scan mapping, an ALVIN cruise, ODP and IODP legs, CGPS, electronic tiltmeters), so there is already sufficient information to start an IODP proposal. The on-land recorded deformation rates are very high precluding success in recording deformation offshore.

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WG2.5: Subduction zones and volcanic arcs.
WG5.1: Geohazards: earthquakes.
WG6.1: Observatories.
WG6.6: Balancing long-term projects and single expeditions.

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Nicoya is a segment of the subduction zone at Middle American Trench. Here the Cocos plate subducts at almost 90 mm/yr under the Caribbean plate (Fig. 1). With the exception of the Nicoya segment, the entire subduction zone along the Middle American Trench has ruptured with large earthquakes in the last 60 years. Nicoya had large earthquakes (Mw>7) in 1853, 1900 and in 1950. Therefore the Nicoya segment constitutes a mature seismic gap (Protti et al., 2001).

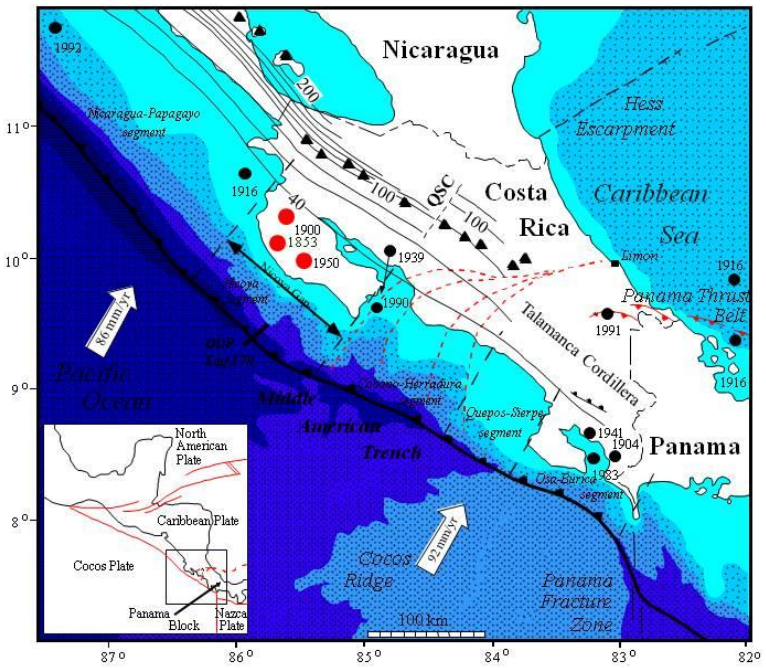

Figure 1. Tectonic setting of the Nicoya, Costa Rica, subduction segment. Solid circles show the location of large (Mw>7) earthquakes in Costa Rica. Solid triangles represent active volcanoes. Lines parallel to the trench are isodepth contours of the top of the Wadati-Benioff zone in 20 km intervals. QSC is the Quesada Sharp Contortion, a tear fault in the subducted Cocos slab.

The Nicoya subduction segment has two important advantages over most subduction zones in the world. First it has a peninsula sitting right over the seismogenic zone of large (Mw>7) earthquakes that allows recording crustal deformation in the very near field with geodetic techniques such as continuous GPS (CGPS) and tiltmeters, as well as with seismic instrumentation. The second advantage is that the upper limit of the seismogenic zone is reachable by drilling with the current drilling vessels capabilities.

Geodetic and seismic instrumentation have recorded two slow slip events on the Nicoya segment, one, in September 2003, believed to have occurred within the seismogenic zone (Protti et al., 2004) and another in May 2007 that went from the upper limit to the downdip limit of the seismogenic zone (Psencik et al., 2008). According to Brown et al., 2005 and LaBonte et al., 2009, slow slip events have also been recorded, in this segment, near the trench through transient

fluid pulsing and seismic tremor, demostrating the importance of continuos borehole monitoring close to the trench.

Recent crustal deformation data from the Nicoya peninsula indicates that locking on this plate boundary starts as close as 30 km from the trench (Norabuena et al 2004) where the plate interface is around 6 km deep. These results make this subduction segment an attractive target for drilling the plate interface and seismogenic zone at several different depths in a margin where collected data suggests is close to rupture.

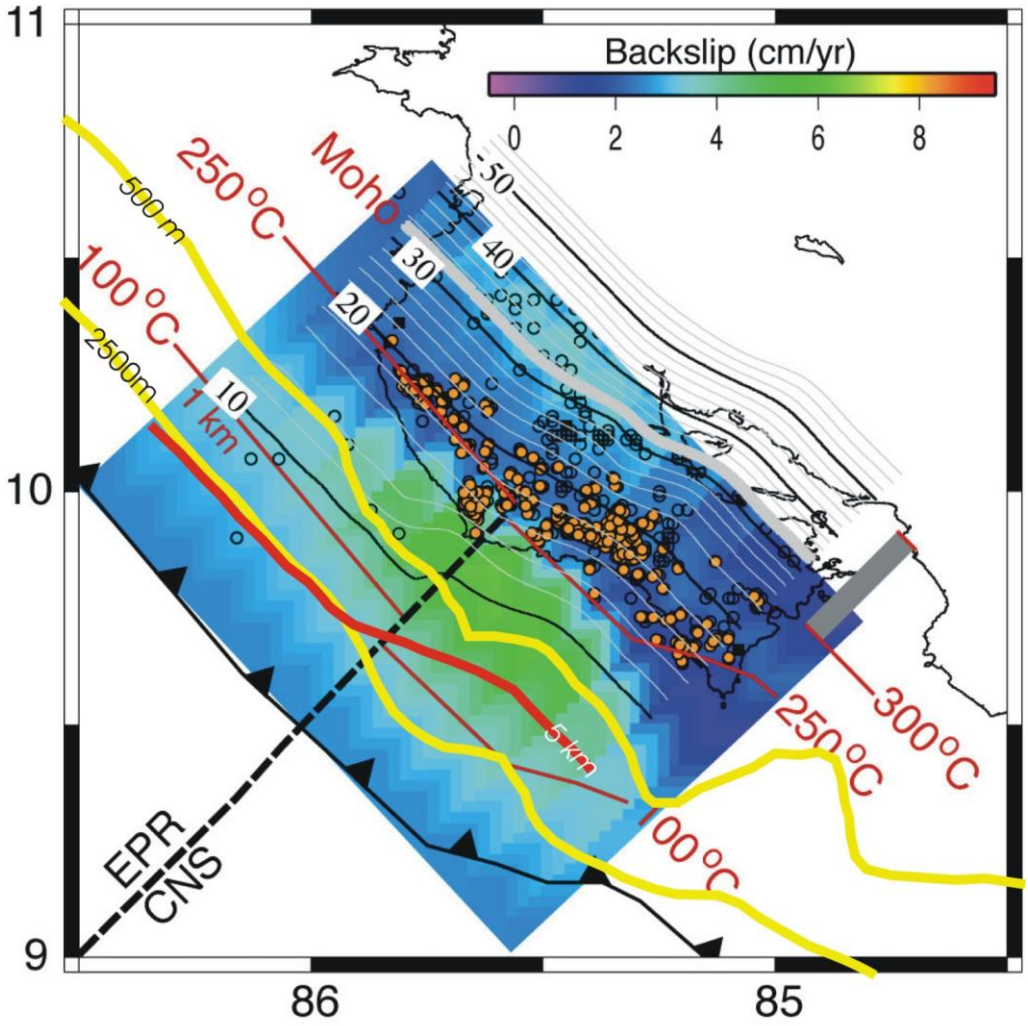

Figure 2. The Nicoya segment of the Middle American Subduction zone (DeShon, et. al., 2005). Color pattern shows the quality of locking along the plate interface (Norabuena et. al., 2004) with the strongest patch where the plate interface is from 5 to 15 km deep (the plate interface is represented by a red line labeled 5 km and solid black lines labeled 10, 20 30, 40 and 50). Orange circles represent interplate seismicity. Temperature isotherms from *Spinelli and Saffer* (2004) updip and *Harris and Wang* (2002) downdip; the grey box indicates the potential variance in the modeled 300ºC isotherm. Yellow solid lines mark the 500 m and 2500 m depth contours, which is the operational water depth interval for Chikyu. Within this depth range Chikyu could target the seismogenic zone at 6 to 7 km.

WHY NICOYA?

IT GENERATES LARGE EARTHQUAKES
SHORT RECURRENCE TIMES
CLOSE TO FAILURE
FAST DEFORMATION RATES
POLITICALLY EASY
LOTS OF DATA AVAILABLE
SMALL AREA (10s of km rather than 100s of km)
LAND CLOSE BY FOR LOGISTICS AND DATA LINKS
THE SEISMOGENIC ZONE IS REACHABLE BY DRILLING

TWO WAYS AND TIMES YOU CAN DO IT:

NOW AND CHEAP
NON-RISER HOLES WITH IN-SITU RECORDING SYSTEMS
LATER AND WITH MORE RESOURCES
CHIKIU DRILLING AND OCCEAN BOTTOM CABLE NETWORKS

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