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JFAST: A Proposal to Drill into the Fault Zone of the 2011 Tohoku Earthquake

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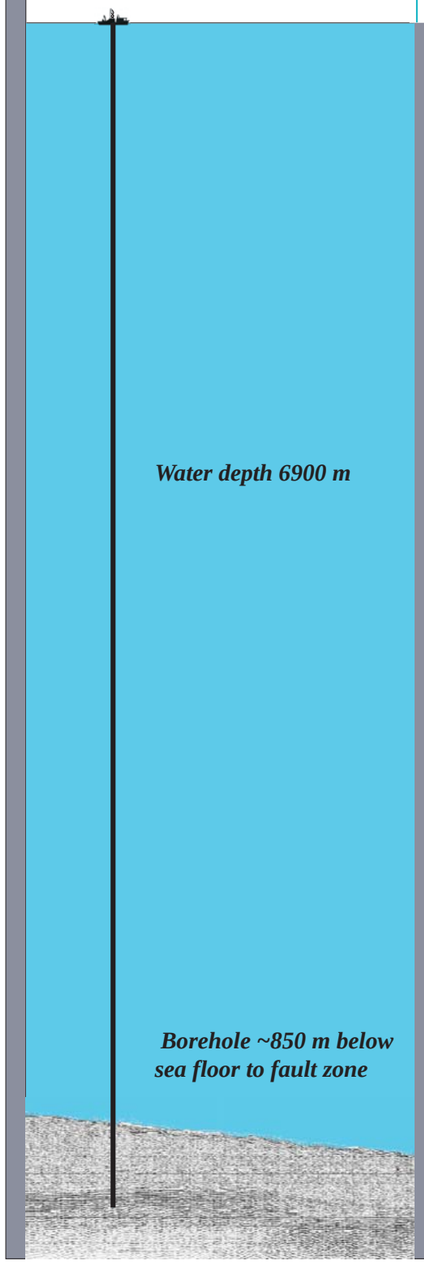


Scientific Objectives

The main science goal of the Japan Trench Fast Drilling Project (JFAST) is to understand the physical mechanisms and dynamics of large slip earthquakes. Specifically, the level of frictional stress during the earthquake rupture and the physical characteristics of the fault zone will be investigated.

Using the RV Chikyu a first borehole will be drilled with Logging while Drilling (LWD) to precisely locate the fault. A second nearby boreholewith by drilled with rotary coring to sample the fault zone. Both holes will be cased and installed with temperature and pressure sensors.

Geologic and geophysical borehole data will address the following issues.

1) What was the stress state on the fault that controls rupture of the earthquake? Was the stress completely released? What stress state allows the rupture to propagate to the toe of accretionary wedge?
Potentially the most significant result of this project will be a value for the dynamic coefficient of friction for the fault.

2) What are the physical characteristics of the fault zone of large earthquakes, especially in regard to frictional properites? How can we distinguish present and past events in fault zone cores?

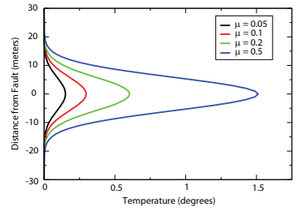
3) Secondary science objectives include carrying out geological, geochemical, and microbiological observations to the greatest extent possible during drilling

Temperature Measurements

The key to understanding the dynamics of large ruptures, is to know the level of friction on the fault. One of the most direct ways to estimate the fault friciton during the earthquake, is to measure the residual heat on the fault zone.

Past temperature measurements have only been done for the 1999 Chi-Chi, Taiwan and 2008 Wenchuan, China earthquakes. The results from both of these earthquakes have shown much lower values of friction that expected. Such low values of dynamic friction need to be verified.

The Tohoku event represents the rare opportunity to measure the friction for the largest slip (30 to 50 m) that has ever been observed for an earthquake.



Estimated temperatures across the fault 18 months after the earthquake, for a slip of 30 meters and various values of the coefficients of friction (μ).

Fault Zone Sampling

Detailed analyses of textures and small-scale structures of core samples of the fault zone will be used to infer the role of fluids and pressurization during rupture. We will look for evidence of melting and other processes that contribute to dynamic strength reduction. Trace elements will be used to estimate the thermal history of the recent and past events.

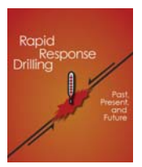
Another important component will be laboratory experimentson fault zone samples from the core. High-speed friction and petrophysical experiments on fault material can be used to characterize the frictional behavior of the fault.

Rapid Response Drilling

As highlighted in the reports listed below, a number of important time-sensitive measurements need to be made soon after an earthquake, such as fault temperature, fault zone permeability, and changing chcmical properties.

The JFAST project represents a rapid mobilization of IODP drilling facilities to measure these time-dependent properties

March 11	2011 Off the Pacific Coast of Tohoku Earthquake
March 30	Rapid Drilling proposed at IODP Science Planning Committee (SPC)
May 18-20	IODP Detailed Planning Group (DPG) Meeting
June 8	DPG Report Submitted Rapid Response Drilling Following Tohoku Eq. http://www.iodp.org/RRD-DPG/
August 1	JFAST Full Drilling Proposal Submitted
April 1 (??)	JFAST Drilling of Earthquake Fault Zone

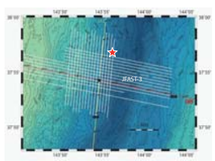


ICDP Workshop in November 2008
Full workshop report:
http://www.pmc.ucsc.edu/~rapid/
Scientific Drilling article: September 2009
EOS article: July 6, 2010

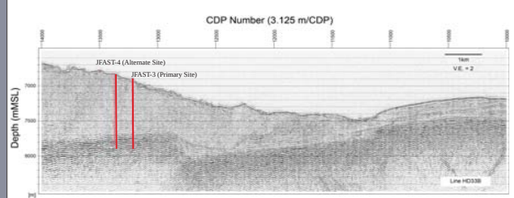
Site Selection

The target of the JFAST drilling is the fault zone where there was large slip of tens of meters. Repeat bathymetry surveys before and after the earthquake indicate that the large slip occurred on the main subhorizontal megathrust (not on steeply dipping splay faults).

Choosing an appropriate site is constrained by limitations of the *Chikyu* riserless drilling. The maximum water depth is 7000 m and maximum fault depth beneath the ocean floor of 1000 m. The primary location for the drilling is site JFAST-3.



Following the earthquake, high resolution bathymetric and seismic surveys were carried out in the area of large slip close to the trench by JAMSTEC

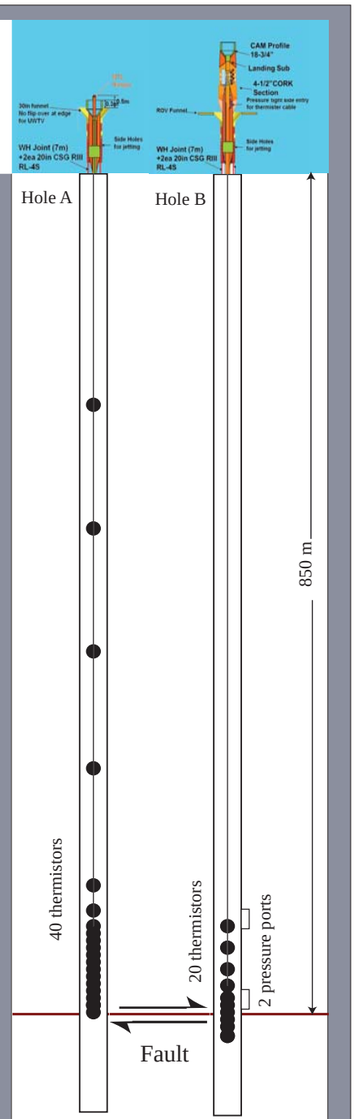


Importance for Understanding the Devasting Tsunami

Past thinking was that fault zone in the region of the accretionary wedge is weak, so that stress does not accumulate and large slip does not occur there during great subduction earthquakes. The 2011 Tohoku earthquake has shown this is not always the case. The huge amount of slip on this shallow portion of the fault, along with the large water depth, were the main source of the very large tsunami that caused so much damage and loss of lives along the coast of northeast Honshu.

Understanding the stress conditions for this shallow portion of the megathrust may be the most important seismological issue for this earthquake. This also has obvious consequences for evaluating future tsunami hazards at other subduction zones around the world.

Geological Setting



Temperature and pressure monitoring will continue for several years after installation. Data will be retrieved periodically with the *ROV Kaiko*