Press Releases

October 8, 2013
JAMSTEC

Causal Mechanisms of Large Slip during the Tohoku Earthquake of 2011 Revealed through Hydraulic Analysis of Fault-Drilling Samples from the Deep-Sea Scientific Drilling Vessel *Chikyu*

1. Overview

Using digging core samples recovered by the Deep-Sea Scientific Drilling Vessel *Chikyu* on Integrated Ocean Drilling Program (IODP) Expedition 343: Japan Trench Fast Drilling Project (JFAST), a team led by Wataru Tanikawa, a scientist at the Kochi Institute for Core Sample Research of the Japan Agency for Marine–Earth Science and Technology, (JAMSTEC: Asahiko Taira, President), assessed and analyzed (hydraulic analysis) the relationship between the plate boundary fault and the behavior of fluids such as groundwater within the fault. Their results revealed that in the 2011 Tohoku Earthquake, permeability near the plate boundary fault was very low (fluids unable to pass easily through the layers of the plate boundary fault) essentially trapping water within its layers. The low permeability resulted in higher fluid pressure due to frictional heating during the slippage of the earthquake fault, and because the large slip caused a friction decrease there was a massive slip extending to the shallow part of the plate boundary (decrease in the sliding frictional resistance of the fault: able to slip more easily).

Conventionally, large seismic slips were not thought to occur in shallow faults close to the Japan Trench axis because of damping due to friction. For the first time, the team proved that large seismic slips do in fact occur even in shallow faults, because a large drop in frictional stress hastens sliding of the fault.

The results were published on October 8, 2013 (JST) in the scientific journal *Earth and Planetary Science Letters*.

Title:Fluid transport properties in sediments and their role in large slip near the surface of the plate boundary fault in the Japan Trench
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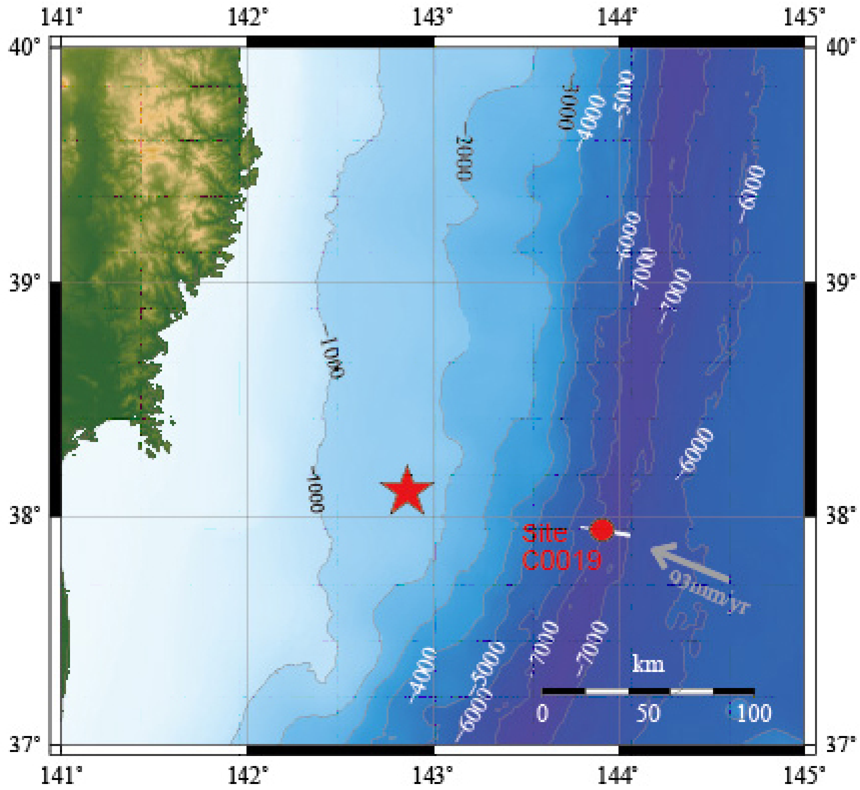

Figure 1: Drill Site

Drilling for JFAST was conducted about 220 km off the Oshika Peninsula, Miyagi, Japan at a site near the axis of the Japan Trench (Site C0019, water depth 6889.5 m). Grey arrow and numbers: Direction of movement of the Pacific Plate and annual speed Red Star: Epicenter of the 2011 Tohoku earthquake main shock White Line: Location of Figure 2 crustal structural cross-section

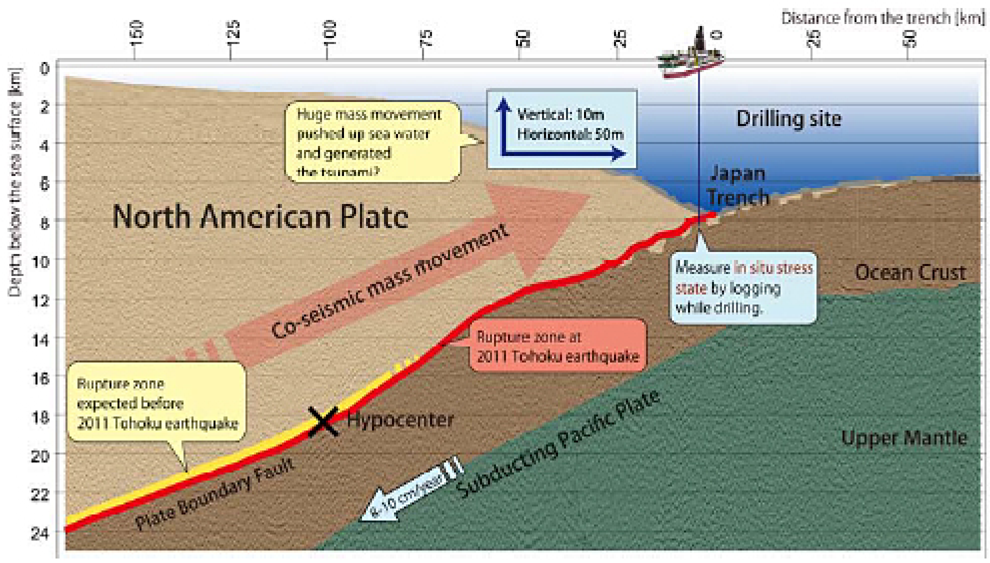

Figure 2: Conceptual image of sub-seafloor structure at the drill site

According to conventional models of subduction zone earthquakes, strain and stress build up over time on an asperity at the deep part of the plate boundary (yellow portion). A major earthquake occurs when the asperity ruptures and slips. The 2011 Tohoku earthquake is suggested to have caused a massive slip close to the trench axis of the plate boundary that exhibits frictional properties of stable sliding. The sea floor near the trench axis moved significantly in both horizontal and vertical directions during the earthquake and displaced massive volumes of sea water causing a huge tsunami.

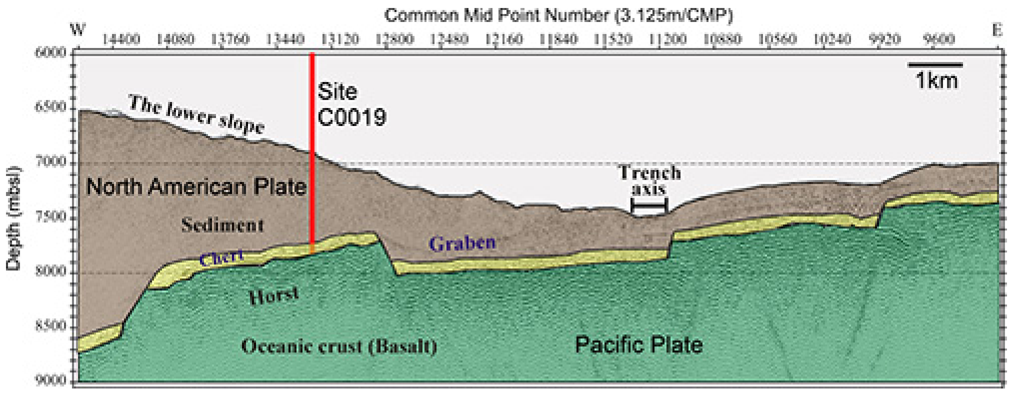

Figure 3: Geologic cross-section of Site C0019.

The vertical red line shows the drilling location and approximate drilled depth.

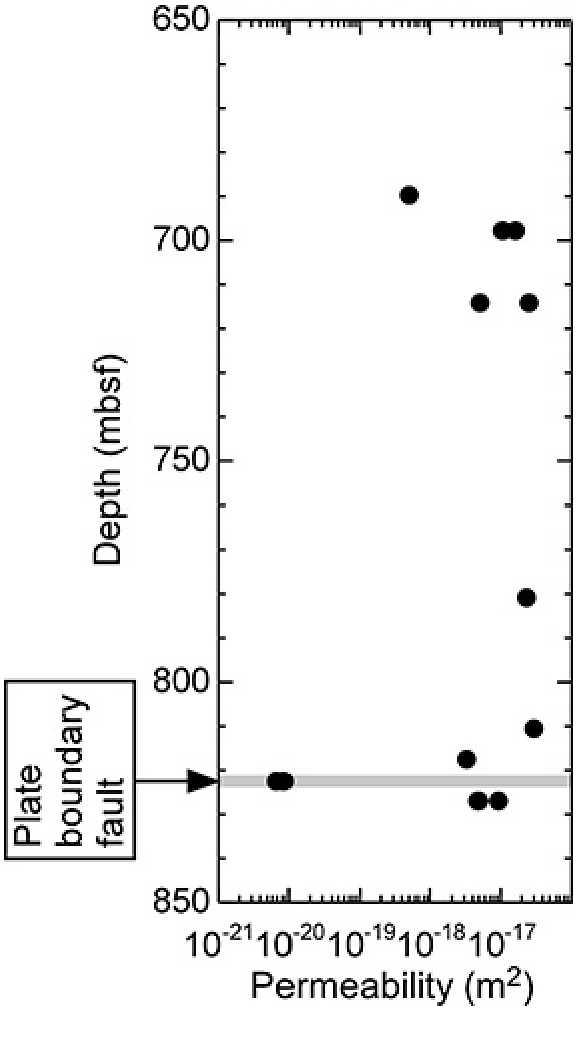

Figure 4: Depth distribution for hydraulic conductivity from 680 m to 830 m below the seafloor.

Fluid flows easily where the hydraulic conductivity is large. The plate boundary fault is located close to 820 m below the seafloor.

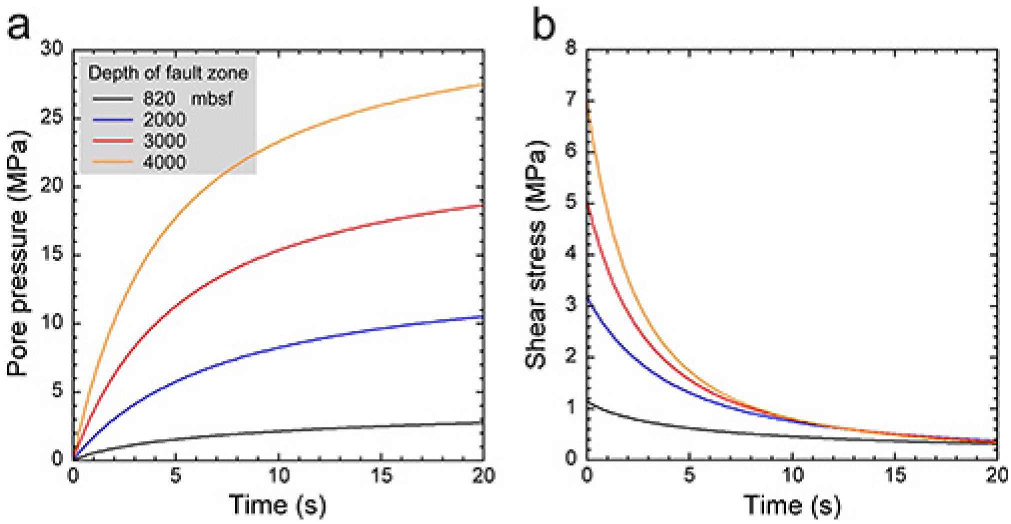

Figure 5: The change in fluid pressure (Fig. 5a) and shear stress change (Fig. 5b) following fault slip

The figures show the changes in both fluid pressure and shear stress relative to the different depths of the plate boundary fault. When the fluid pressure rises, the sliding friction force drops. In other words, a rise in fluid pressure leads to a lower slip resistance for the fault.

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