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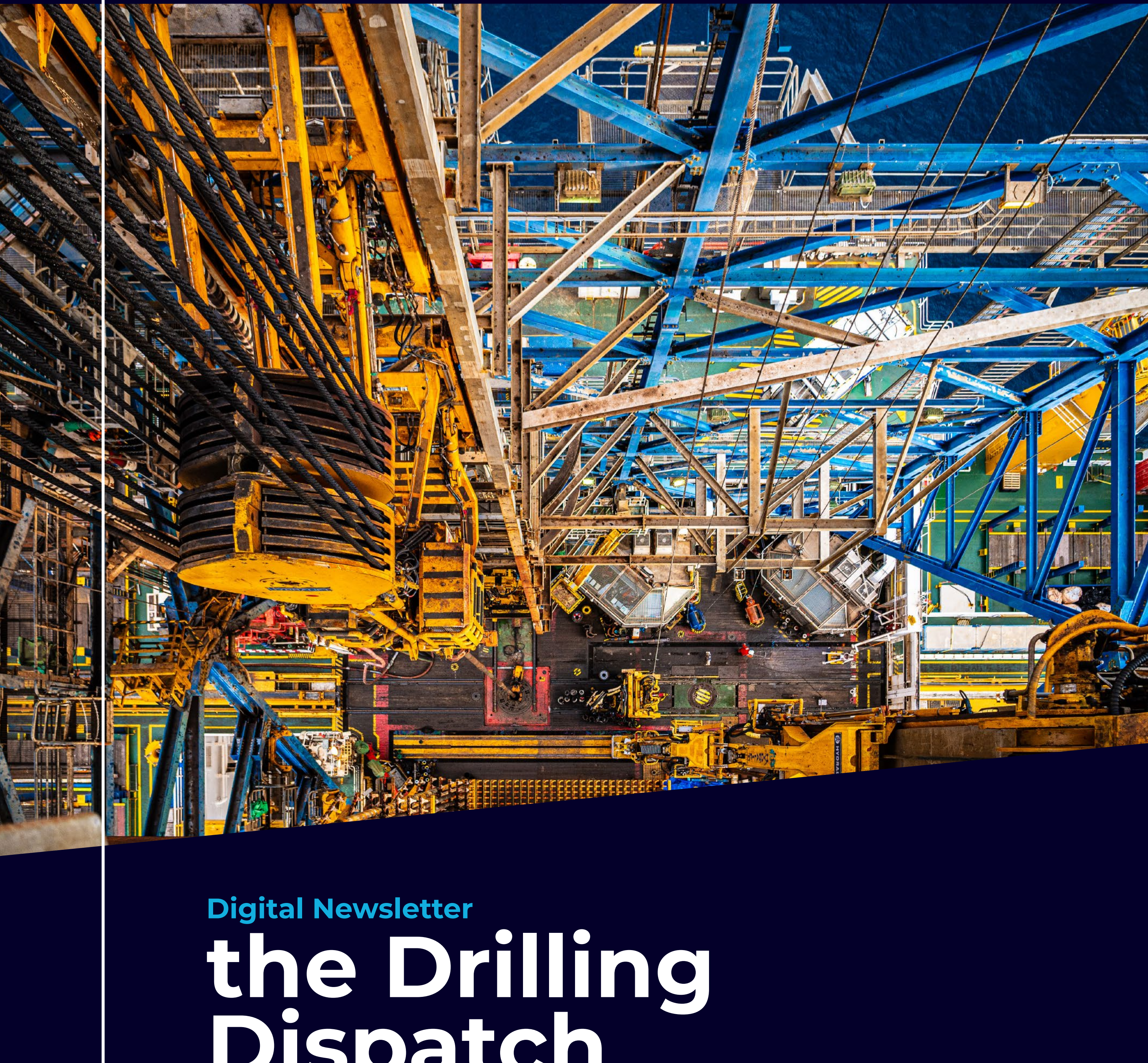
CREDIT: Dick Peterse & JAMSTEC/IODP



Digital Newsletter

the Drilling Dispatch

December 2024

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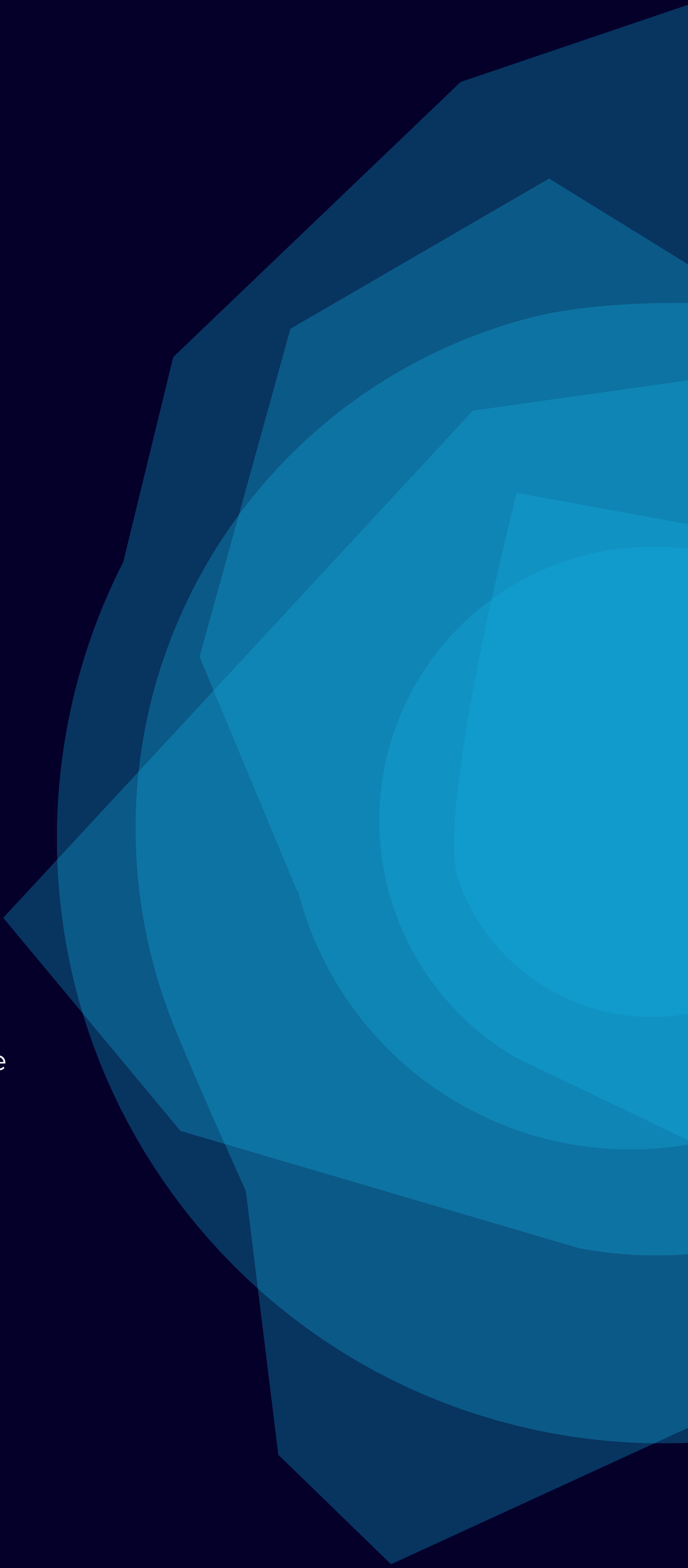


In This Issue

Happening now...
Expedition 405: Tracking Tsunamigenic Slip Across the Japan Trench (JTRACK)

Expedition 405 Co-Chief Scientists
Shuichi Kodaira, Marianne Conin, Patrick Fulton,
Jamie Kirkpatrick, Christine Regalla, and Kohtaro Ujiie

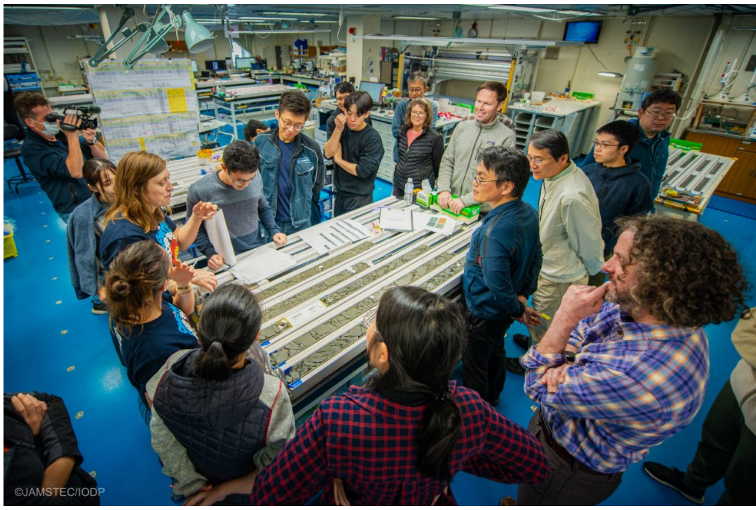
Expedition Project Managers
Natsumi Okutsu, Lena Maeda, Sean Toczko, and Nobu Eguchi

written by Maya Pincus, Expedition 405 Onboard Outreach Officer

On the crest of the wave

Over 260 kilometers east of the nearest landmass, roughly 7000 meters above the seafloor, the drilling vessel *Chikyu* hums with activity. Now entering its fourth and final month, Expedition 405: Tracking Tsunamigenic Slip Across the Japan Trench can report great advances in the effort to shed light on the conditions that led to the cataclysmic 2011 Great East Japan (Tōhoku-Oki) earthquake and tsunami.

The crossover period between science party Windows 1 and 2 was a tightly choreographed transition over the course of several days, with frequent helicopter flights depositing researchers fresh from their home institutions and carrying off those who had just completed two months at sea. Incoming scientists were shuttled almost directly from the helideck to the labs, where they were met with a backlog of cores from the extraordinarily successful small diameter rotary



TOP: Window 2 scientists were ferried to the *Chikyu* by helicopter (Yu-Chun Chang & JAMSTEC/IODP). BOTTOM: Scientists share their observations and interpretations of a core (Dick Peterse & JAMSTEC/IODP).

LEFT: Paleomagnetologists Taizo Uchida and Sara Satolli discuss their findings at the crossover between shifts (Dick Peterse & JAMSTEC/IODP). RIGHT: Scientists prepare to divde a new core into sections (Ron Hackney & JAMSTEC/IODP).

core barrel (SD-RCB) drilling ongoing at expedition Site C0019. Given the urgency of the situation, the dedication with which the newly arrived scientists got to work cannot go unacknowledged.

The situation only intensified from there. Once SD-RCB coring into the plate boundary fault was completed, operations switched to the hydraulic piston coring system (HPCS), a method for sampling shallow soft seafloor sediments that has become so efficient—especially considering how much time the core barrel spends traveling up and down seven kilometers of pipe—cores were coming up to the rig floor every three hours. Offshore Installations Manager Charlie McGregor, who oversees the drilling operations, described the tension between wanting to recover as many cores as possible while still acknowledging that scientists need ample time to analyze the fresh samples. It gets to a point where the core flow process can only go as quickly as the laboratory equipment allows. “I’m always encouraged to go faster, faster, faster,” he said in his brusque Scottish accent, “but we in operations need to remember that scientists need time to process the cores when they come up!”

Researchers eagerly spent up to 14 hours a day on their feet, trying to keep pace with the excitement of fresh sediment cores being recovered from increasing depths. The labs bustled in a frenzied ballet as scientists and marine technicians orbited instruments and tables, compiling an archive of data that will be used in research for many years to come. Scientists worked so hard and so effectively that by the end of the fifth week of Window 2, they had earned themselves a well-deserved day off to catch up on rest. Not only did this break do wonders for morale, it gave them the mental space to ponder potential interpretations of the features in their cores.

Waiting on weather, waiting on rock

Relatively warm (23°C) Pacific waters have kept the skies roiling with clouds and rain, to the extent that this outreach officer's embarkation by helicopter was delayed a day to avoid a storm. Strong winds rocked the ship just enough to induce seasickness in the more sensitive scientists, and foreshadowed a need to wait on weather as the crew got to work tripping pipe.

As the expedition was planned, JTRACK had three priorities for coring at both sites: (1) drilling down to the plate boundary fault zone in order to collect rocks from the interface between the incoming Pacific plate and the overlying Eurasian plate, (2) sampling the sediments around the fault zone to better understand the stresses and deformation propagating through the region, and (3) coring down to the basalt basement in the incoming Pacific Plate. By November 15th, two of these goals had been accomplished, meaning that "We are now living in bonus days," in the words of Co-Chief Scientist Patrick Fulton. That meant there was plenty of time for the third coring priority: SD-RCB drilling to even greater depths, with the goal of collecting basaltic rocks from the oceanic crust beneath the plate boundary fault zone.

It took more than 20 hours for the drilling team to trip over seven kilometers of pipe back to the rig floor, where the previously used HPCS bottom hole assembly could be exchanged for a new SD-RCB system. It then took another day to reconstruct the drill string to return to the depth the bit had just left.

The first estimate for core on deck was set at noon on November 20th. Then it was 4:00 PM, or maybe 6:30. The outreach team discussed strategies for efficiently donning PPE and racing to the core receiving area with cameras in hand, ready to document the event. When the ETA was pushed back to 10:00 PM, we started to consider how late we were willing to stay up, especially when one of us had a live broadcast scheduled for 2:00 the next morning (which, because of the time difference, translates to a much more reasonable mid-day event in the U.S.). When the OIM adjusted the prediction to midnight, we made a pact to use the room phones to wake each other up so we could all be there for the momentous first core. We started our days on November 21st having slept peacefully through the night, and upon waking learned that the drill had been rotating for hours with almost no advancement. The drilling team was no longer willing to provide a target time for us to hope.

After so many futile hours, the expedition management team decided to try something new.

TOP: The contrast between a new center bit (left) and the one recovered from Hole C0019M (right) (Dick Peterse & JAMSTEC/IODP). BOTTOM: Chert – 1 point. Drill bit – 0 (Lena Maeda & JAMSTEC/IODP).

Let the report writing begin! (Dick Peterse & JAMSTEC/IODP).

Drillers pulled the center bit out of the drill string to see what they could learn from its appearance and if any progress could be made with just the coring bit. What they discovered was striking if not surprising: the specialized tool made of steel and tungsten carbide was polished almost completely smooth. Though this result was disappointing, it was not unexpected. Lying above the basaltic ocean crust was a roughly 100m thick layer of chert. This rock, formed of microcrystalline quartz, is a formidable opponent to any drill bit. Removing the center bit had no effect on drilling advancement, so the next step could only be to withdraw the entire drill string, install a new bit, and try again. Once a free-fall funnel was deployed, it was like living the same day twice. It took more than 20 hours for the drilling team to trip over seven kilometers of pipe back to the rig floor, change the bit, and trip back down to the seafloor, with a new operational plan to drill straight through the chert. This strategy means scientists will focus their efforts to recover basalt from this site alone.

The days spent waiting on this multi-day operation are not unproductive. Co-chief scientist Jamie Kirkpatrick offered some zen advice for what might begin to feel like a holding pattern: “[Being in between cores for so long] is a different way to exist on *Chikyu*. Use this time to keep your mind fresh and your brain active.” The Window 2 science party is taking this to heart, using the time without core to think more deeply about their work. At the daily update meetings, scientists have been presenting pop-up talks to share their plans for post-cruise research. This not only serves as a way to get to know each other’s interests; the presentations are becoming ample inspiration for future collaborations.

(Beatriz Martinez-Rius & JAMSTEC/IODP).

The final phase

Where things stand, JTRACK has achieved enough to satisfy even the most insatiable scientist, with over

LEFT: A core barrel newly recovered from the seafloor is readied by drillers to be handed over to scientists. MIDDLE: Drillers make up the bottom hole assembly with a new SD-RCB bit. RIGHT: Window 2 scientists and new marine technicians are given a tour of ship operations. (Dick Peterse & JAMSTEC/IODP).

700 meters of sediment and rock collected from 165 cores from nine holes from two sites. Shipboard analyses for these sections are complete, personal samples have been collected, and now Window 2 researchers are hard at work compiling site reports for publication. After the new attempt to core basalt from Site C0019 times out (cores or not), the final phase of the expedition will begin with the installation of a borehole observatory.

Modeled after the JFAST observatory, which was successfully reinstrumented during Window 1 of this expedition, this new long-term monitoring system goes deeper than the previous one and with more than double the number of sensors. In a seemingly impossible feat, the team will place a long string of sensors into a new observatory hole, where they will collect temperature data to an accuracy of ~0.001°C every ten seconds until the observatory can be retrieved during a future expedition. By studying minute temperature changes over time and depth, scientists will map fluid flow and heat conduction in the fault zone, shedding light on the conditions that engendered unforeseen shallow slip in a fault zone, and, as stated in the Expedition 405 *Scientific Prospectus*, "providing valuable insights for assessing earthquake and tsunami risks worldwide."

Less than one month remains to End of Expedition, but the research is just beginning. With several "first look" papers in the works, and thousands of personal samples still to process, JTRACK will contribute to global natural hazard research well into the future.

How to...

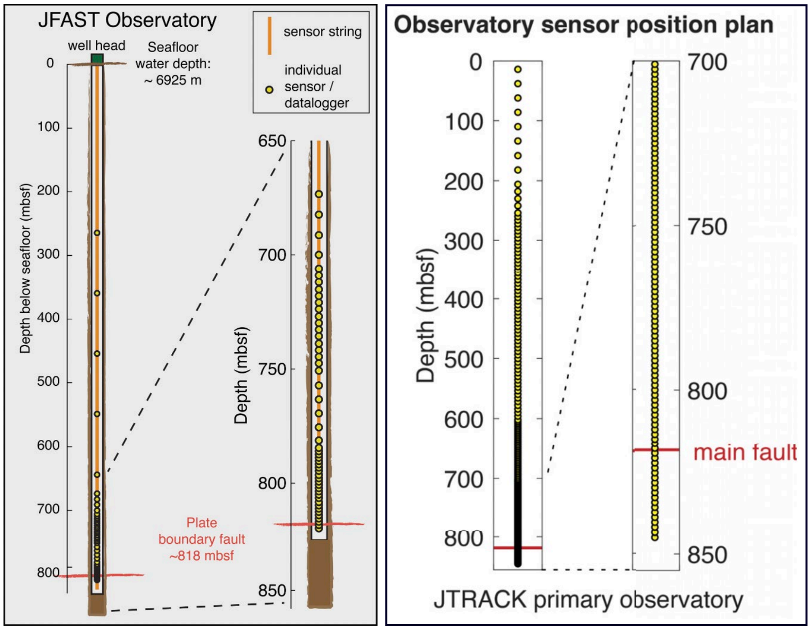
Design and build a borehole temperature observatory

written by Maya Pincus, Expedition 405 Onboard Outreach Officer
with help from Patrick Fulton, Expedition 405 Co-Chief Scientist

Expedition 405: Tracking Tsunamigenic Slip Across the Japan Trench is preparing to enter its final phase: the drilling and installation of a new long-term borehole observatory at Site C0019. This monitoring station, modeled after a similar system installed during JFAST, will record *high-resolution spatially dense time series measurements of borehole temperature* to depths almost a kilometer below the seafloor.

Why go through the trouble? In a nutshell, "We want to measure temperature underground," explains Expedition 405 Co-Chief Scientist Patrick Fulton, lead proponent of the observatory project. JFAST scientists were initially interested in measuring subseafloor temperature after the 2011 Tōhoku-oki earthquake to measure the residual heat caused by friction during the megathrust event. By monitoring thermal anomalies over time down the length of the drilled hole—which crossed the plate boundary fault along which the earthquake was generated—it became possible to determine the amount of dynamic friction on the fault during the earthquake. They discovered that the fault was incredibly slippery; there were effectively no lithological "brakes" to stop the rupture at this site (Fulton et al., 2013). In addition to measuring the frictional heat, the temperature data also enabled the scientists to map the hydrogeologic structure of the crust where the earthquake took place and see how the fluids move around in response to continued aftershocks in the region (Fulton and Brodsky, 2016). Researchers have reason to believe that fluid flow in the Earth's crust plays an important role in how stresses are distributed along faults, which can determine, where, when, and how intensely ruptures can occur.

When synthesized with data acquired from cores and downhole logging, observatory measurements are one more piece of the puzzle that will help us identify the factors that lead to great earthquakes. Now, after two years of meticulous planning, the new JTRACK observatory is almost ready for installation. This article outlines its development, from initial ideation to eventual data retrieval.



Schematics of the JFAST (Chester et al., 2013) and JTRACK (Kodaira et al., 2023) temperature observatories.

- **Step 1: Design the sensor array**

Not unsurprisingly, there are many factors to consider when planning a subseafloor observatory, in terms of both data collection and engineering. The two biggest questions can be summarized as *How can we make the measurements we want?* and *How can we get the data back?* In the case of JTRACK, we want a record of temperature that is high-resolution in space as well as time, meaning we need A LOT of sensors that make A LOT of measurements.

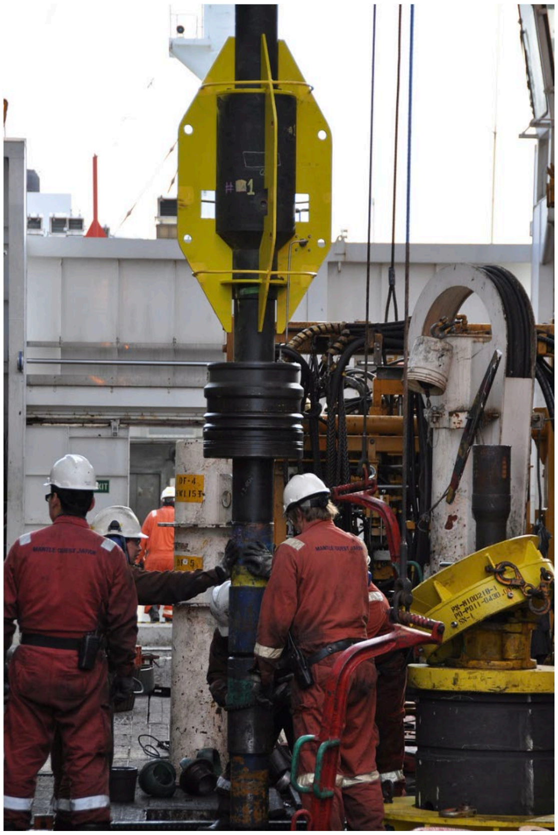
The JFAST observatory comprised a record-breaking 55 sensors over its 821 meter length. This offered scientists a first look at underground pathways of fluid flow, "essentially underground springs that change in response to earthquakes" as Patrick describes it. For the new JTRACK observatory, the goal is to continue this long-term observation in even higher-resolution, mapping where water moves through fractures and permeable rocks. To determine where to place the sensors, we are relying on downhole logging data and cores collected during the earlier phases of the expedition. "If we see something in coring and logging that's really neat, like 'Ooh that's really interesting, we should measure around there,'" Patrick explains, we can concentrate sensors in those target areas. Since "some of the signals that we want to see are really, really small, and they're probably distributed all at different depths," it is necessary to space the sensors in a way that aligns to existing observations.

In the planning phase, "We spent a lot of time trying to think about where we want the sensors," Patrick recalls. "We definitely want them across the plate boundary fault but also deeper. And we've also found some other shallower features that we want to highlight." While the primary area of interest remains the plate boundary fault, Expedition 405 researchers are eager to see the bigger picture in the surrounding rocks and sediment below the seafloor.

- **Step 2: Source the supplies**

The success of an observatory is fundamentally linked to the materials it is made of. In this case, the main considerations are the sensors themselves, as well as the rope that will support them. The sensors will reach depths almost eight kilometers below the sea surface, meaning they will be subjected to almost 800 times the ambient pressure we experience at sea level. Patrick cautions against using materials that are standard in sensor casing, matter-of-factly stating, "they will implode if you just put down something that's cased in plastic or steel."

Instead, the sensors must be enclosed in titanium, a metal strong enough to withstand the deep sea. Patrick has been collaborating with an oceanographic instrument manufacturer to design and build the streamlined instruments, ensuring that they are sensitive enough to measure accurately to around 0.001°C.



Drillers prepare the JFAST observatory for deployment. (JAMSTEC/IODP)

For this job, it is necessary to use “a special type of rope that is super strong.” Patrick specifies, “We want a rope that does not stretch at all, so that when we put it in the borehole, we know our sensors are going to be exactly at the depths that we think they’re going to be.” This can be best understood with a thought experiment: Even if the rope stretches by just one percent, that means that for a 900m long observatory, the bottom-most sensors could come to rest up to nine meters deeper than intended. The ideal rope is made of a material called Vectran, a synthetic fiber that can support the weight of the instrument array even at a diameter of less than half an inch.

- **Step 3: Put it all together**

Once the sensors are programmed, it’s time to ready them for the ocean floor. Moisture is a huge concern, as even the tiniest drop can cause a sensor to short-circuit. If there is any water vapor in the casing, it will condense when it reaches the near freezing temperatures just above the seafloor. So, before the titanium cases are sealed with two O-rings to keep out water, they are filled with a silica desiccant and pumped with nitrogen to help remove any moisture.

TOP: Patrick inspects the new set of 128 sensors (Credit: Dick Peterse & JAMSTEC/IODP). BOTTOM: To form the JFAST instrument string, sensors were first attached to the rope, then wrapped in a protective coating (Credit: JAMSTEC/IODP).

The sensors are tied on using a double fisherman’s knot (“It’s a special knot, but we can all learn it,” Patrick asserts). Spaced at intentional intervals between the sensors are planned “weak links,” where the rope is designed to break in case some sensors get stuck if rocks around a fault shift and pinch the observatory. In case of a snag, it’s better to let a few sensors break off than to lose the whole string of sensors

The final step to prepare the sensors for deployment is to cover them with a protective rubber coating wrapped with tape, which serves the dual purpose of providing a smooth surface that will make insertion and retrieval much easier and protecting them from rattling along the walls of the observatory. Through experiments and experience, Patrick learned that all-weather, all-purpose Gorilla tape is really effective for this job (“Duct tape sucks under water. It has no stick in the water, so it will just fall off.”) Colorful “top of the line” electrical tape composes the final layer, so that scientists can write labels along the rope and keep track of how much of it has been inserted.

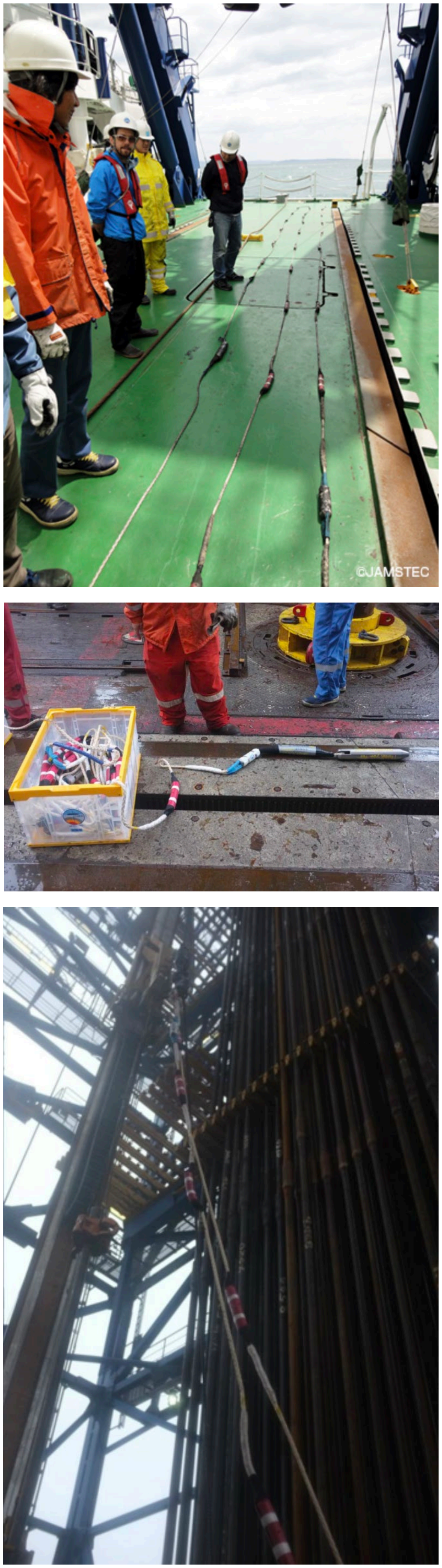
Readers should remember that this process must be repeated for each of the 100+ sensors. Knowing that he will be assisted by a team of scientists and laboratory technicians, Patrick is optimistic that the entire process can be completed in just a few days.

- **Step 4: Deploy!**

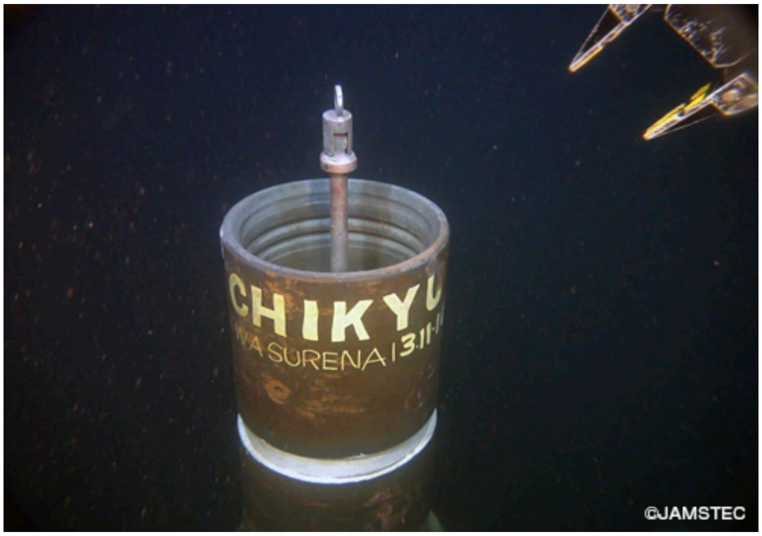
The array of sensors is not technically the borehole observatory; rather, it is the instrument string that will be housed within it. Deployment of the observatory itself involves not just the production of the instrument string, but also a series of drilling operations to prepare the hole and install the observatory. First, the location of the new hole must be outfitted with a conductor tube, a ~30-inch diameter pipe that is pushed into the seafloor as the observatory base. From there, drillers need to trip pipe back up to the ship, convert the bottom hole assembly to a drilling system, trip back down to the ocean floor, locate the conductor pipe using the underwater television, and drill through the conductor pipe to the target depth.

The instrument string resides within a ~900m long steel tube assembled below the ship that protects the sensors from potential hole collapse underground. A valve at the bottom of this tube allows water to circulate out during installation, but then prevents new water from entering and skewing the data from the bottom. With a 17kg sinker bar attached to the bottom to weigh it down, the instrument string is then threaded through the tube from the rig floor, topped with another, much heavier weight, and attached to a hanger that fits into the top of the tubing within the wellhead that serves as a cap to the observatory.

When the observatory finally is assembled below the rig floor, drillers connect to the wellhead with drill pipe and once more trip down to the ocean floor. The observatory will be inserted into the conductor tube and then released from the drill pipe to gather high-resolution temperature data until the sensor string is later retrieved.



To prepare for deployment, the instrument string must first be carefully laid out on the rig floor, inspected one more time, connected to weights at either end, then brought to the top of the derrick to thread through the casing that will house them (Credit: JAMSTEC/IODP).



TOP: The top of the JFAST wellhead prior to recovery (Credit: JAMSTEC/IODP). BOTTOM: Patrick works with Expedition 405 scientist Huiyun Guo ("an aspiring observatory scientist") to program the new JTRACK sensors (Credit: Maya Pincus & JAMSTEC/IODP).

- **Step 5: Recover the data**

Patrick hopes to leave the observatory in the ground for a minimum of several months, to ensure sufficient data is collected to tell the story. But eventually, it will need to be pulled back up to the ocean surface to access the millions of data points recorded by the sensors. This is one of the trickiest parts of the whole process.

Eventually *Chikyu* will return to Hole C0019Q, string together thousands of meters of pipe, relocate the wellhead, and connect to it a special up-side down funnel through which the core line can be used to grab the sensor string and winch it through the drill string up to the ship. The top of the sensor string's hanger was designed to mimic a core barrel, so *Chikyu* already has the infrastructure necessary to fish it up from the seafloor. Once successfully recovered, it's a straightforward process to cut the sensors out of the tape they are wrapped in, open the cases, and download the data.

Given all the work that goes into developing the borehole observatory, Patrick hopes that its use is not just a one-time thing, and that the instrument string can eventually be redeployed. "You can essentially open these things up, download the data, flip out the batteries, put new ones in, reprogram the sensors, and put it all back in." He is also confident that this could be accomplished in just a few hours. "*Chikyu* costs a lot, time is money. We'll have to have… not an army, but a peace corps… a peace corps of people that are here working in parallel" to prepare the observatory for immediate redeployment.

With its 128 sensors, the new JTRACK observatory is a first in the history of long-term borehole installations. "I don't know of anything in terms of temperature sensors and arrays like this that have had this many temperature sensors in high resolution," Patrick reflects. "But we saw *so much* when we put them together this close [during JFAST]. This way, we can really see how water is moving around faults and fractures and such." Though it will be quite some time before the data can actually be analyzed and understood, this final phase of Expedition 405 will be fundamental in understanding the hydrogeologic structure, properties, and conditions in plate boundary fault zones, and the role these factors play in seismic events.

FEATURED VIDEO

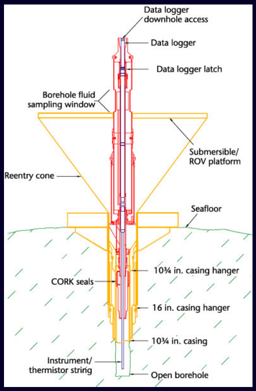
JTRACK Expedition Targets

IODP Expedition 405 is drilling into the Japan Trench subduction zone with the goal of finding out what controls shallow slip during great earthquakes.

For your calendar

- **Request for proposals: Workshops in support of Scientific Ocean Drilling**
  (deadline: 1 December 2024; learn more)
- **American Geophysical Union Annual Meeting**
  (9-13 December 2024; Washington, D.C., USA; learn more)
- **Apply for a Schlanger Ocean Drilling Fellowship**
  (application deadline: 20 December 2024; learn more)
- **Autonomous Investigation during Drilling workshop**
  (15-17 January, 2025; Massachusetts, USA; learn more)
- **U.S. Advisory Committee for Scientific Ocean Drilling meeting**
  (27-30 January 2025; Dauphin Island, AL, USA; learn more)
- **Provide input on Future Ocean Drilling in the U.S. (FOCUS)**
  (open deadline; learn more)

SCI COMM RESOURCE OF THE MONTH



Aboard the D/V *Chikyu*, Expedition 405 scientists prepare to install a subseafloor observatory to measure high-resolution temperature over time at multiple depths within the fault zone. In this activity, students learn about CORKs, another type of observatory.

Corks in the Crust

Spotlight on...

Marianne Conin

Dr. Marianne Conin is a geophysicist, geomechanicist, and a professor at the Université de Lorraine, France. One of the six co-chief scientists for IODP Exp 405, Marianne had her first experience aboard *Chikyu* in 2007 during IODP Exp 314 as a graduate student, as well as being part of the science party for J-FAST.

WATCH THE VIDEO!

Christine Regalla

Dr. Christine Regalla is a structural geologist at Northern Arizona University. One of six co-chief scientists for IODP Exp 405, Christine has sailed aboard Chikyu many times, the first time in 2012 as a science party member of IODP Expedition 343, J-FAST.

WATCH THE VIDEO!

Kohtaro Ujiie

Dr. Kohtaro Ujiie is a structural geologist at the University of Tsukuba, Japan. One of six co-chief scientists for IODP Exp 405, Kohtaro has sailed aboard *Chikyu* many times, first in 2007 as a science party member of IODP Exp 316. Kohtaro was also aboard J-FAST, again as a structural geologist.

WATCH THE VIDEO!

Call for contributions

If there's one thing that can be said about the International Ocean Discovery Program (and the Integrated Ocean Drilling Program, and the Ocean Drilling Program, and the Deep Sea Drilling Project), it's that we are a tight-knit community. Just as much as this newsletter is for you, we want it to be from you, too! In future editions we will highlight our readers by featuring the following community contributions:

- **From the Field** - Have you had an experience with scientific ocean drilling that you want to share? Write a piece to tell us your perspective "from the field" for our next edition. Bonus points if you include some pictures!

- **Scientist Spotlight** - Do you know someone who's making waves in the ocean drilling scene, whether it's a grad student or accomplished scientist? Send us a nomination! Briefly tell us why this person deserves a shout-out, and ideally how to get in touch with them. Self-nominations are also accepted.

- **Photo Montage** - We'll take any photos you want to share!

- **Creative COREner** - Scientists are creators too! Send in your paintings, drawings, digital designs, poems, short stories, sculptures, or any other ocean science art you've made.

Send your contributions (and questions and concerns) to mpincus@ldeo.columbia.edu no later than **December 20, 2024** to be featured in next month's newsletter.

See you next month!