Potential drilling target for Geohazard program

Controls of pre-existing heterogeneities on rupturing of the subduction zone faults

- distribution of fluid, cements and strain, build-up of stress, and tsunami-genic vs. seismogenic faulting

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Abstract

Increasing quality and quantity of 3D seismic survey revealed variation in seismic impedance along a decollement (Bangs et al., 2004) or a splay fault (Moore et al., 2007), that may imply distribution of contrasting physical properties or uneven distribution of fluid across a fault. Submersible observations along the Shionomisaki canyon agreed that there are uneven distribution of cementation (hatched area in Fig. 1) and cold seepage just above the faults. Such uneven distribution of cements and fluids must have influence on processes of stress build-up, overall distribution of strain, and recurrence of the seismogenic faulting in accertionary prisms. There are also places in the world, where seismogenic faulting (with high slip rate) and tsunamigenic faulting take place in the same area. Having these in mind, my suggestion aims to understand relationship between occurrence of faulting with various slip rate and fault distribution in relation to distribution of physical properties (rock type, texture, cement, fluid) that in turn controls frictional strength along a fault and/or processes of stress build-up.

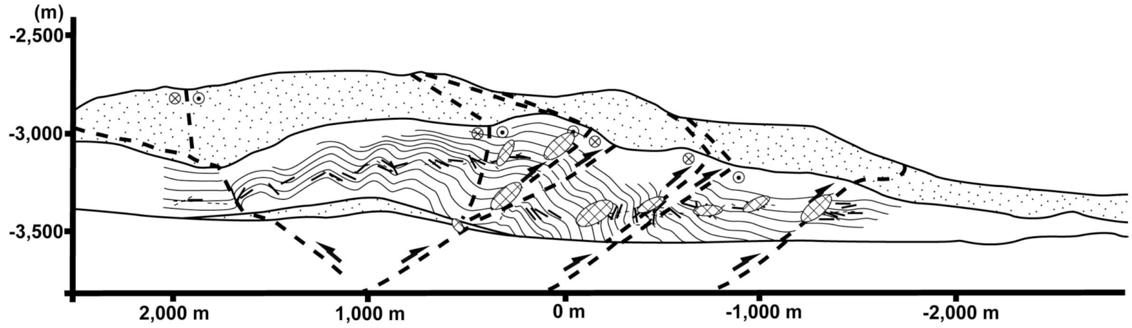

Figure 1: Geological structures, distribution of chemosynthesic biocommunities that mark the position of cold seepages along active faults, and distribution of carbonate cementation along an NS profile of the Nankai accretionary prism (Anma, submitted).

Working hypothesis:

1. Faults with different slip rate develop different textures and they used different lithology when rupturing took place.

Offshore of Sanriku area, NE Japan, where two tsunami-genic earthquake took place in 1896 and 1933, the former accompanied strong shake whereas the latter did not, is a good target to test this hypothesis. Other possible target area is offshore of Java. Occurrence of tsunami itself implies that the rupture reached to near sea-floor to a drillable depth. Therefore, these working hypotheses are testable by drilling. By testing the hypotheses and developing recognition criteria, one can start comparing and relating the structures obtained through drilling project with those in on-land accretionary complexes. Such study would provide fundamental knowledge of fracture mechanisms.

2. Contrast in seismic impedance along a fault plane is due to uneven distribution of cements and fluids, and the uneven distribution controls processes of stress build-up, faulting and further fluid migration.

Any accretionary prism where detailed 3D seismic data of splay faults are available and contrast in impedance was revealed (for example, Nankai or Barbados) is a good target.

Schematic sketches in figure 18 illustrate possible scenarios of how heterogeneity developed in an accretionary prism and how it controls future deformation. For example, fault seal materials with low permeability (Fig. 18a) may concentrate fluid flows beneath the fault plane, which precipitate carbonate cements. The zone of fluid flow will be eventually hardened, zone of stress localization will move forward, and new fault plane will be developed underneath the cemented zone. In contrast, $CaCO_3$-saturated fluids may repeatedly migrate along a fault plane and precipitate carbonate nearby sandstones with high pore connectivity and permeability (Fig. 18b). In both case, strengthened ridge front will be formed, which may act as indenter for the inner wedge, and as backstop for the outer wedge. New splay fault may be formed behind the ridge front, whereas frontal imbrications may propagate forward in the outer wedge.

Revealing distribution of fluid and cementation (or any heterogeneity) along a fault would be a fundamental progress in understanding initiation and propagation of a rupturing. Whether such heterogeneities control processes of stress build-up, faulting and further fluid migration, may be tested by installing instruments in the drill holes to monitor in-situ stresses, seismicity and fluid flow. Long-term monitoring would also be important for earthquake hazard mitigation.

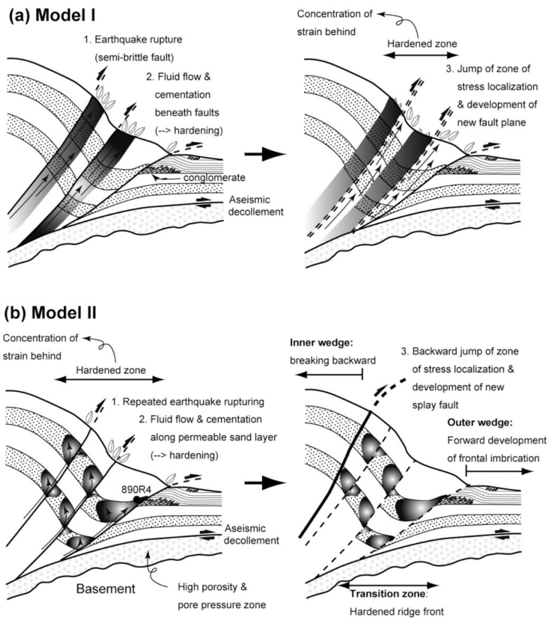

Figure 18; Schematic sketches account for cementation above active cold seepage zones. (a) A fault seal model. (b) A model in which CaCO3-saturated fluids repeatedly migrate along a fault plane and precipitate carbonate nearby sandstones with high pore connectivity and permeability (Anma, submitted).

Anma et al., (2009) Fig. 18

Role of transverse faulting on development of accretionary prisms

It seems that strike slip fault systems in accretionary prism also play an important role in overall patterns of strain distribution and stress build-up especially in ridge subduction zones or oblique subduction zones (Fig. 1). Eastern part of the Tenryu submarine canyon (the area Japan-French KAIKO project covered) is an attractive target. How any strain was accommodated by such transverse faults may be important when estimating overall strain-stress distribution above a subduction system.

Platform and drilling strategy

"Chikyu" with deeper drilling capacity and with better borehole stability is obviously preferable for this project. Nevertheless, inclined drilling or numerous shallow drilling will easily test some of working hypotheses. Drilling from the bottom of a submarine canyon may decrease the drilling depth to target.