A SEISMOGENIC ZONE INVESTIGATION IN THE EROSIONAL SETTING OF MIDDLE AMERICA

A major goal of the International Ocean Drilling Program (IODP) is to sample seismogenic zones and install down-hole instrumentation for long term monitoring. The scientific riser drill ship Chikyu can reach the seismogenic zone in only a few places limiting the diversity of seismogenic behavior that can be investigated with direct observations. The Nankai margin where accretion dominates tectonics and the Cocos Ridge area where subduction erosion dominates are currently proposed for seismogenic zone drilling. Investigation of these diverse seismogenic zones is complimentary because of their fundamental differences. For instance, Central American earthquakes are more frequent but smaller than Nankai earthquakes despite more than twice the rate of convergence. Subducted material off Nankai is marine sediment whereas that off Costa Rica is predominantly upper plate erosional debris. The differing mechanical properties of material along the plate interface and the rates of interplate convergence should correlate with differences in seismogenic behavior.

A central objective of this proposal is to advance understanding of processes resulting in large earthquakes along erosional convergent margins. Sampling the seismogenic zone will significantly increase understanding of the physical, chemical and temporal character of seismogenic behavior. With samples, the dynamic response and geochemical changes that occur as material and fluid are subducted to deep levels can be investigated. With down-hole instrumentation the in-situ dynamic behavior can be observed. Emplacement of strain meters offshore can indicate the seaward extent of subduction zone strain during the earthquake cycle observed with GPS on land. Down-hole seismometers can return signals well below the threshold of surface instruments and allow critical structure to be observed with exploration seismic techniques. Therefore drilling will open a new observational domain pertaining to fundamental processes generating seismicity.

Convergent margin environments along Middle America extend across a broad geologic spectrum and thus involve varied investigations. Proposed investigations include drilling the tsunamigenic Nicaragua margin to compare with that of Costa Rica. In addition to Seismogenic zone objectives are Subduction Factory objectives to understand the steep geochemical gradients of arc volcanic rock relative to subducted fluids and solids and the recent surface ship sampling of fluid from numerous vents. At the JOI/USSSP funded workshop in December we will continue discussing the scope of the overview document for the submitted complex seismogenic drilling proposal and expand the current proponent group. The proposed deep drilling will relate to many objectives of the Subduction Factory initiative and the concerns of ongoing investigations both offshore and onshore. The subduction fluxes, subduction zone hydrology, lateral changes in character of seismicity, and lateral changes in volcanism should be illuminated by discoveries deep in the subduction zone. In addition to quantifying rates of subduction erosion, resolution of small-scale structure and characterizing rock along the plate boundary should show why convergent margins are erosional.

Why drill an erosional margin off Costa Rica? The area has long been a focus of international scientific investigation since ODP drilling in the late 1970's and it is a focal area in the current Margins Programs. Opposite the Osa Peninsula the subducting Cocos Ridge introduces high temperature crust to the subduction zone. That brings diagenetic processes, metamorphism, and mineral transformations to shallower than usual depths. The high thermal gradient near the Osa Peninsula allows non-riser drilling with the 4-string casing system into rock at more than 140 C where the mineral transformations that may promote stick-slip behavior begin to occur. The updip end of the seismogenic zone can be reached with riser drilling and Osa Peninsula provides sites on land where the seismogenic zone is reachable. A moderate climate, lack of strong currents, and proximity to an international airport optimize operations. Therefore scientific targets occur at depths where IODP drilling can penetrate and directly explore a seismogenic zone in an erosional setting for the first time.

A 3 stage IODP drilling program integrated with intervening geophysical programs is proposed. Each drilling stage is part of systematic approach where one stage is directed to solving unknown issues for the next stage.

Stage 1. Objectives are to quantify tectonic processes, date impact of Cocos Ridge, chronicle pre-Cocos volcanism and constrain rock and fluid input to the subduction zone. Work to be accomplished - **Characterize the unsampled bedrock geology, chronicle a Neogene tectonic and volcanic history, investigate the hydrology and geochemistry of margin wedge fluids and that of the adjacent ocean crust.** Required are 4 non-riser drill holes, ~500m – 800m deep, that return sediment and acoustic basement, including a reference hole into the adjacent ocean crust. Down-hole instruments will be deployed.

Stage 1 Geophysical experiment Acquire high-resolution seismic images of plate boundary structure and from the analysis of seismic attributes, estimate physical properties below and around drill holes with down-hole instruments. Down-hole strain meters will record stress around the possible locked zone.

Stage 2. Objectives are to characterize the deep physical and geochemical environment at the plate boundary 15 km landward of the trench to explore conditions just up dip of the onset of seismogenic behavior. Work to be accomplished – **Examine deep geology physical properties, fluids of the margin wedge, and the proto-seismogenic zone.** Requires one hole 2 to 3 km deep, deployment of instruments down the hole, and a cork.

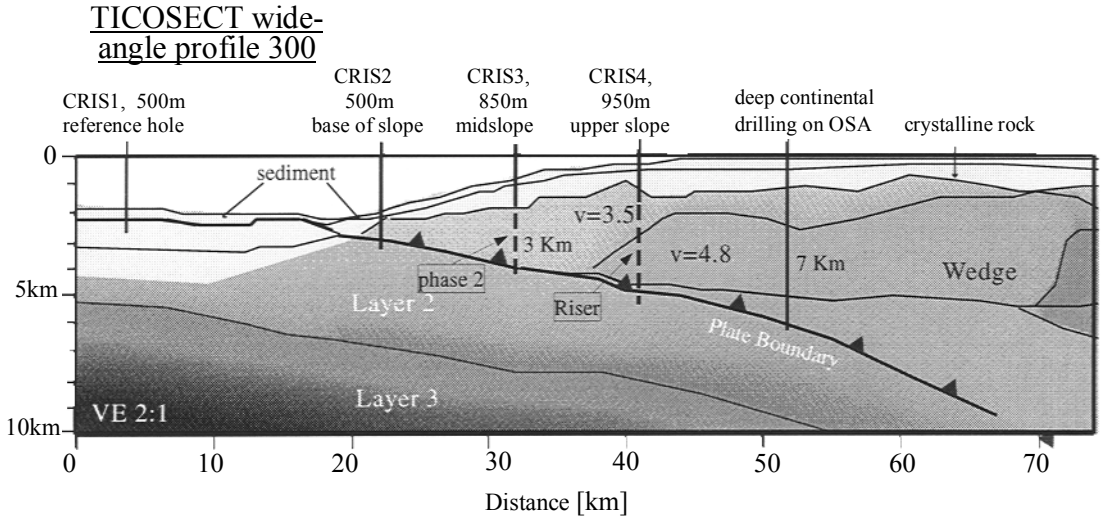
Stage 2 Geophysical experiments A deep drill hole will allow high resolution seismic imaging of the plate boundary and analysis of seismic attributes to derive physical properties. A 3D seismic survey over the candidate site for riser drilling will probably follow.

Stage 3. Objectives are to sample the seismogenic zone, observe physical conditions and monitor long term changes perhaps associated with an earthquake in the zone

currently inferred to be locked. Processes in the subduction factory can be observed. Work to be accomplished – **Riser drilling to 4-5 km depth and perhaps into the subducted ocean crust. A down-hole laboratory for long term monitoring will be installed.** Requires a single hole between 4 and 5 km depth. In this area such a hole can be drilled in water depths less than 1 km.

If successful, this integrated program could be the basis for a continental drill program on Osa Peninsula where the plate boundary is 6-7 km deep. Drilling there would sample the central part of the seismogenic zone.

During the workshop 3-5 December in Menlo Park, California, the unpublicized data from several cruises in 2002 and results from Leg 205 will be shown in posters and described. The scientific objectives and other issues to be addressed in the proposed Osa drill transect will be presented and discussed in groups of specialists. The deliberations of the workshop will be integrated into the overview proposal for the complex drill proposal submitted to IODP.



Location of proposed drill sites on a crustal section (v=velocity in km/s). Stage 1 non riser sites CRIS 1 through 4 are annotated with proposed drill depth represented by solid lines. CRIS 3 is the non-riser deep drill site of Stage 2 with extension to the plate boundary shown as a dashed line. CRIS 4 is a candidate riser-ship site for Stage 3 where the plate boundary reflective zone in seismic sections is 4-5 km deep. The projected position of a possible continental drill site on the Osa Peninsula is shown

The JOI/USSSP supported workshop in Menlo Park, is co-convened by Kevin Brown and Roland von Huene with a steering committee including Guillermo Alvarado and Marino Protti as Costa Rican representatives, Cesar Ranero as the European, Kiyoshi Suyehiro representing Japan and Kirk McIntosh, and Julie Morris, representing US institutions. Our host at the USGS facility in Menlo Park is David Scholl.