Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-23 Room:302 Time:May 22 12:00-12:15

Fluid-rock interaction and resultant rupture of great earthquake -An exercise from fossilized seismogenic plate boundary

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Recent investigations of exhumed and fossilized plate boundary thrusts and megasplay faults strongly suggest that unraveling the physico-chemical dynamics of fluid-rock interaction and resultant rupture of great earthquake and tsunami is the scientific target of the seimogenic plate boundary processes, which is accessible only by Chikyu-deep riser drilling. The expected result of drilling into the active and living fault in depth will be a great step of science.

Technological advantage of the Chikyu Riser drilling is no doubt for its ability of deep hole with coring, logging and observatory installation. A main target of IODP was direct drilling into the sesimogenic plate boundary thrust in the Nankai Trough of subduction zone. After the first proposal for the NantroSEIZE many new discoveries have been reported from subduction zones, e.g. deep low frequency earthquakes, shallow low frequency earthquakes, high velocity slip even along the plate boundary decollement and on-going stress build-up within the hanging wall accretionary prism. However, unfortunately the deep target of IODP has not been reached yet.

Before drilling into the seismogenic deep splay fault and plate boundary thrust, we have conducted investigation of exhumed and fossilized splay fault of the Nobeoka thrust and plate boundary fault rocks recorded as melange in the Shimanto belt, Japan.
The Nobeoka thrust was once buried at the depth more than 10 km in subduction zone. Combining with inspection of surface exposure, drilling with logging for physical properties and borehole imaging was operated to compare the one dimension data set with the three dimensional occurrences of the fault zone.

Even though surface weathering and cracking with exhumation, the results of coring, logging, and borehole imaging present the condition of the fault in the depth of plate boundary. They show porosity less than several percentages with contrast between the hanging wall and footwall, which are well correlated with electric resistivity, and elastic wave velocities of Vp and Vs. They are systematically changes with the development of discrete slip zones in the shear zone and define a quantitative damage zone. Abundant mineral precipitation is characteristic in the fault and presents a catalog of fault rocks from friction melt of pseudotachylyte to fluidized fault rock suggesting various fault mechanisms of dynamic weakening.

REE pattern of carbonate vein precipitated along the slip surfaces and extensional cracks suggests that fluid flow along the fault, which might be co-seismic, would be under reductive condition but inter-seismic fluid appear to be oxidized condition. The change in chemical property appear be from rupture-related fluid-rock interaction along the plate boundary.

Exploration of the fossilized plate boundary to deep living ones is the revolving jump like autopsy to modern open-heart surgery in medical science. The drilling into various plate boundaries with different subduction parameters is quite essential.