Temperature data to reveal frictional heat generated by fault slip during the Tohoku earthquake

May 1 2013, by Tim Stephens

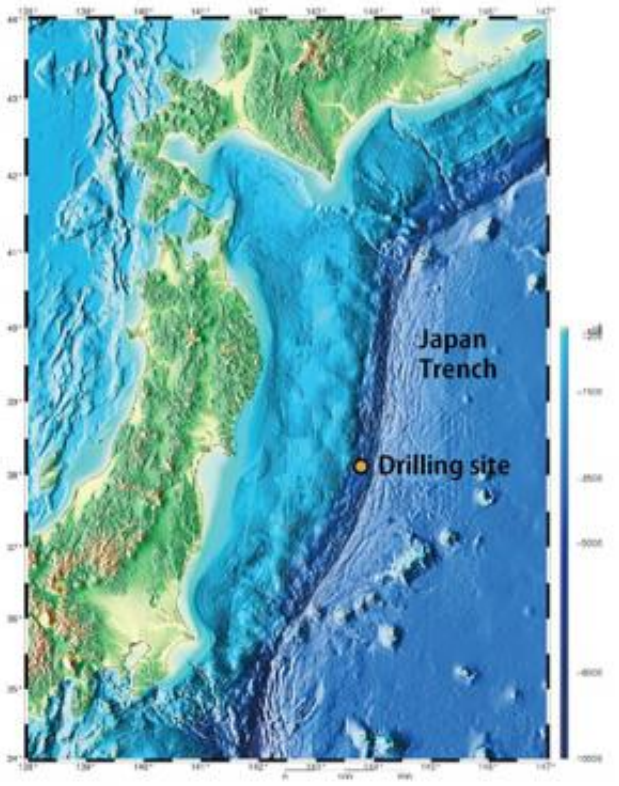


Figure shows the drilling site of IODP Expedition 343/343T.

With the successful retrieval of a string of instruments from deep beneath the seafloor, an international team of scientists has completed an unprecedented series of operations to obtain crucial temperature

measurements of the fault that caused the devastating Tohoku earthquake and tsunami in March 2011.

Emily Brodsky, a professor of Earth and planetary sciences at UC Santa Cruz, helped organize the Japan Trench Fast Drilling Project (JFAST), which successfully drilled across the Tohoku earthquake fault last year and installed a borehole observatory nearly 7 kilometers beneath the ocean surface. UCSC research scientist Patrick Fulton was on board the research vessel Kairei, operated by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), for the retrieval of the string of pressure and temperature sensors that was installed across the fault zone at about 800 meters beneath the seafloor.

This was the last phase of operations for JFAST, designed to investigate the huge slip (50 meters or more) on the shallow portion of the plate boundary fault that was largely responsible for the Tohoku earthquake and tsunami. The data recovered from the sensors provide a very high-precision record of temperature at 55 different depths across the plate boundary. Many of the sensors also recorded water pressure.

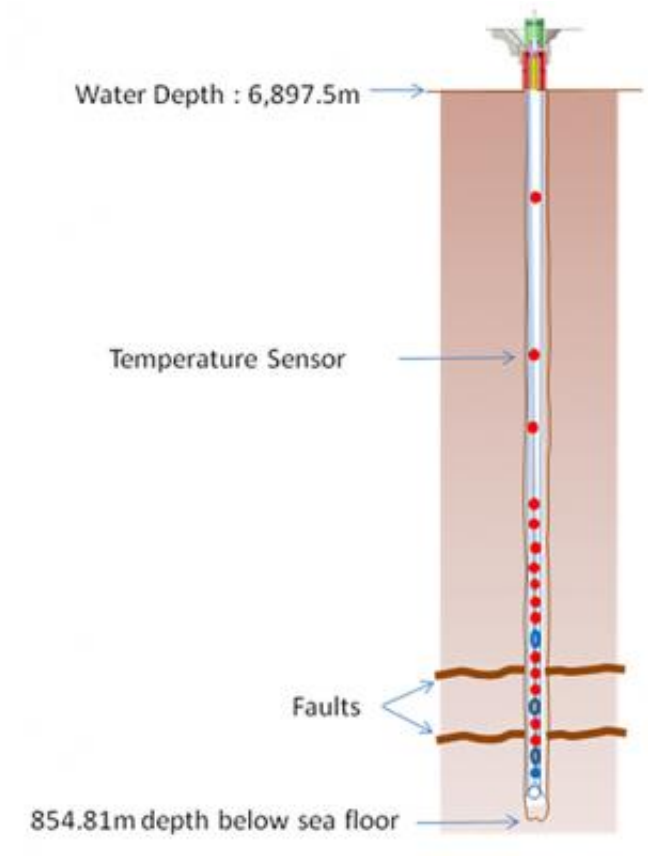


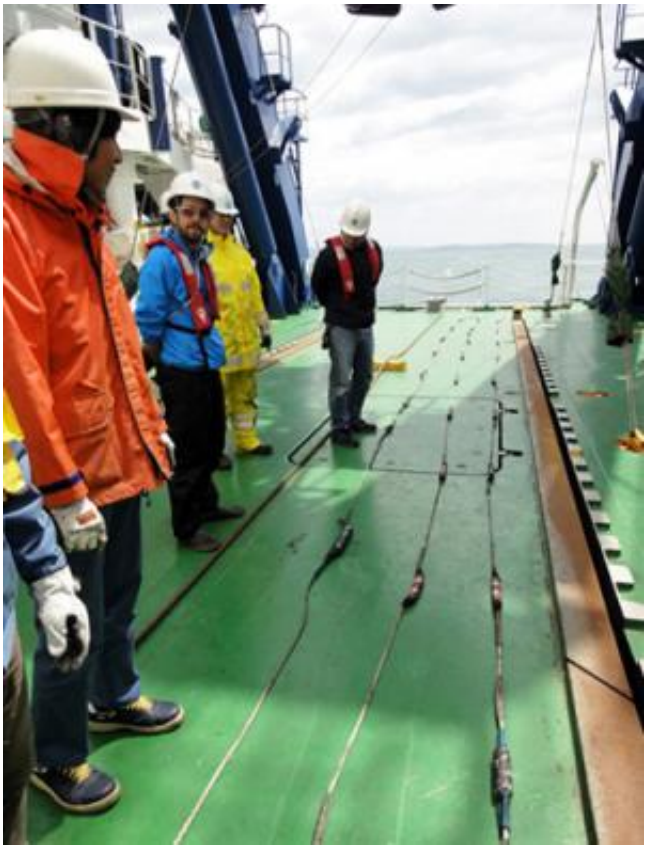
Figure shows the temperature sensor assembly in the borehole. Total 55 temperature sensing loggers were installed and successfully retrieved after about nine-month measurement.

"We will be analyzing the data to characterize the amount of frictional heat on the fault during the Tohoku earthquake," Fulton said. "We'll also be closely investigating the effects of other processes within the subsurface, such as groundwater flow and seafloor movement due to aftershocks. It is exciting to finally have this amazing data in hand."

According to Brodsky, the entire project was unprecedented on many levels. "Nobody had done rapid-response drilling in the ocean, nobody had drilled anything substantial under 7 kilometers of water, nobody had placed an observatory in a fault that deep, and nobody had retrieved a

string of instruments from that deep," she said.

The scientific drilling vessel Chikyu installed the observatory in a dedicated borehole that penetrated 855 meters below the seafloor in a water depth of 6897.5 meters during the Integrated Ocean Drilling Program (IODP) Expedition 343/343T, April-July 2012. Brodsky said the team was very worried after an earthquake occurred in the area in December, raising the possibility of an undersea landslide that could have buried the wellhead of the observatory. So it was a great relief when the instrument string was successfully recovered on April 26, 2013.



UCSC researcher Patrick Fulton (blue jacket) and other scientists examine the retrieved instrument string on the deck of the research vessel Kairei. Credit: JAMSTEC

The recovered sensors provide data that will be used to determine the frictional heat generated by fault slip during the Tohoku earthquake. Scientists will infer the forces on the fault during the earthquake from these measurements of dissipated energy. The new data are critical to understanding the causes of the large, shallow displacements during earthquakes that can generate devastating tsunamis. The JFAST observatory provides the first temperature measurements at a subduction plate boundary fault immediately after an earthquake.

Fulton described the recovery operation in an email from aboard the Kairei: "Everyone was overjoyed in the Kaiko ROV control room as we started to faintly see the observatory come into view and the words 'wa suranai 3.11' we had painted on the side of the observatory, which means: 'Never forget 3.11,' the day of the earthquake and tsunami. We then used the ROV robot arms to grab the sensor string and then pull the sensors out of the hole. It was a tense moment and I was extremely uneasy. There was a very strong possibility that the fault may have continued to move, [trapping] our sensor string. It was a few very long seconds until we realized that everything was coming out smoothly and we had probably recovered everything. A few hours later, under a starry night with a lightning storm brewing on the horizon, we had pulled the sensor string onto the boat and confirmed we had all 55 sensors."

Brodsky and Fulton will be busy analyzing the data over the next few weeks in preparation for the Japan Geoscience Union Meeting, May 19 to 24, when they will present some of the initial results.

Provided by University of California - Santa Cruz