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INDEX

Complex fault rupture processes simulated using the world's largest rock friction apparatus

Futoshi Yamashita (Research Division for Earthquake and Tsunami Generation Mechanisms, NIED)

NIED (National Research Institute for Earth Science and Disaster Resilience) has been conducting experimental research to understand the physics underlying complex rupture processes and their initiation by simulating and observing ruptures in detail in laboratory experiments with large rock specimens. We found that heterogeneity in the simulated fault controls the initial rupture phase and accompanying foreshock activity (Yamashita et al., 2021), and that the slip rate of slow slip events correlates with the foreshock activity that the slow slips induce (Yamashita et al., 2022). The simulated fault lengths for the first- and second-generation apparatuses used in these studies are 1.5 and 4.0 m, respectively. Although these are much longer than most simulated faults, it is difficult to observe fast rupture propagation in detail because the rupture edges reach the ends of the simulated fault shortly after nucleation. In addition, once initiated, the rupture does not stop midway along the fault, but rather propagates across the entire fault. Furthermore, the location of rupture initiation depends primarily on the loading conditions, and thus is not controllable.

To overcome these challenges, we developed a third-generation apparatus in 2023, which is larger than the second-generation apparatus (Fig. 1). The large black blocks within the apparatus frame (see Fig. 1) are stacked rock specimens. The contact or simulated fault area is 6.0 m long and 0.5 m wide, which is the largest in the world currently in operation. The normal load is applied using six hydraulic jacks installed between the frame and the top of the upper specimen. Then, a shear load is applied using a large hydraulic jack fixed to the western pillar of the frame, causing stick–slip events. Many strain gauges and displacement sensors are installed along the fault to monitor the local stress and fault slip, respectively.

We examined these data to understand how the fault ruptures during stick–slip events. We found that in most simple shear loading experiments, the rupture began propagating suddenly from the eastern end of the fault and moved to the west, with no obvious nucleation process. Next, we conducted an unloading experiment. We applied a shear load to the critical level, then reduced the load on the westernmost normal load jack, which caused a slip event. The data reveal fast rupture propagation, followed by clear nucleation around the unloading jack (Fig. 2a). This situation is mechanically equivalent to injecting high-pressure fluid into the fault.

We induced several further slip events in the central area of the fault by reducing the normal load around the center, then reduced the load on the westernmost jack again after shear reloading. Although this caused similar nucleation to the first event, the rupture stopped in the middle of the fault, and the eastern part of the fault did not slip (Fig. 2b).

The local stress data before the last partial event suggest that the shear stress on the eastern part of the fault did not recover sufficiently even after the shear reloading; consequently, the strain energy was insufficient for rupture propagation. This result shows that the rupture pattern and magnitude of slip events depend on the local stress distribution on the fault, even for a fixed macroscopic load and nucleation location. We will conduct further experiments to quantify the conditions that lead to the cessation of fault rupture.

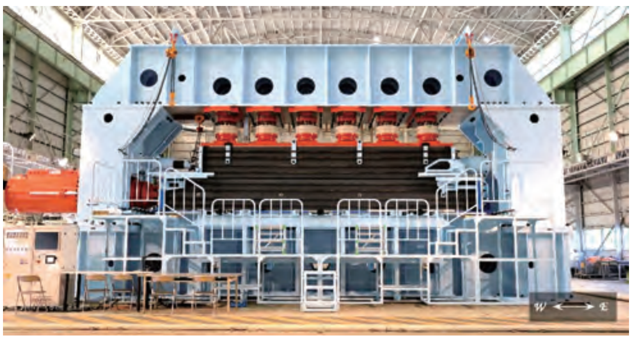

Figure1: Overview of the third-generation large-scale rock friction apparatus at NIED. East is to the right.

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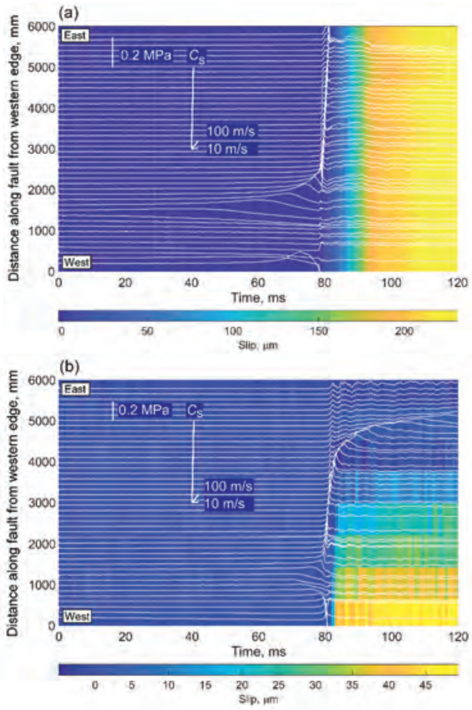


Figure2 : Local shear stress change and fault slip showing the pattern of a rupture induced by the unloading of the local normal load, for cases where (a) the entire fault ruptured and (b) the rupture stopped in the middle of the fault and the eastern part did not slip.

The relationship between load cycles and deformation in subduction wedge analogs made of dry sand layers

Satoshi Tonai, Nodoka Oda (Faculty of Science and Technology, Kochi University)

It is common for multiple thrusts to develop in the frontal part of a subduction wedge that forms in a plate convergence zone, indicating horizontal shortening. These structures are thought to strongly influence crustal deformation and material circulation, including shallow slow earthquakes; however, in natural subduction wedges, the formation cycle of thrusts is estimated to last tens of thousands to hundreds of thousands of years, making it difficult to observe the process continuously in the field. One way to address this issue is by conducting analog laboratory experiments using dry sand (e.g., Dotare et al., 2016; Ritter et al., 2018). We conducted wedge formation experiments using dry sand layers to better understand the deformation cycles occurring at the tip of a subduction wedge by comparing synchronized load measurements with analyses obtained using digital image correlation (DIC).

In our experiments, we constructed an analog subduction wedge by placing Toyoura silica sand (grain size = 100–300 μm) into an acrylic box lined with a plastic sheet (width = 118 mm, length = 693 mm, height = 158 mm). The sand was deposited freely to a thickness of 20 mm, and the plastic sheet was then pulled horizontally at a constant rate of 0.125 mm/s over a distance of 250 mm, pressing the sand layer against a fixed wall. The deformation process was recorded at 1 s intervals using two digital cameras positioned at the side and above the apparatus. The horizontal load exerted during the experiment was measured using a load cell.

In the experiments, the subduction wedge grew progressively through the successive formation of multiple thrusts (Fig. 1). The recorded load generally increased as the wedge developed, but also exhibited characteristic periodic decreases. To investigate the relationship between the load variations and wedge deformation, each complete cycle of thrust formation was divided into four stages (Fig. 2).

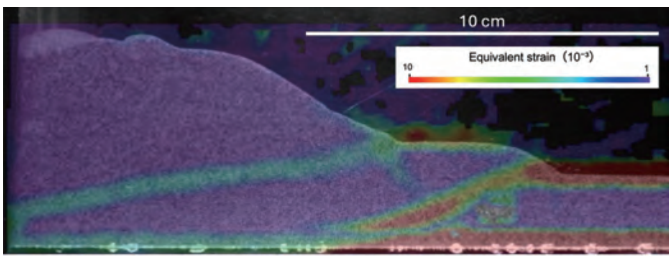


Figure 1: Internal deformation of the experimental wedge. Colors show equivalent strain over 0.125 mm of displacement of the sheet. Multiple thrusts are active.

Stage I corresponds to the period immediately following the formation of a new thrust, when the load remained constant or increased gradually. Strain analysis revealed that during this stage, displacement continued along the thrust that formed during the previous cycle, although the rate of displacement decreased. Stage II is the period of rapid load increase, when the previous thrust became almost completely inactive.

The load then stopped increasing and started decreasing, with the decreasing phase being shorter in duration and occurring in two steps. The first step, Stage III, featured small strain concentrations ahead of the active thrust, interpreted as the weak shear band reported by Dotare et al. (2016) that forms before a new thrust is formed. The load decrease during Stage III slowed temporarily before accelerating again, marking the beginning of Stage IV. Strain analysis indicates that a new thrust forms within the weak shear band at the start of this stage.

Our study reveals the relationship between load and deformation. By investigating the effects of initial conditions on load and deformation systematically, we expect to gain a better understanding of the formation of the diverse subduction wedges observed in nature, as well as the associated variability in deformation pattern.

References
Dotare et al. (2016) Tectonophysics, 684, 148–156.
Ritter et al. (2018) Tectonophysics, 722, 400–409.

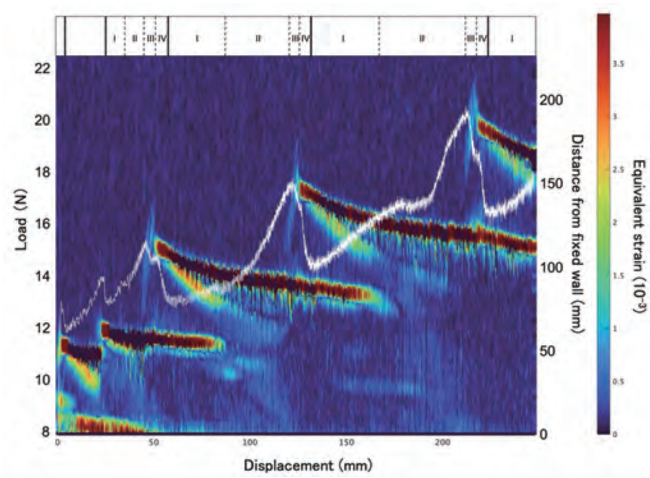
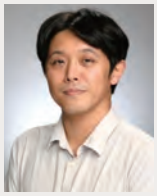


Figure 2: Relationship between load and deformation during wedge growth. White lines indicate the load, and colors show the distribution of equivalent strain viewed from above. High-strain areas correspond to shear bands (thrusts) or regions of slope failure. The Roman numerals I-IV show the four stages within the loading cycle.

Temporal variations in seismic velocity in the Nankai subduction zone: Implications for plate coupling

Takashi Tonegawa (Research Institute for Marine Geodynamics, JAMSTEC)



Large earthquakes have historically occurred at the plate interface in the Nankai subduction zone. Land-based observations have revealed slow earthquakes on the downdip side of the source areas of large earthquakes. Slow earthquakes on the updip side of the source area have also been detected by land-based observations, and their distributions have recently been estimated using ocean-bottom observations. Understanding the distribution of plate locking and the stress field in the overriding plate is an effective way of identifying the generation mechanisms of regular and slow earthquakes on the plate interface. We observed long-term seismic velocity changes and found that they respond to the amount of fluid within the accretionary prism and that they indirectly indicate the stress field in the overriding plate.

A permanent seismometer network, the Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET), has been deployed in the Nankai subduction zone since 2011 (Figure 1a)(Aoi et al. 2020). We calculated ambient noise correlation using the vertical components of ocean-bottom seismometers and detected the wavefield propagating between two stations. We investigated temporal variations in the amplitude and phase of the scattered waves, because if the seismic velocity between two stations changes through time, the amplitude and phase will also change.

Our results show that seismic velocity increased gradually at the toe of the accretionary prism in the Kumano-nada area (Figure 1b). In addition, although the increase was relatively small, velocity increases were observed near land in the Kumano basin and Kii channel (Figure 1a). In contrast, such increases were not observed near the trough offshore of Shikoku and the Kii Peninsula.

We propose that the compressional stress field north of the Nankai Trough is dominated by the subduction of the Philippine Sea Plate. This reduces the amount of fluid in the upper part of the accretionary prism and results in increases in seismic velocity. In addition, the distribution of plate coupling may be linked to spatial variations in seismic velocity. We computed the stress field within the accretionary prism when a locked part of the plate interface drags the overriding plate to greater depths, which creates a compressional stress field above the locked area. The results indicate that seismic velocity changes can be used to monitor plate-locking conditions.

Reference

Aoi et al. (2020) Earth, Planets and Space, 72,126

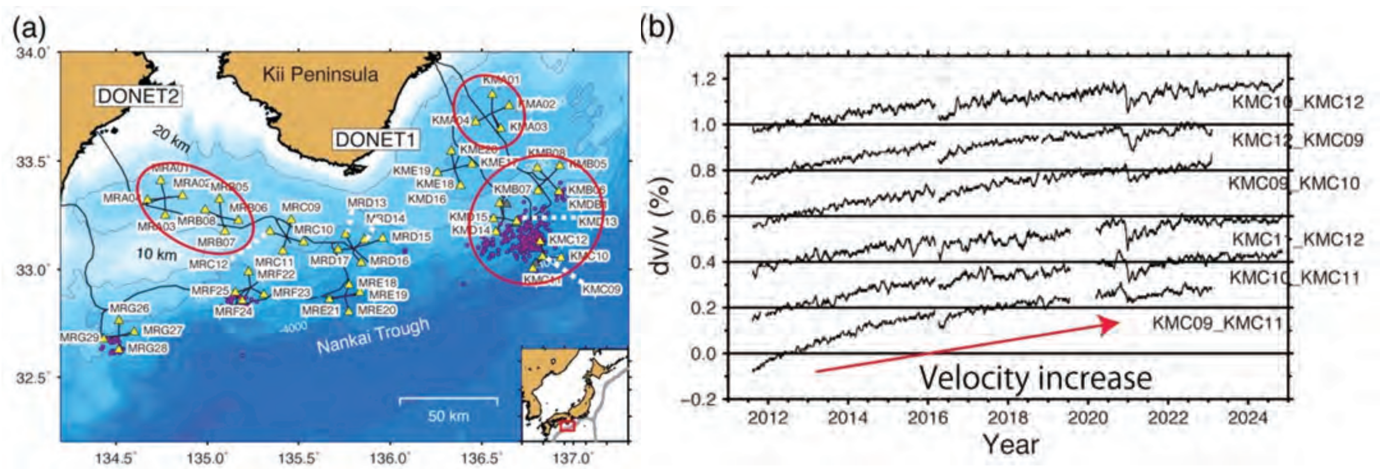


Figure 1: (a) Locations of DONET stations (yellow triangles). Red circles represent the regions where seismic velocity increases are observed. Purple circles indicate the tremor distribution from a previous study. (b) Temporal variations in seismic velocity for 6 pairs of node KMC.

What is the temperature at the base of the seismogenic zone?

Simon Wallis (Department of Earth and Planetary Science, Faculty of Science, the University of Tokyo)

What is the temperature at the base of the seismogenic zone? This is a key question to answer if we are to understand the processes controlling the change from fast to slow earthquakes. The transition from brittle to ductile deformation depends on various factors, including rock type, presence of fluid, and strain rate; however, in continental crust it is controlled most strongly by temperature and corresponds broadly to the onset of plastic deformation in quartz at ~ 300 °C. Similar temperatures are commonly suggested for this mechanical transition along the subduction interface; however, there are few good constraints. Subduction zones contain rocks that differ from those common in continental crust, they contain greater volumes of fluids and experience much higher strain rates; consequently the transition from brittle to ductile deformation is likely to be more complex. The temperature of a subduction boundary can be estimated from thermal models, but such estimates disagree by several 100 °C. One of the key reasons for the discrepancy is the way in which shear heating is considered in models. Many simply ignore it. Two recent studies that examined both the rock record of ancient subduction and heat flow in an active subduction zone of NE Japan suggest shear heating is significant and the temperature of the base of the seismogenic zone is 500 – 600 °C, substantially higher than generally thought.

Ishii & Wallis (2020) highlighted the potential of pressure (P)–temperature (T) paths of metamorphic rocks in estimating the degree of shear heating. Shear heating is focused along the shallow frictional part of the plate interface; consequently, extra heat will be reflected in a low P/T gradient. After rocks have subducted beyond the zone of frictional heating, they will follow paths with higher P/T gradients. Ishii & Wallis (2020) combined such data with thermal modeling and suggest the brittle–ductile transition in the Sanbagawa Belt occurred at ~ 500 °C.

Surface heat flow in active subduction zones offers an alternative way to estimate temperatures along the subduction interface; however, such heat flow data are generally strongly scattered, making quantitative assessments difficult. NE Japan has probably the best heat flow data of any convergent margin, and this area also has detailed geochemical data that enable estimates of the contribution of upper-crustal radioactive decay to heat flow. England et al. (2025) used these data to derive a temperature at the base of the seismogenic zone of 660 ± 220 °C. The above two studies suggest that slow earthquakes can occur in domains undergoing high-grade metamorphism.

Reference

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Ishii, K., & Wallis, S. R. (2020). Earth and Planetary Science Letters, 531, 115935.

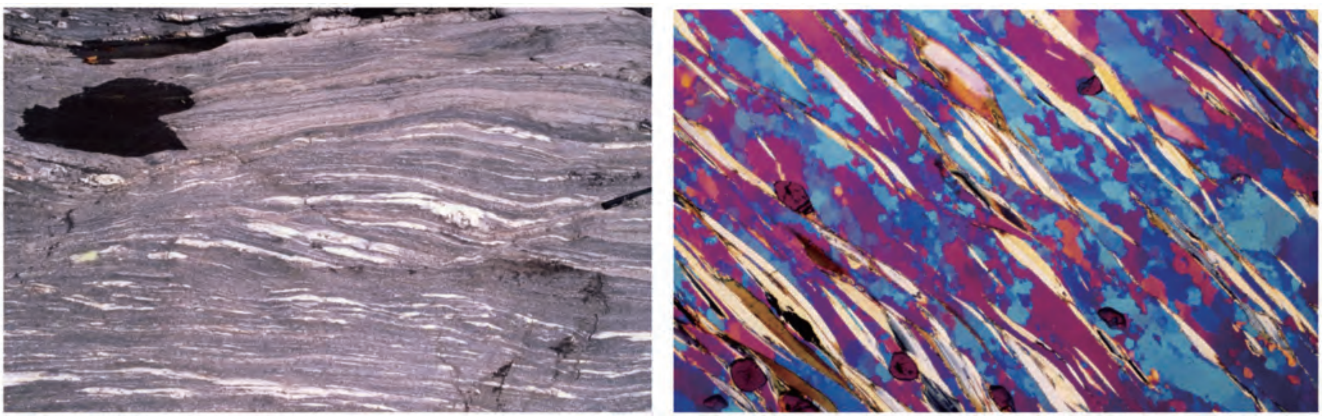

Figure 1: High-grade pelitic schist in the Sanbagawa Belt. (Left) Shear bands with a spacing of about 50 cm. (Right) Micro shear bands and the preferred orientation of quartz (photomicrograph is ~3.5 mm wide).

Elucidating the mechanisms of diverse fault slip in the Hikurangi subduction zone

Kimihiro Mochizuki (Earthquake Research Institute, University of Tokyo)

Along the Hikurangi Trough, off the east coast of New Zealand's North Island, the Pacific plate is subducting beneath the Australian plate at a rate of ~5 cm/yr, and a variety of fault slip behaviors occur on the plate interface in addition to regular seismicity, including slow slip events (SSEs) and tectonic tremor. Onshore GNSS observations reveal a sharp change in coupling strength beneath the central North Island. Strong locking has been identified to ~20 km depth in the south, whereas in the north it is limited to depths shallower than ~9 km.

Along the entire margin, SSEs occur along the downdip edge of the locked interplate zone. In the north, SSEs recur every ~2 yr and last for 2–3 weeks, whereas in the south they recur every ~5 yr and last for ~1 month. In the northern part of the margin, SSEs occur frequently along the very shallow plate interface. Moreover, seismic and electromagnetic surveys and observations have imaged the subsurface structure, including subducting seamounts, at high resolution. As a result, this region is ideal for investigating the environment in which diverse slip behaviors occur. Along the central part of the margin, where interplate locking strength changes abruptly along strike, studies are underway to clarify the origin of this change and its relationship with fault-slip modes.

Repeated marine seismic and geodetic observations along the northern Hikurangi margin have captured SSEs in the region directly beneath the network. These observations show that slip during SSEs extends to very shallow depths near the trough axis, while bypassing the subducting seamounts (Wallace et al., 2016). In addition, tectonic tremor and repeating earthquake swarms start during the termination stage of SSEs and continue for ~3 weeks, suggesting that fluid migration is involved (Shaddox and Schwartz, 2019). Seismic tomography has revealed a fluid-rich high-Vp/Vs region within the oceanic crust down-dip of a subducting seamount and just below the portions of the plate interface where large SSEs occur (Mochizuki et al., 2021). Furthermore, earthquakes within the oceanic crust show a mixture of normal and strike-slip mechanisms during the period before SSEs, compared with mainly normal-faulting events during the period after SSEs. These observations are interpreted as follows. Prior to SSEs, fluids are trapped within the oceanic crust by sealing along the plate interface, allowing slip on a variety of fault planes. Once an SSE occurs, the seal is broken, fluids are released, and slip becomes concentrated on normal faults (i.e., the fault-valve model; Warren-Smith et al., 2019).

In the central part of the margin, we have also succeeded in observing SSEs directly beneath the network. In this case, SSEs occur only on the northern side of the transition zone, which marks an abrupt along-strike boundary between strongly locked and weakly locked interplate segments.The associated earthquakes and tectonic tremor are concentrated to the north, along the boundary of the locked zone. These observations indicate a strong correlation between the various slip behaviors and the strength of interplate locking. We therefore consider that constraining the geometry of the plate interface and the physical properties of its surroundings will lead to a better understanding of the factors controlling fault-slip characteristics. By capturing the spatiotemporal variations in both fault slip and physical properties, we expect to clarify the mechanisms governing fault-slip generation.

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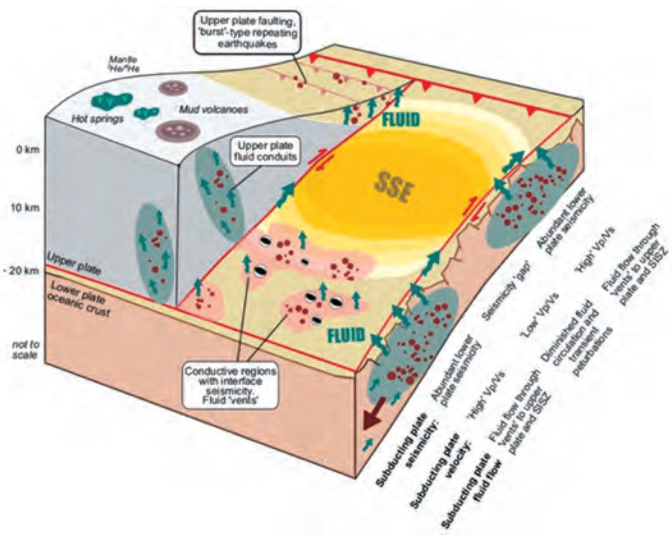

Figure: Relationship between fluids, slow slip, and seismicity at the northern Hikurangi subduction zone. SISZ: subduction interface shear zone.

Research on fluid-rock chemical interactions in slow earthquake source regions

Tsuyoshi Ishikawa (Kochi Institute for Core Sample Research, JAMSTEC)

Fluid–rock interactions, including the formation of zones of high pore pressure, are thought to play an essential role in the genesis of various types of slow earthquakes; however, the source, composition, and transfer of slow-earthquake-related subduction-zone fluids, as well as how chemical reactions associated with these fluids can weaken faults, are not well understood. Our studies focus on decoding the chemical signals of fluid–rock interactions recorded in subduction zone fluids and rocks. This approach is particularly effective for studying deep slow earthquakes, because the high temperatures (>350 °C) in the source region facilitate fluid–rock chemical reactions that can be detected by analyzing fluid-mobile elements and their isotopic compositions.

Recent studies have revealed that deep-seated brines with specific chemical characteristics which well up in southwest Japan, including those from the Arima hot spring (Arima-type fluids), may represent fluids liberated from the subducting oceanic plate (e.g., Kusuda et al., 2014). Our Li isotopic analyses of deep groundwaters from the eastern Kii Peninsula suggest that some Arima-like fluids originate in the source regions of deep slow earthquakes (Umam et al., 2022).

Do such Arima-type saline fluids really exist in the source regions of deep slow earthquakes? If so, how do the chemical interactions between those fluids and the surrounding rocks relate to the occurrence of deep slow earthquakes? To answer these questions, we are conducting trace-element and isotopic studies on a suite of rocks that constituted paleo-deep slow earthquake source regions along the subduction zone megathrust. Our current research targets are the metapelite–metabasite contacts of the paleo-megathrust in the Makimine mélange of the Shimanto accretionary complex and the Nishikashiyama mélange of the Nishisonogi metamorphic rocks in Kyushu, Japan (Figure 1A). In these areas, chemical reactions between fluids and metapelites are suggested to have facilitated the occurrence of aseismic slip or episodic slow slip events with tremor (Ujiie et al., 2022). The reaction zones contain abundant newly formed Na-plagioclase (albite), suggesting the involvement of saline fluids. Analyses of these reaction-zone rocks reveal substantial changes in the fluid-mobile element contents and isotopic ratios compared with the original metapelite compositions. Figure 1B shows a model that explains how the fluid-mobile element contents of a pelitic rock change through successive reactions with hypothetical Arima-type fluids at 350°C. By comparing these model results with the observed compositions of the reaction zone rocks, we can estimate the fluid compositions, fluid/rock ratios, and fluid transport associated with the reactions. We can also identify the sources of these fluids (sediments versus basaltic crust in the subducting plate) through Sr and other isotopic analyses of the reaction-zone rocks. We expect these geochemical studies to improve our understanding of the nature of fluid–rock chemical reactions and their role in the source regions of deep slow earthquakes.

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Kusuda et al. (2014) Earth Planet Space, 66, 119.
Ujiie et al. (2022) Geochem. Geophys. Geosystems, 23, e2022GC010569.
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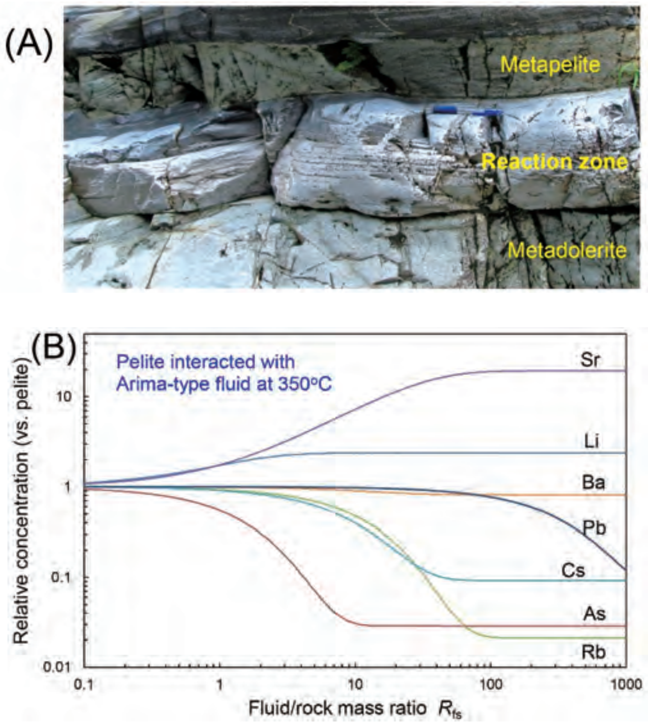
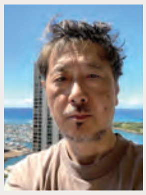


Figure 1. (A) Reaction zone along the contact between metapelite and metadolerite in the Makimine mélange. (B) Modelled fluid-mobile element contents of pelitic rock that has reacted with hypothetical Arima-type fluids at 350° C. The vertical axis represents the element contents normalized to the original pelitic rock composition. The horizontal axis indicates the fluid/rock ratio during the reaction.

Broadband seismic observations in ultra-deep ocean



Hajime Shiobara (Earthquake Research Institute, The University of Tokyo)

We have been trying to extend seafloor observations in multiple dimensions, including terms of observation period, area, and signal strength. One approach is the development of ocean bottom seismometers (OBSs) for ultra-deep areas (>6000 m water depth) that can be deployed even along deep trenches. The components of typical deep-sea instruments have a depth limit of 6000 m, as this can cover 98% of the entire seafloor. Although it may appear that an ultra-deep OBS (UDOBS) is a niche concern, it is important to observe the regions above plate boundaries where large earthquakes occur, such as the ultra-deep area a few hundred kilometers wide at the Japan Trench.

Several trials have encountered problems related to the casing design and components used in the previous UDOBS design since 1989. We deployed our new UDOBS (NUDOBS) for long-term observations in 2013 at the Boso triple junction at 9200 m depth. It had no external molded electric cable that might cause problems. Instead, a mechanical two-step retractable pin from the acoustic transponder controlled the deployment state, observations, and recovery of the whole system. However, the NUDOBS did not answer during recovery in 2014, although it replied that it was functioning correctly when observations started. One possible reason for the failure was that the retractable pin had been pushed unexpectedly into the inside of the NUDOBS by the high pressure at 9200 m depth, which would place 1464 kgf at the top of the pin (diameter = 14 mm). As a countermeasure, we have improved the driving mechanism for the retractable pin using a shoji-lock gear (including a break mechanism) that cannot be moved by external force, and our autonomous self-penetrator sensor broadband OBS, NX-2G, was developed in 2017 (Shiobara et al., 2019) and has a similar mechanism.

In 2021, we restarted the program to develop a modified UDOBS based on the previous design, but with a broadband sensor that meets current scientific objectives: a modern high-precision accelerometer (203POD-60, Silicon Audio) that is lightweight, small, low power, and tilt tolerant enough for the narrow space in the pressure case. Its lowest frequency coverage is ~0.01 Hz. The entire system is slightly more compact than the previous design. This new UDOBS (UDBBOBS) was deployed in the Kumano Sea in September 2024 for an in situ test, with recovery planned for November 2025. It will be tested in an ultra-deep area after 2026.

Reference

H. Shiobara, A. Ito, H. Sugioka, and M. Shinohara, New Era of Ocean Bottom Broadband Seismology with Penetrator System of the Autonomous BBOBS-NX (NX-2G), 27th IUGG General Assembly, S05a, IUGG19-0453, 16 July 2019.

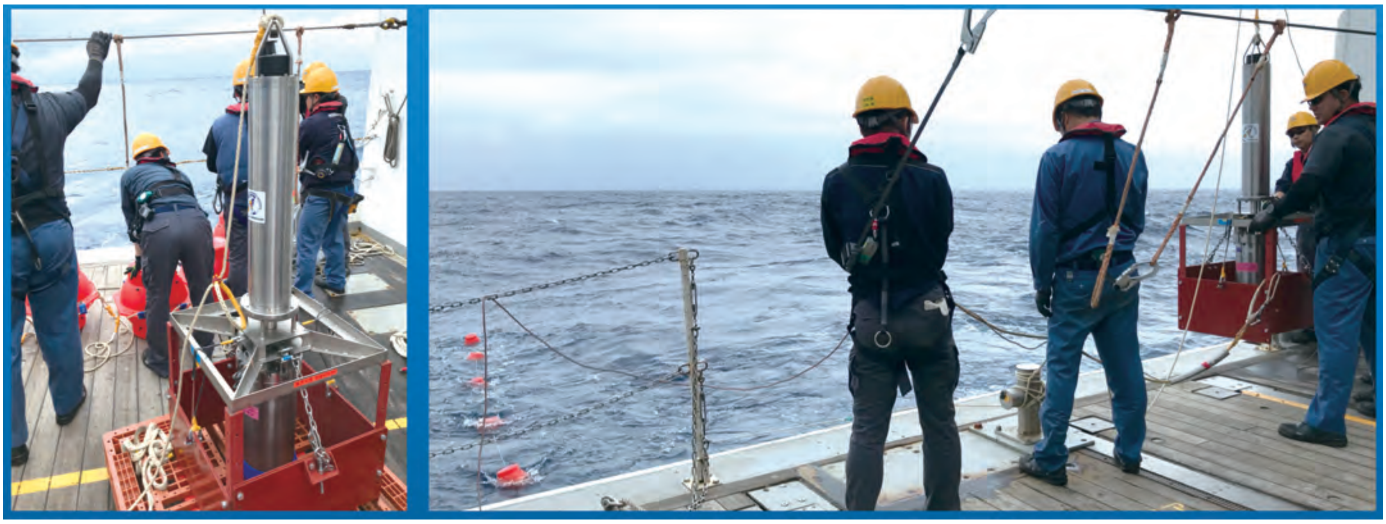


Figure 1 : Deployment of the UDBBOBS in September 2024. The upper part of the metallic tube is the acoustic transponder, which controls the mechanical function of the system. The lower tube contains the instruments for seismic observation. The tubes are separated during recording to isolate the instrument from the vibration of the orange glass floats in the water, which provide the buoyancy needed for recovery.

Detecting underground fluid movement using an observation network of compact gravimeters based on optical communication technology

Akito Araya (Earthquake Research Institute, The University of Tokyo)

Seismometers and global navigation satellite system (GNSS) instruments observe ground motion precisely and provide information on subsurface fracturing and deformation. Since these instruments are installed on the surface in a network, we can use data from the affected region quickly when an event occurs. Gravity observation is another monitoring method. Precise gravity measurements can detect the movement of underground material due to universal gravitational attraction. The remote attraction force allows direct observation of the quantity and density of underground materials without being affected by the state of the intervening rock; however, gravitational changes are extremely small: even significant fluctuations amount to only about one-hundred-millionth of the gravity at Earth's surface. To detect these variations, expensive gravimeters incorporating precision lasers are required, resulting in a limited number of observation points. For example, although fluids are inferred to be involved in the seismic activity on the Noto Peninsula, only temporary gravity observations have been conducted at a few locations (Tanaka et al., 2025). To resolve this, we aim to achieve seamless multi-scale gravity observations across time and space. In collaboration with researchers in the field of optical communications, we are developing compact gravimeters that can be deployed to numerous locations for continuous monitoring.

An absolute gravimeter operates by dropping a mirror in a vacuum chamber and measuring its acceleration with a laser. Conventional gravimeters use wavelength-stabilized lasers that can only operate at room temperature, which limits potential observation locations. We use infrared lasers capable of long-distance transmission, as are widely used in optical communication. By introducing a laser beam into the gravimeter via an optical fiber from a separate location, we miniaturize the gravimeter and increase the range of temperatures at which it can operate (Araya et al., 2020). Furthermore, sharing lasers across multiple locations reduces the cost and enables deployment to numerous locations. Wavelength stabilization for infrared communication lasers has already been achieved by B01 members Assoc. Prof. Kasai and Prof. Yoshida of Tohoku University (Kasai et al., 2016). We are developing a system with numerous gravimeters across observation areas, enabling real-time, wide-area monitoring of gravity changes. Using techniques and equipment from the field of optical communications has significant advantages, including long-distance transmission along optical fibers, light amplification, high-speed signal modulation and detection, and the use of existing optical fiber networks, all of which are difficult to achieve with the red-light lasers used in conventional gravimeters and optical measurements.

We conducted gravity measurements in the laboratory with an infrared laser (Figure 1) and confirmed that three detection signals from the gravimeter could be time-division multiplexed and transmitted efficiently via a single optical fiber (Figure 2). Based on these results, the next step will involve trial observations at an observatory using multiple gravimeters. By expanding gravity observations from individual points to wider areas, we aim to detect the movement of subsurface fluids directly and acquire new data to elucidate the transition from slow to fast earthquake phenomena.

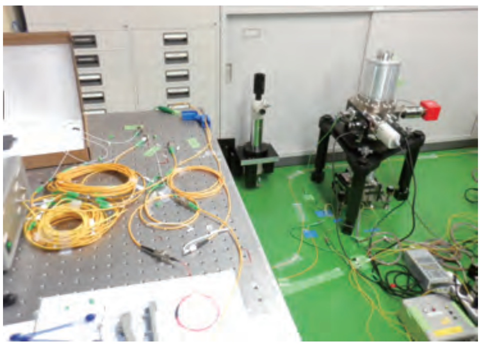


Figure 1 : Gravity measurement using an optical communication laser. The yellow cables on the left are the optical fibers introducing the laser to the gravimeter on the right.

Reference

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B01 members (Tohoku Univ.)

Keisuke Kasai (RIEC)

Masato Yoshida (Grad. Sch. Engineering)

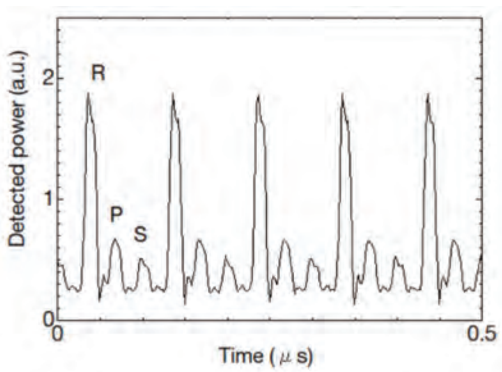

Figure 2: Time-division multiplexing of three signals (R, P, S) that were previously transmitted via three optical fibers.

The forearc seismic belt revealed by S-net and Phasenet

Naoki Uchida (Earthquake Research Institute, The University of Tokyo)

As demonstrated by the 2024 Noto Peninsula Earthquake and earthquakes induced by oil and gas production in the United States, water at depth can weaken fault strength and trigger earthquakes. In contrast, if the pore fluid pressure rises even higher and fault strength is reduced further, the fault may no longer slip quickly, leading to slow earthquakes. In this way, both slow and fast earthquakes can be influenced by fluids (water) in the Earth.

I conducted this study in collaboration with Rintaro Suzuki (a graduate student at Tohoku University), who visited the United States as part of the overseas training program for young researchers under the “Science of Slow Earthquakes” project, the predecessor to the current Transformative Research Area project (Photograph 1). This study began as an effort to construct a catalog of repeating earthquakes using a newly installed ocean-bottom seismic observation network (S-net). To process long-term seismic observation data efficiently, including those from S-net stations, and to produce an earthquake catalog, we first developed a deep learning model for automatic waveform picking. We trained a deep learning model called PhaseNet using manually picked P- and S-wave arrival times to create a waveform picking model optimized for determining hypocenter locations in northeastern Japan. Applying this model to 90 TB of digital waveform data recorded at 594 stations from 2016 to 2020 yielded hypocenter information for 587, 585 earthquakes. This new earthquake catalog contains ~ 6 times more earthquakes in offshore areas than the Japan Meteorological Agency’s catalog for the same period, and the accuracy of depth determination for offshore earthquakes has been improved substantially.

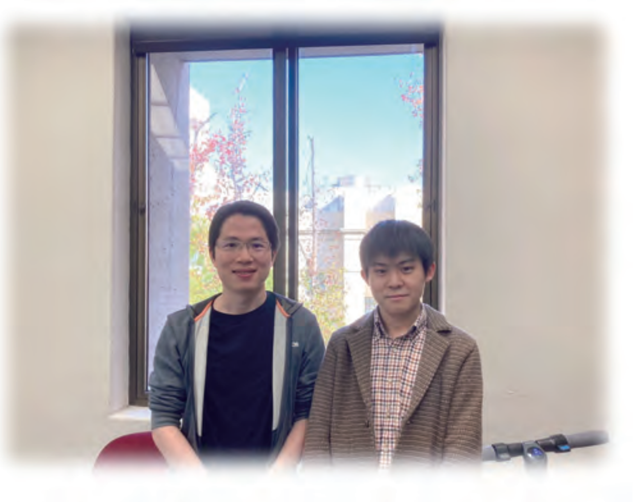

Photo: Dr. Weiqiang Zhu (left) and Rintaroh Suzuki (right) at Caltech (reproduced from the 2021 Overseas Researcher Dispatch Report).

I have yet to detect repeating earthquakes using the new catalog, but our interpretation of the catalog revealed seismicity extending upward vertically from the plate interface where the plate-boundary depth is 35 – 75 km (Fig. 1; Suzuki et al., 2025).

The deepest earthquakes in the vertical forearc seismic zone are located within the crust of the subducting Pacific Plate and are interpreted as seismicity caused by the dewatering of rocks. The water released from the subducting plate likely increases the pore fluid pressure on the overlying plate boundary fault, further weakening the mature fault and triggering slow slip events. Many of the repeating earthquakes that we targeted initially are located in this seismic zone, which is consistent with the idea that upwardly migrating fluids weaken interplate coupling. Such slow slip due to weak coupling is thought to inhibit the propagation of seismic slip during large plate boundary earthquakes (e.g., the 2011 Tohoku-Oki earthquake) into deeper parts of the plate boundary. The water that migrates to shallower depths (overlying plate) is thought to raise the pore fluid pressure in relatively strong immature faults, triggering shallow earthquakes (Fig. 1; Suzuki et al., 2025).

This study suggests that water migration from the deep subducting plate to the shallow forearc region is involved in both suppressing the propagation of slip during large plate boundary earthquakes and controlling the distribution of shallow seismic activity. We are grateful for the strong support of this Transformative Research Area project and hope to further deepen our understanding of the diversity of fault slip behavior using the newly discovered seismic activity.

Reference

Suzuki, R. et al. (2025) Science., 389, 190-194. Doi:10.1126/science.adt6389.

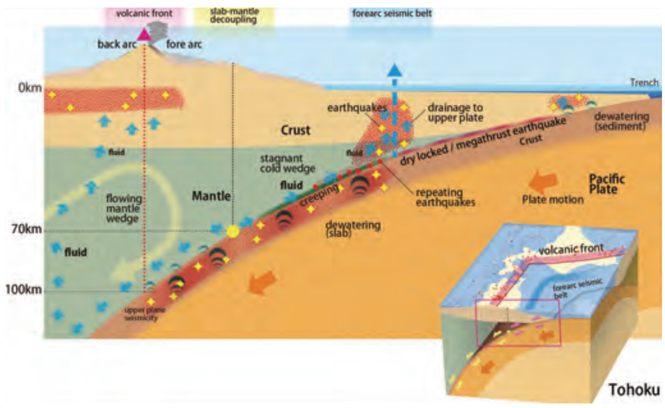

Figure 1: Forearc seismic belt and migration of water.

AI-Powered Insights into Offshore Slow Earthquakes

Kodai Sagae, Takahiko Uchide (Geological Survey of Japan, AIST)

Tectonic tremor, a type of slow earthquake, is an important phenomenon for understanding stress accumulation and release along plate boundaries. Traditionally, tremor detection has relied on evaluating waveform similarity between seismic stations; however, this method also detects fast earthquakes, making it necessary to distinguish them from tremor, especially in seismically active regions such as the Japan Trench. Moreover, the presence of thick sedimentary layers on the seafloor complicates waveform characteristics, making tremor detection even more difficult. To capture the tremor occurring in offshore regions comprehensively, we have developed a tremor detection workflow that leverages machine learning (a subfield of AI).

Our workflow (Sagae et al., 2025) consists of three main components (Figure 1). Here, we focus on two of them: (1) classifying seismic waveforms into earthquake, tremor, and noise; and (2) identifying groups of stations that have detected tremor.

For waveform classification, we developed an AI model called DiET (Discriminator for Earthquake and Tremor). This model takes spectrograms of seismic waveforms as input and classifies the waveforms at each station. Previous studies have demonstrated the effectiveness of AI models trained on spectrograms (Nakano et al., 2019; Takahashi et al., 2021). We extended this approach by training the model on a broader frequency band and using data from all 150 stations along the Japan Trench, greatly enhancing model generalizability. As a result, DiET achieved classification accuracies of > 97%, enabling efficient station-based tremor detection.

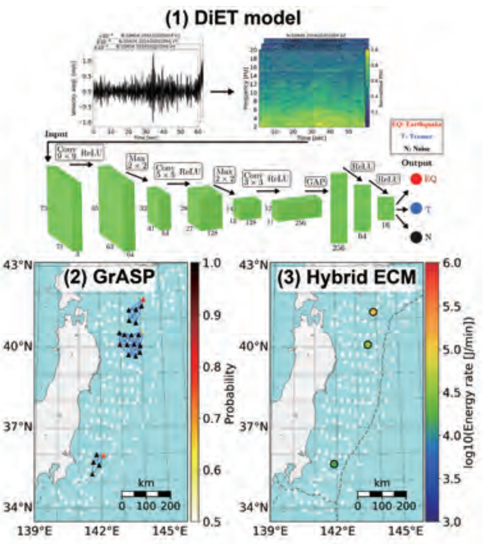

Figure 1: Tremor detection workflow developed in this study: (1) classification into earthquakes, tremors, and noise (DiET); (2) extraction of groups of stations where tremor was detected (GrASP); and (3) tremor hypocenter determination.

To further improve the reliability of tremor detection, it is necessary to confirm that tremor signals are detected simultaneously at multiple nearby stations. To do this, we developed GrASP (Graph-based Associator with Signal Probability), a new method for extracting groups of stations where tremor was detected. GrASP uses spectral clustering, a graph-theory-based clustering technique. Using graph theory, we can construct a network that accounts for the spatial relationships among stations and automatically extract coherent station groups that detected tremor. This enables the robust identification of tremor-related station groups, even when tremor signals occur across multiple locations, and links them effectively to subsequent hypocenter determination.

Applying this workflow to eight years (August 2016 – August 2024) of seismic waveform data, we succeeded in detecting about seven times more tremors than previous methods (Nishikawa et al., 2023; Figure 2). These detections include newly identified tremor episodes in previously unrecognized regions and periods. This comprehensive detection revealed the spatiotemporal behavior of tremor activity and its relationship with geodetically observed slow slip events. Our findings provide valuable insights into the mechanisms of slow earthquakes and their interactions with fast earthquake activity.

Reference
Nakano, M. et al. (2019) Seismol. Res. Lett., 90, 530–538.
Nishikawa, T. et al. (2023) Prog. Earth Planet. Sci., 10(1), 1–51.
Sagae, K. et al. (2025) J. Geophys. Res., 130, e2025JB031348.
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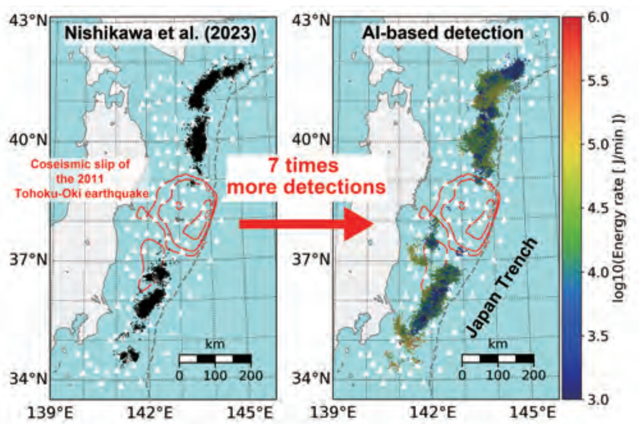


Figure 2: Improved detection of tectonic tremors using machine learning. Colored dots indicate the epicenters of tectonic tremors, with the color indicating the tremor energy rate (logarithmic scale).

Numerical modeling of Kanto earthquakes and Boso slow slip events

Takanori Matsuzawa (Department of Catastrophic Geohazard Research, NIED)

Megathrust earthquakes recur at intervals of 200–300 y along the boundary between the subducting Philippine Sea Plate and the overriding plate in the Kanto region, Japan. In addition, slow slip events (SSEs) occur repeatedly at intervals 2–8 y offshore of the Boso Peninsula. Large earthquakes, including the 1703 Genroku Kanto Earthquake and the 1923 Taisho Kanto Earthquake, have devastating impacts. The estimated magnitudes of the Genroku and Taisho earthquakes are Mw 7.8–8.2 and Mw 8.1–8.5, respectively (Satake, 2023). The main slip area of the Genroku earthquake includes the Off-Awa region, where significant slip is not thought to have occurred during the Taisho earthquake.

Saito and Noda (2023) directly estimated the stress accumulation rate (SR) on the Philippine Sea Plate beneath the Kanto region (Fig. 1a) using GNSS data. In many cases, it is not straightforward to determine frictional parameters in numerical simulations based on observations; however, their results provide useful constraints.

To simulate the two types of Kanto earthquake and the Boso SSEs, we adopted a rate- and state-dependent friction law with cutoff velocities and calculated the evolution of slip velocity and state variables on ~73,000 small triangular elements representing the geometry of the subducting plate. We assumed a negative (a − b) value in the friction law (Fig. 1b) based on the high-SR region suggested by Saito and Noda (2023). A low effective normal stress was assumed in the Off-Boso region to reproduce SSEs, whereas a high effective normal stress was assumed in the Off-Awa region to characterize Genroku-type earthquakes. This assumption is consistent with the longer recurrence intervals of Genroku-type earthquakes (e.g., 1300–2000 y; Komori et al., 2021) compared with Taisho-type earthquakes.

Our numerical model reproduces Taisho- and Genroku-type Kanto earthquakes and Boso SSEs successfully, with recurrence intervals of ~200–300 y, ~1000–1500 y (Fig. 2a), and ~6–7 years (Fig. 2b), respectively. The simulated magnitudes of the Taisho- and Genroku-type earthquakes are Mw 8.0–8.1 and Mw 8.5–8.6, respectively, consistent with actual events. In our models, the high-SR region shrinks as the seismic cycle progresses (Fig. 2d), reflecting stress accumulation. Moreover, the recurrence intervals of SSEs become shorter following a large earthquake and longer during the interseismic period, then slightly shorter again towards the end of the seismic cycle (Fig. 2b). These behaviors may reflect changes in slip rate in the surrounding region, including Off-Awa.

The behaviors predicted by our model can be validated through long-term geodetic observations. Because the spatial and temporal variations in the SR are closely related to the distribution of frictional parameters, comparing observations with the results of the model will help to better constrain the frictional properties along the plate interface.

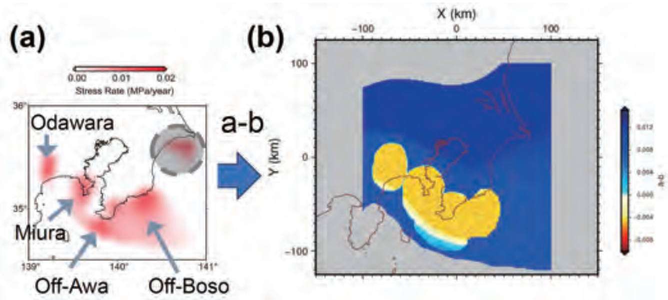


Figure 1: (a) Stress accumulation ratio on the subducting Philippine Sea Plate (Saito and Noda, 2023). (b) Assumed distribution of a − b values in the rate- and state-dependent friction law.

Reference

Komori, J. et al. (2021) Quaternary Sci. Rev. 272, 107217.

Saito, T. & Noda, A. (2023) Bull. Seismol. Soc. Am., 113, 1842-1855.

Satake, K. (2023) Bull. Seismol. Soc. Am., 113, 1826-1841.

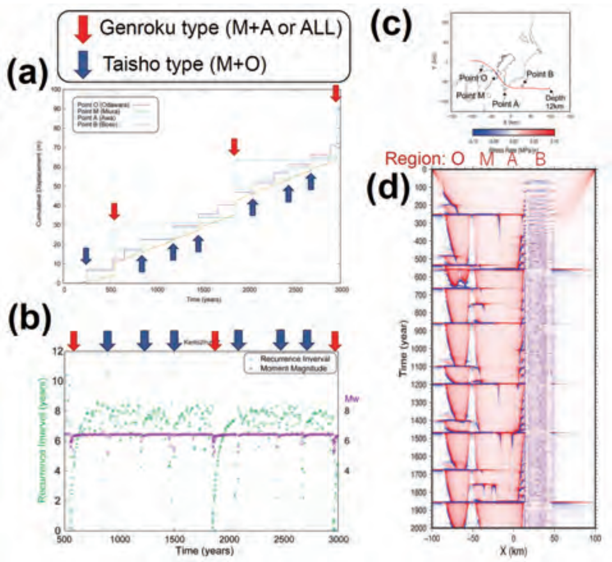


Figure 2: (a) Cumulative displacement at each point indicated in (c). (b) Recurrence intervals (green crosses) and Mw (purple crosses) of Boso SSEs. (c) Locations of the points used in (a). The red line is the 12 km isodepth. (d) Spatiotemporal distribution of the stress accumulation rate at a depth of 12 km [red line in (c)].

Enhancing the Renewal Process Model for Predicting Repeating Earthquakes

Shunichi Nomura (Graduate School of Accountancy, Waseda University)

Slow and fast earthquakes that occur repeatedly in the same region exhibit certain regularities in their recurrence intervals. For such repeating earthquakes, the renewal process model is widely used to estimate the probability distribution of the recurrence interval between successive events and forecast the timing of the next occurrence. In Japan, the Headquarters for Earthquake Research Promotion applies renewal process models to major active faults and subduction zones to estimate the probability of earthquakes occurring over the coming decades.

For large earthquakes, the recurrence intervals range from several decades to centuries; therefore, long-term observation is necessary to validate the accuracy of the forecasts. In contrast, smaller repeating earthquakes occur at shorter intervals (from several months to several years), and experimental studies have been conducted to test the predictive performance of renewal process models for such events (Okada et al., 2012). We introduce two studies that enhance renewal process models and produce better forecasts of repeating earthquakes.

1. Nonstationary Renewal Process Model After a Great Earthquake

The recurrence intervals of repeating earthquakes offshore of Kamaishi shortened sharply after the 2011 Tohoku earthquake (yellow vertical line in Figure 1), then recovered gradually. Conventional renewal process models cannot represent such temporal changes (nonstationarity) in recurrence intervals; therefore, Nomura and Tanaka (2021) introduced a time transformation based on the Omori–Utsu law, which describes the temporal decay in aftershock activity, and applied a renewal process model to the transformed occurrence times to account for the nonstationary behavior. This model has been used for experimental forecasts of repeating earthquakes offshore of the Tohoku region by the Meteorological Research Institute of the Japan Meteorological Agency through the Coordinating Committee for Earthquake Prediction.

2. Considering Tidal Stress in Forecasts of Slow Earthquake Recurrence

Ide and Nomura (2022) conducted a detailed analysis of tectonic tremors (slow earthquakes) in southwest Japan and estimated the distribution of recurrence intervals at each location by decomposing it into long-term (weeks to months) and short-term (hours to days) components. They demonstrated that tidal stress affects the probability of tremor occurrence and developed a renewal process model incorporating tidal stress (Figure 2).

These two studies aimed to improve the prediction of repeating earthquakes by incorporating nonstationarity and the response to external forces into renewal process models. These approaches are expected to be applied to a wider range of regions and timescales in the future.

Reference

Ide, S. & Nomura, S. (2022) Progress in Earth and Planetary Science, 9, 67.

Okada, M. et al. (2012) Earth, Planets, and Space, 64, 703-715.

Nomura, S. & Tanaka, M. (2021) Statistical Mathematics, 69(2), 239-254.

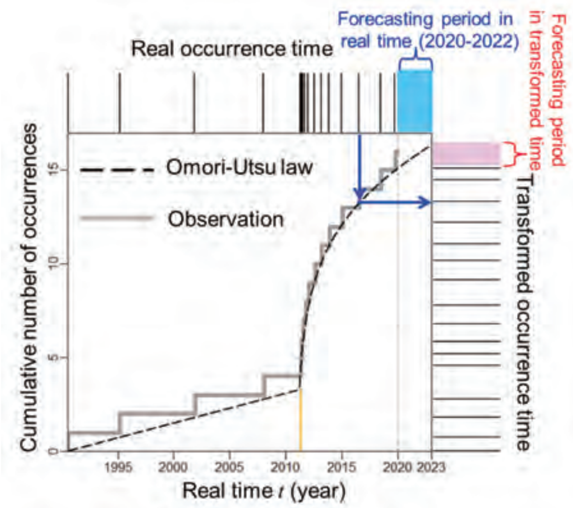


Figure 1: Cumulative count of repeating earthquakes offshore of Kamaishi and a curve fitted using the Omori–Utsu law. The actual occurrence times above the panel are transformed along the fitted curve as displayed on the right.

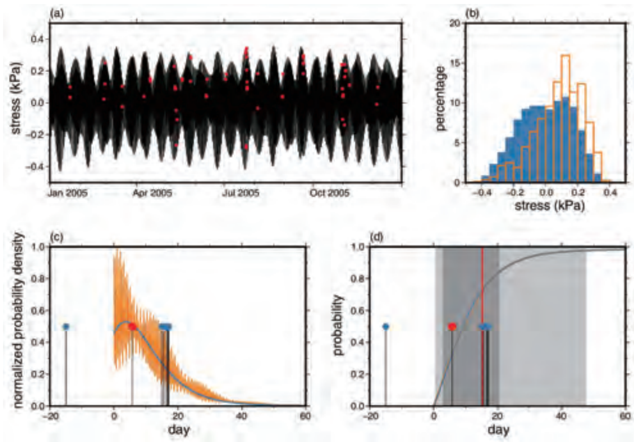


Figure 2: Evaluation of the effects of tidal stress on tectonic tremors (Ide and Nomura, 2022). (a) Tidal stress level (black line) and tremor events (red dots). (b) Histograms of tidal stress levels (blue) and tremor occurrence times (orange). (c) Probability density functions for the next occurrence time estimated using renewal process models with (orange) and without (blue) tidal stress modulation. (d) Cumulative distribution functions for the next occurrence time with 95% (light gray) and 68% (dark gray) prediction intervals.

Publicly Offered Research in Group A01

Pressure oscillations induced by silica precipitation: A record from a synthetic quartz vein

Atsushi Okamoto (Graduate School of Environmental Studies, Tohoku University)

The fault-valve model, which links the earthquake cycle to changes in fluid pressure, has been widely accepted. Quartz veins in seismogenic zones exhibit structures that are interpreted as evidence of repeated cracking and sealing, including fluid inclusion bands and growth zoning; however, linking vein microstructures to fluid pressure variations remains challenging. We conducted silica precipitation experiments by injecting a silica-rich solution into a granite slit at a constant flow rate, which sealed the slit through silica precipitation. During the course of the experiment, the differential pressure (ΔP) between the upstream and downstream ends of the experiment began to increase. Interestingly, we observed oscillations in differential pressure characterized by a gradual increase followed by a sudden drop. The precipitated silica showed a systematic change along the flow direction, from amorphous silica, to nucleated quartz particles, then to quartz overgrowths on the host rock. The zone composed of a mixture of amorphous silica and nucleated quartz exhibited the lowest porosity. Some quartz grains contain multiple bands of fluid inclusions. These results represent the first experimental reproduction of fault-valve behavior, characterized by the cyclic formation and failure of weak sealing layers. Our experiment suggests that at high temperatures in the crust, silica particle formation and transport may play a key role in processes such as earthquake swarms triggered by fluid influx.

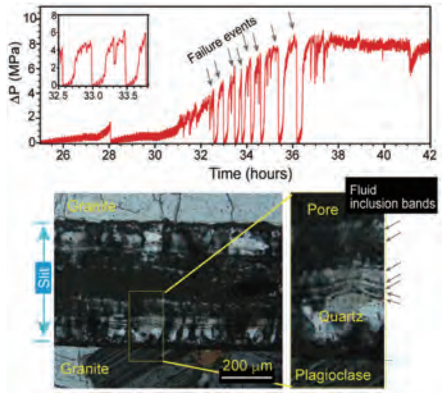


Figure: (Top) Fluid pressure oscillations caused by silica precipitation and (bottom) fluid inclusion bands in quartz grains from the silica precipitation experiment.

Publicly Offered Research in Group A01

Investigating the Generation of Slow and Fast Earthquakes Through Fluid-Injection Experiments

Makoto Naoi (Faculty of Science, Hokkaido University)

To investigate the interaction between fluids and fault slip, which is thought to play a key role in the generation of slow earthquakes, we injected pressurized fluids into rock samples and monitored microfracturing using acoustic emission (AE) data. We will use deep learning to develop event catalogs from the AE records, estimate source mechanisms, and delineate the evolution of failure in detail. Because AE records are challenging to analyze, we will carefully correct the frequency response and sensitivity variations using methods we have developed, enabling a reliable estimation of source characteristics and identification of slow-event candidates with dominant low-frequency content. By combining deep-learning-based arrival-time and event detection with template matching, we will greatly expand the number of detected events in a high-quality catalog and investigate their activity at high resolution. Integrating these results with thin-section observations that highlight fluid-infiltration zones, we will elucidate fracture mechanisms and growth driven by fluid injection. We also aim to apply the deep-learning expertise developed using large laboratory datasets to the analysis of natural earthquakes.

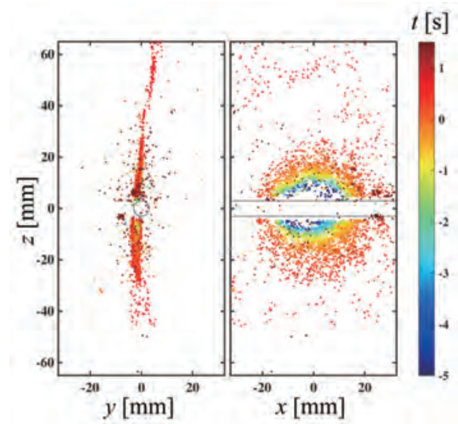


Figure: Hypocenter distribution of AE events obtained from an experiment with a shale block (adapted from Naoi et al., 2025).

Publicly Offered Research in Group A02

Scale dependence of seismic velocity and permeability in subduction zones

Yuya Akamatsu (Research Institute for Marine Geodynamics, JAMSTEC)

Slow and large earthquakes in subduction zones are thought to be linked closely to fluid migration within rocks. Pore fluids alter the elastic properties of rocks significantly, allowing the amount and state of fluids to be inferred from seismic velocity observations; however, natural geological systems contain voids (cracks or fractures) of various scales, from micrometers to meters. Therefore, to estimate fluid properties quantitatively from observed seismic velocities, it is essential to determine the scale of porosity that influences seismic wave propagation and earthquake generation. We measured the P-wave velocity of drillcore samples collected from the western extension of the Yokonami mélange in the Shimanto Belt, Susaki, Kochi. We compared these laboratory measurements with borehole logging data that reflect structures on a larger scale to examine how measurement scale affects the observed values. The results show that seismic velocities obtained from borehole logging are ~1 km/s lower than those measured in the laboratory. This discrepancy indicates that cracks larger than laboratory samples dominate the in situ seismic velocity. Furthermore, such large fractures likely enhance rock permeability and facilitate efficient fluid migration, suggesting a possible relationship between these mesoscale fractures, fluid movement, and earthquake activity.

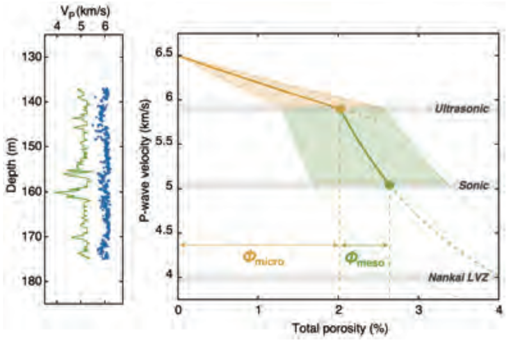


Figure : (Left) Comparison between laboratory-measured P-wave velocities (blue) and borehole logging data (green). (Right) Relationship between porosity and P-wave velocity estimated from theoretical modeling. Explaining the sonic log data requires incorporating mesoscale porosity.

Publicly Offered Research in Group A02

Geological nature of fault-valve behavior in the source regions of deep slow earthquakes

Ken-ichi Hirauchi (Department of Geosciences, Faculty of Science, Shizuoka University)

At the tip of the mantle wedge in subduction zones, deep slow earthquakes (known as episodic tremor and slip, ETS) are thought to occur repeatedly within shear zones under high pore fluid pressures (Fig. A). To clarify how ETS occurs within these shear zones, I am conducting an integrated study combining high-pressure (P) and high-temperature (T) deformation experiments with field-based geological observations.

Deformation experiments on serpentinite samples under P–T conditions corresponding to the ETS source regions reveal that under extremely high pore fluid pressures, numerous extensional and extensional–shear fractures develop throughout the samples, forming a fault-fracture mesh structure (Fig. B). This structure likely represents the process that generates ETS events.

Field observations of mantle-wedge serpentinite shear zones that formed at similar P–T conditions to those of the deformation experiments further suggest that the recurrence interval of ETS may be controlled by the time required for fractures to be sealed through the precipitation of new serpentinite minerals. Such cyclic fracturing and sealing of fractures is known as fault-valve behavior, which may explain the temporal variations in seismic velocity (e.g., Vp) observed in ETS source regions (Fig. C). These findings reveal the geological manifestation of fault-valve behavior at depth and suggest that similar mechanisms operate not only in serpentinite, but also in slab-derived materials, pointing to a universal process for ETS generation.

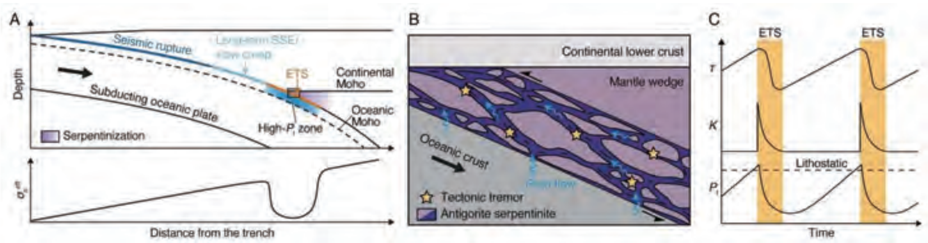


Figure : Fault-valve behavior in a forearc mantle wedge shear zone during ETS (Hirauchi et al., 2025). (A) Schematic cross-section of a warm subduction zone that generates both great earthquakes and ETS. The rectangle in (A) marks an ETS-generating serpentinite shear zone, which is enlarged in (B). (C) Temporal variations in shear stress (τ), fault zone permeability (K), and pore fluid pressure (P_f) during ETS cycles.

Publicly Offered Research in Group A02

Detection of repeating earthquakes during the Noto earthquake swarm

Junichi Nakajima (School of Science, Institute of Science Tokyo)

Repeating earthquakes are earthquakes that repeatedly rupture an isolated asperity on a fault plane through aseismic slip on the surrounding portion of the fault. Because the recurrence intervals of repeating earthquakes can be used to estimate the rate of aseismic slip, they serve as "creepmeters". We detected repeating earthquakes to investigate the temporal evolution of aseismic slip associated with the Noto Peninsula earthquake swarm.

Identification of repeating earthquakes requires two key conditions: waveform similarity and overlapping source areas. We adopted stricter criteria for waveform similarity than in previous studies, requiring a correlation coefficient of ≥0.95 at >7 stations and ≥0.98 at >2 stations. Our evaluation of source-area overlap was also more stringent. As a result, from the 1,929 earthquakes analyzed (M ≥ 2 from 2020 to 2023), 68 events belonging to 33 sequences were identified as repeating earthquakes. Even when the criteria were further tightened (e.g., by adopting a higher frequency band for correlation and increasing the stress drop threshold for evaluating source overlap), about half of these 68 events still satisfied the definition of repeating earthquakes. This strongly indicates that repeating earthquakes do indeed occur within the focal area of the Noto Peninsula earthquake swarm.

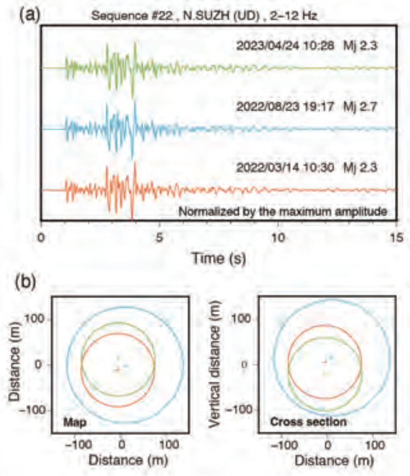


Figure: (a) Example of the waveforms of repeating earthquakes (CC values ≥0.99) and (b) overlap of the source areas (a stress drop of 3 MPa is assumed).

Publicly Offered Research in Group A03

Controls on earthquake growth identified from high-resolution analyses of repeating earthquakes

Keisuke Yoshida (Graduate School of Science, Tohoku University)

After the 2011 Tohoku earthquake, new repeating earthquakes (REs) began to occur along the Japan Trench plate boundary, alongside systematic changes in the sizes of pre-existing REs. These phenomena provide crucial clues to the way in which aseismic slip accelerates to seismic slip and how ruptures grow and eventually arrest. We aim to elucidate the factors that control rupture growth by resolving the rupture processes of REs.

We examined an unusual RE sequence that has significant variability in magnitude (star in Fig. a). First, by locating the rupture areas precisely, we found a hierarchical structure in which smaller rupture patches are nested within a larger patch (Fig. b). The moment magnitude (Mw) for each event increased transiently immediately after the Tohoku earthquake, then returned gradually towards the pre-event level (Fig. c). Source-time functions indicate that for ~1 y following the Tohoku earthquake, rupture extended beyond the usual rupture area into adjacent areas (Fig. d).

These clear temporal changes suggest that the propensity of rupture to arrest was strongly affected by the change in loading rate, which was associated with postseismic slip from the Tohoku earthquake. A remaining task is to clarify the specific physical processes by which the loading rate influences arrest.

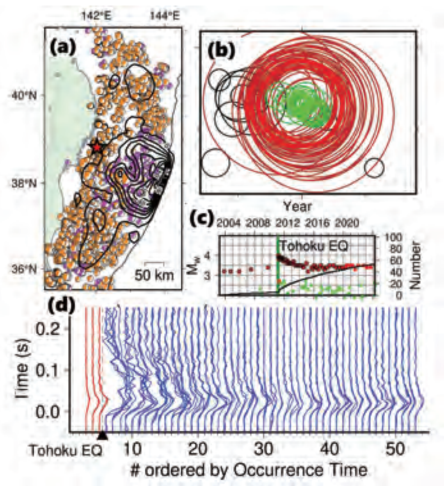


Figure: The analyzed repeating earthquakes and their characteristics. (a) Location of the repeating earthquakes (red star). Contours show the slip distribution of the 2011 Tohoku earthquake. Orange and purple symbols denote earthquakes that occurred before and after the Tohoku earthquake, respectively. (b) Enlarged view of the source region. (c) Temporal evolution of moment magnitude (Mw). (d) Source-time functions for individual events.

Publicly Offered Research in Group B01

Seismic analysis of fast and slow earthquakes using distributed acoustic sensing data

Satoru Baba (Faculty of Science, Kyushu University)

Distributed acoustic sensing (DAS) measures strain changes along a fiber-optic cable. Because DAS realizes high-density observations, which are difficult to achieve with conventional seismometer networks, it has been used for seismic observations in recent years. In particular, DAS is expected to play a major role in offshore areas, where the installation of seismometers is expensive, and in volcanic areas, where shallow structures are important.

Continuous DAS observations have been conducted off the coast of Cape Muroto in Shikoku, where the seismogenic zone and slow earthquake activity are adjacent near the Nankai Trough. On 1 January 2024, minor shallow tremor activity was observed by DAS three hours after the M 7.6 Noto Peninsula earthquake. We suggest that these tremors may have been caused by transient stress change due to the Noto Peninsula earthquake. DAS is useful for monitoring fast and slow earthquake activity after large earthquakes (Baba et al., 2025).

Kyushu University conducted DAS observations near the Futagawa and Hinagu faults in Kumamoto prefecture in 2023. This DAS measurement recorded signals from fast earthquakes with magnitudes of 1–2 (Hamanaka & Emoto, 2024). We attempt to monitor seismic activity on the Futagawa and Hinagu faults using DAS data by picking P- and S-wave arrivals using deep learning and estimate focal mechanisms using amplitude distributions.

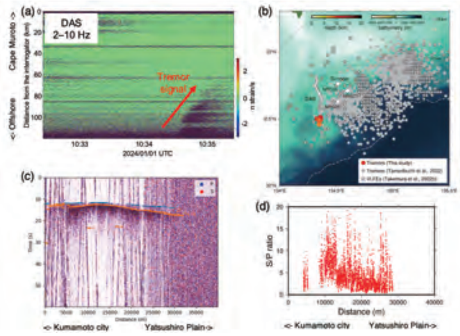


Figure: Shallow tremors observed by the Muroto DAS and regular earthquakes observed by the Kumamoto DAS. (a) Spatiotemporal distribution of strain rates from a shallow tremor observed by the Muroto DAS. (b) Distribution of shallow tremors observed by DAS. Gray circles and stars show the distribution of tremors and very low frequency earthquakes (VLFEs) revealed by previous studies, respectively. (c) A regular earthquake (M 1.4) observed by the Kumamoto DAS. P- and S-wave arrivals were picked by PhaseNet-DAS (Zhu et al., 2023). (d) Distribution of the S- to P-wave amplitude ratios of a regular earthquake (M 1.8) observed by the Kumamoto DAS.

Publicly Offered Research in Group B03

Frictional heterogeneity estimated from the 2010 Bungo Slow Slip Events by Physics-Informed Neural Networks

Masayuki Kano (Disaster Prevention Research Institute, Kyoto University)

Fast and slow earthquakes are fault slip phenomena governed by friction. Previous observations have shown that fast and slow earthquakes occur in spatially distinct areas and that slow slip behavior varies by region, suggesting the existence of spatial heterogeneity in frictional properties along the subducting plate interface; however, few studies have evaluated the spatial distribution of frictional properties quantitatively based on laboratory-derived friction laws.

We estimated the spatial distribution of frictional properties using global navigation satellite system (GNSS) crustal deformation data combined with a data assimilation approach. We used physics-informed neural networks (PINNs), a machine learning technique that incorporates physical laws, to tackle the high-dimensional inverse problem with fewer prior constraints, which has been difficult for conventional methods. We focused on the 2010 slow slip event in the Bungo Channel, southwest Japan. Our results reveal heterogeneous frictional properties in the southwestern part of Shikoku, where slip nucleated and subsequently propagated westward. Moreover, the estimated fault slip reproduced the spatiotemporal pattern of surface displacement successfully, which conventional assimilation methods with strong constraints could not capture.

These findings demonstrate the effectiveness of physics-based inversion using PINNs and highlight the potential of this method for advancing our understanding of fault mechanics and for predicting fault slip behavior.

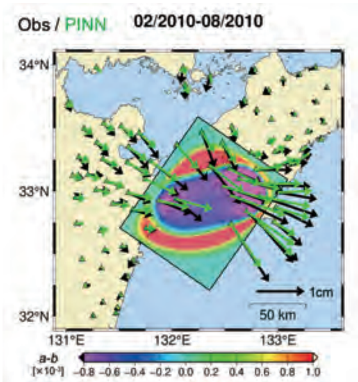


Figure: Spatial distribution of frictional properties (a−b), estimated using physics-informed neural networks. Green triangles indicate the GNSS observation sites used in this analysis. "Obs" indicates the observed displacements.

Publicly Offered Research in Group B03

Physics-based earthquake generation model for coupled island arc–trench systems

Ryosuke Ando (Graduate School of Science, The University of Tokyo)

In island arc–trench systems, such as those in Japan, subduction drives earthquake activity; however, the physical mechanisms behind stress accumulation in inland areas, and the spatiotemporal interactions between interplate and intraplate earthquakes, remain unclear. Recent theoretical studies have revealed that fault curvature can produce characteristic stress patterns around faults. We developed two-dimensional models that incorporate the actual geometry of the subduction zones in the Tohoku and Kyushu regions. We then analyzed how stress accumulates along plate boundaries and inland areas.

Our results show that considering realistic plate geometry reproduces the known stress fields successfully: normal faulting on the forearc side and reverse faulting on the backarc side in Tohoku (Figure 1), and normal faulting in Kyushu.

We also introduced inland and intraplate faults governed by friction laws and examined the spatiotemporal patterns of earthquakes. We found that inland normal faulting earthquakes tend to occur shortly after interplate earthquakes, while reverse faulting earthquakes tend to precede them. This reflects the characteristic stress field changes caused by locking and slip at the plate boundary.

These findings highlight the significance of fault curvature, which is a relatively simple factor, in explaining diverse stress and earthquake phenomena.

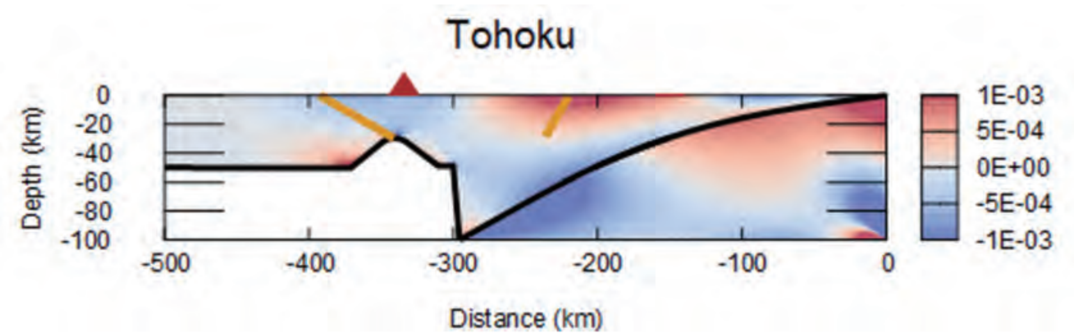
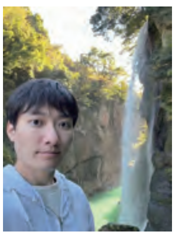


Figure: Plate geometry and distribution of the stress rate (MPa/yr). Warm colors indicate extensional (normal faulting) stress, cool colors indicate compression (reverse faulting). Red triangles represent volcanoes and orange lines represent inland faults in the Tohoku region.

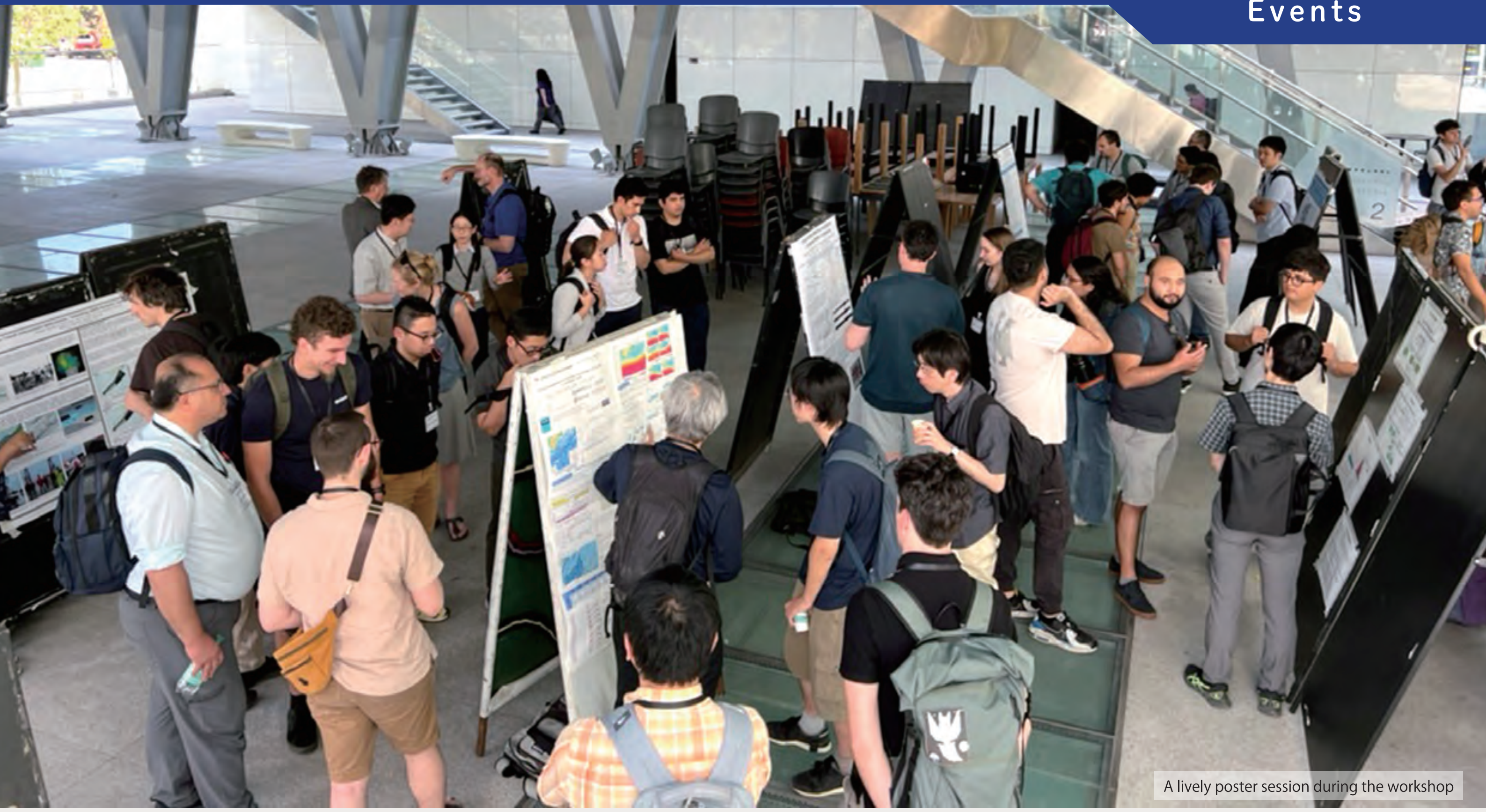
New Member



A03 - RC

Ritsuya Shibata
Postdoctoral Researcher, National Research Institute for Earth Science and Disaster Resilience

Specialty: Seismology
Keywords: Source process, Seismicity



A lively poster session during the workshop

Self-invited Workshop in Chile: Nejiri-gama, Seafloor Observations, and Slow Earthquakes

Yoshihiro Ito, Disaster Prevention Research Institute, Kyoto University

On 13–14 January 2025 we held the Self-invited International Joint Workshop on Slow-to-Fast Earthquakes in Chile at the University of Chile in Santiago. This lively and enjoyable event was organized in collaboration with the SZNet Ocean Floor Observational Technology Workshop (15–16 January), hosted by SZnet, a subgroup of the U.S. SZ4D program. More than 100 people attended, including 21 from Japan. The atmosphere was buzzing from start to finish.

The program featured 45 oral presentations and 9 posters, covering not only Chilean studies but also research from offshore Alaska, Canada, the U.S., Mexico, and Peru. The sessions were packed with questions, comments, and even laughter, making the discussions both exciting and memorable for everyone involved.

The SZNet Ocean Floor Observational Technology Workshop highlighted Japan's cutting-edge seafloor observation technologies, drawing strong interest from international colleagues. In the breakout sessions, Japanese participants stood out with their active contributions, leaving a strong impression of Japan's presence on the global stage.

Before the workshops, we also enjoyed a two-day field excursion. On 11 January we visited a trench investigation along the San Ramón Fault near Santiago. A fun surprise was seeing Chilean researchers using Japanese nejiri-gama (twisted sickle blades) for their work—something that might make a perfect souvenir for future visits! On 12 January we headed to the terraces along the Maipo River and hiked up from El Cabrerío to view San José Volcano. Although the summit was hidden by clouds, the 30-minute trek under blue skies, with glacial landforms all around, was an unforgettable experience and a great chance to bond with colleagues outside the seminar hall.

All in all, the workshops and field trips were not only about sharing research but also about building friendships and deepening connections across borders. With these new ties, we look forward to pushing slow-to-fast earthquake science even further together.

A big thank you to everyone who joined us in Chile!

On the trail to San José Volcano

International Joint Workshop on Slow-to-Fast Earthquakes 2025

Satoshi Ide, Graduate School of Science, The University of Tokyo

This year, the International Joint Workshop on Slow-to-Fast Earthquakes 2025 was held during 24–26 September at Kochi City Culture Plaza CUL-PORT. The workshop attracted 199 on-site participants, including 44 from overseas. In addition, 31 participants joined online, including 7 from outside Japan. Many on-site participants also viewed the hybrid presentations from satellite rooms. Over the three days, the program featured 26 oral presentations and 169 poster presentations, along with a reception on the first evening and group discussions on the final day.

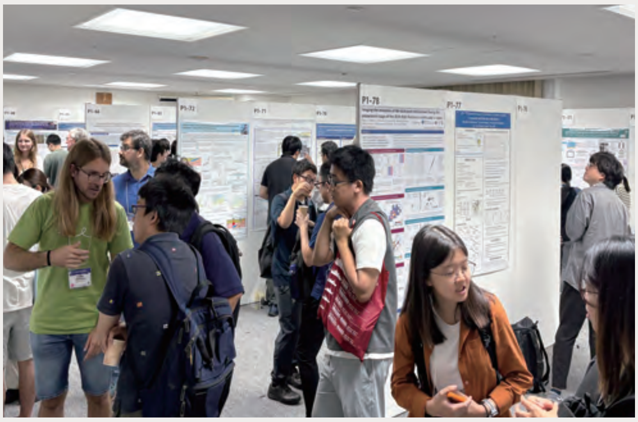
This year's workshop was organized around the following special topics, each covered in one day with two keynote lectures and four invited oral presentations:

- Cutting-Edge Approaches to Measurement and Data Analysis
- Data-constrained numerical modeling and model-informed observations
- Environment and generation processes of slow and fast phenomena

The first day focused on state-of-the-art approaches to data analysis and observation, featuring talks on AI-based data processing, new event detection methods, probabilistic forecasting, novel fiber-optic measurements, and seismic observations at KAGURA. The second day, dedicated to data-constrained numerical modeling, showcased studies of dynamic fault-slip modeling, pore-fluid measurements, and their roles in fault rupture processes. The third day explored the geological and physical environments of earthquake generation, including field observations of seismogenic zones, laboratory experiments on micro-scale fault valve formation, seismological evidence of fluid activity, and high-resolution subsurface imaging.

Poster sessions were held over two days, with separate core morning and afternoon times. Although the poster hall was somewhat compact, discussions were more vibrant than ever. At the same time, we recognize that the venue was too small for the number of participants; some researchers, including project members, could not register once the capacity was reached—we apologize sincerely for this. On the positive side, the satellite room prepared as an overflow space turned out to be unexpectedly popular. Participants enjoyed clear slide visibility and the relaxed atmosphere, where they could listen to talks while having coffee and chatting. It felt like we discovered a new, enjoyable way of running hybrid meetings.

This workshop was organized jointly by the Earthquake Research Institute, the University of Tokyo, and the Disaster Prevention Research Institute, Kyoto University, with generous support from Kochi Prefecture. We express our sincere gratitude to Yohei Hamada (JAMSTEC) and other members of the local organizing committee, as well as all participants and collaborators who contributed to the success of the event.



Slow to Fast Earthquake International Workshop in Kochi 2025
A Pre-Meeting field excursion report

Yoshitaka Hashimoto, Kochi University

On 23 September 2025, a field excursion to the Cretaceous Shimanto Belt was conducted prior to the Slow to Fast Earthquake International Workshop to provide participants with first-hand insights into accretionary complexes in Japan. I led the excursion with PhD students Takahiro Hosokawa and Taizo Uchida and Dr. Asuka Yamaguchi, which was attended by ~75 researchers from Japan and abroad across various Earth science fields. In the morning, the group visited the Yokonami Mélange. Participants observed a block-in-matrix structure, in which sandstone and black shale blocks are embedded in a foliated shale matrix, and discussed deformation and fluid processes related to subduction. Based on previous fluid inclusion and stress analyses, active debates were held on stress cycles and fluid migration in the seismogenic zone. At the northern boundary fault, relationships among the cataclasite zone, damage zone, and principal slip surface were examined. In the afternoon, the group moved to the Kure Mélange, representing a higher-temperature domain. The thermal gap to the south and late out-of-sequence thrusting were explained, and observations of underplating-related structures and mineral veins stimulated discussion on the complex thermal and deformation history. The trip concluded with visits to Kure Hachiman Shrine, Taisho market and a tsunami evacuation tower, highlighting the link between geology, hazard awareness, and communities. The excursion deepened our understanding of the Shimanto Belt's structural evolution and promoted international collaboration among participants.

Participants engaged in enthusiastic observations and lively discussions at an outcrop of the Kure Mélange.

Report from a field excursion to the Sanbagawa belt

Atsushi Okamoto, Graduate School of Environmental Studies

A one-day field excursion was held in the Besshi area of the Sanbagawa metamorphic belt (central Shikoku) following the workshop at Kochi. Sixty-eight participants joined. Although the meeting days were rainy, the excursion was blessed with pleasant fall weather and proceeded smoothly.

Stop 1 featured an outcrop of the chlorite zone in the greenschist facies. Participants observed dense quartz veins aligned with and cutting the schistosity of the pelitic schist. Many participants were seeing high-pressure metamorphic rocks for the first time and showed interest in fluid activity from the base of the seismogenic zone. Stop 2 was a serpentinite body from the mantle wedge in the high-temperature part of the garnet zone. Discussion focused on the deformation structures of high-temperature serpentinite composed of lens-shaped blocks and matrix. A reaction zone with talc, amphibole, and chlorite at the serpentinite–pelitic schist contact revealed localized deformation due to metasomatic processes. Stop 3 involved observing and sampling a float of mafic gneiss with garnet, which had experienced eclogite-facies metamorphism and has been uplifted from >50 km depth. Participants were happy to collect samples with large garnet crystals. Overall, the excursion offered valuable insights into heterogeneous structures formed by fluid–rock interaction along a subduction zone plate boundary.

Drone photograph of the group on the Tomisato serpentinite.

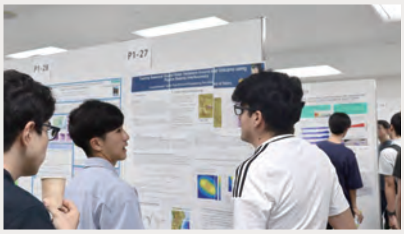
Social Events for Early Career Researchers Organized by the Science of Slow-to-Fast Earthquakes Project

Yutaro Okada, International Research Institute of Disaster Science, Tohoku University

The Science of Slow-to-Fast Earthquakes Project organizes two social events each year to promote interaction among early career researchers (ECRs). At the Japan Geoscience Union Meeting 2025, we held a career-discussion event for students and ECRs. Because there are many undergraduate and Master's students in fields related to the project, but fewer Ph.D. students, we held an event discussing broad topics about the Ph.D. course primarily for undergraduate and Master's students. To ensure broad and useful discussion for participants from diverse backgrounds, we invited four Ph.D. students representing varied research areas, institutions, and genders as presenters. Students from undergraduate through doctoral levels attended, listened attentively to the presenters, and actively asked questions, making the discussion lively and productive.

We held the research networking event before the International Joint Workshop on Slow-to-Fast Earthquakes 2025, so that the ECR participants of the workshop could deepen their understanding of each other's studies. Participants discussed their research for ~ 2 h with ~ 45 posters presented. The ECR participants interacted with each other, bridging different fields in a free-spirited atmosphere; therefore, this event was meaningful both for the ECR workshop participants and the Slow-to-Fast Earthquakes Project.

Photograph of the career-discussion event.

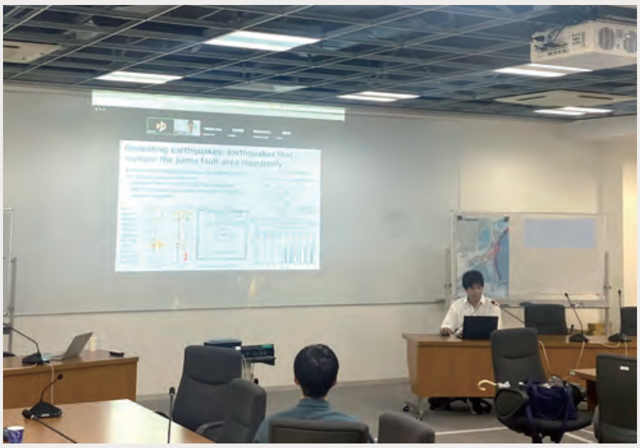


Photograph of the research networking event.

2025 Annual Report from the Young Researchers and Diversity Promotion Taskforce

Saeko Kita, Building Research Institute

During this fiscal year, the Slow-to-Fast Seismology Café was held four times. During the 6th session (June 2025), researchers from different backgrounds discussed topics that included the challenges during the postdoctoral period and childcare during summer vacations, as well as trends in the United States. During the 7th session (August 2025), Ms. Ayako Tsuchiyama (MIT) gave a talk on the generation mechanisms of intermediate-depth earthquake swarms in Columbia. The 8th session (August 2025) featured Dr. Keisuke Yoshida (Tohoku University), who presented a talk titled "Chain rupture of repeating earthquakes and the initiation of M7 earthquakes caused by seismic-to-aseismic transition after the 2011 Tohoku-Oki earthquake," which discussed the diversity and hierarchy of rupture processes of earthquakes on the plate boundary after the M9 event. This session also included dialogue between scientists from observational and theoretical fields, and discussions on the future direction of this research area. During the 9th session (September 2025), Dr. Tianhaozhe Sun (Geological Survey of Canada) presented his research on the lithosphere–asthenosphere boundary based on post-seismic deformation following the Tohoku earthquake, and Dr. Yijian Zhou (Caltech) presented his research on peculiar repeating earthquakes along the East Anatolian Fault and aseismic slip events on remote faults triggered by the 2023 Turkey–Syria earthquake.



Photograph of the 8th Slow-to-fast Earthquakes Project Café (August, 2025)

Report on workshop 2025 from oversea

Activity report: The Workshop on Slow-to-Fast Earthquakes 2025 in Kochi and Chile-Japan Academic Forum 2025 in Kyoto

José González-Alfaro, University of Chile

My visit to Japan through the Slow-to-Fast Earthquake Workshop and the Chile-Japan Academic Forum significantly advanced my postdoctoral research on the Puerto Aldea Fault by integrating field observations of exhumed subduction rocks, real-time feedback on microseismicity and Quaternary deformation from international experts, and broader interdisciplinary insights into subduction hazards and disaster preparedness. The field trips in the Shimanto and Sanbagawa belts provided direct analogs for understudied Chilean mélanges, while presentations and discussions refined my ongoing manuscript and sparked potential collaborations on GPS modeling, slow-slip processes, and multi-hazard risk assessment. Overall, these activities strengthened Chile-Japan scientific ties, enriched my understanding of slow-to-fast earthquake mechanics, and positioned me to contribute meaningfully to future bilateral projects in seismology and subduction-zone geology.

Underplated basalts.

AOGS

Participation in AOGS 2025

Aitaro Kato, Earthquake Research Institute, The University of Tokyo

The Asia Oceania Geosciences Society Annual Meeting 2025 (AOGS2025) was held from 27 July to 1 August 2025 at the Sands Expo and Convention Centre in the Marina Bay Sands, Singapore. The venue, situated in the heart of the city, offered a scenic view of the iconic Merlion in the distance. We organized a session titled "Science of Slow-to-fast Earthquakes" (Figure). The session featured 16 oral presentations on the morning of 1 August and 11 poster presentations on the afternoon of 30 July. Presentations covered the latest studies on slow earthquakes, plate boundary locking, and seismicity, followed by lively discussions and Q&A sessions. After the oral session, a lunch gathering provided an excellent opportunity for further academic and personal exchange among participants. Across AOGS2025 as a whole, the Solid Earth Sciences section had fewer presentations compared with other disciplines, suggesting significant room for future growth and collaboration. The next meeting, AOGS2026, will be held in Fukuoka, Japan, in early August 2026. We will again organize a session on slow and fast earthquakes, and we warmly encourage those who have not yet attended AOGS to consider joining us next year.

The "Science of Slow-to-fast Earthquakes" session at AOGS2025.

Collaborative Research at the University of Florence and Martin Luther University Halle-Wittenberg

Takahiro Hosokawa, Taizo Uchida, Graduate School of Integrated Art and Sciences, Kochi University

In October 2024, we carried out a three-week research visit to the University of Florence in Italy and Martin Luther University Halle-Wittenberg (Halle University) in Germany. The visit was devoted to conducting our respective research. We also presented our research at a seminar at Halle University. During our stay, we participated in field trips, including to the Ligurian units exposed along the Piombino coast in Italy and Paleozoic igneous and sedimentary rocks near the Saale River in Germany. We observed deformation structures, including mineral veins, and discussed the complex tectonics of Europe.

Hosokawa: At the University of Florence, I focused on developing numerical modeling skills under the guidance of Professor Paola Vannucchi, Dr. Jason P. Morgan, and Mr. Guanzhi Wang (Southern University of Science and Technology), who was also visiting at the time. We discussed methods for incorporating geological constraints from fault zones into numerical models. At Halle University, in collaboration with Professor Michael Stipp and Dr. Rüdiger Kilian, I conducted microstructural observations of thin sections of fault rock from a subduction plate boundary (the Mugi mélange in the Cretaceous Shimanto Belt) using scanning electron microscope-cathodoluminescence (SEM-CL) analysis, which allowed me to acquire data on features unobservable under optical microscopy, including microfractures in quartz and calcite, and mineral growth histories. In the future, I plan to process the data to reveal cycles of brittle fracturing and healing, reflecting dynamic fluid–rock interactions during the seismic cycle.

The author (Uchida) presenting at a seminar in the Geodynamics Department at Halle University.

Outcrop in Piombino, Italy.

Uchida: In Florence, I met with Dr. Chiara Montemagni and Prof. Paola Vannucchi to discuss our future collaborative research focusing on pseudotachylytes in the Southern Alps. We aim to apply paleomagnetic and rock magnetic methods to investigate earthquake dynamics, particularly the heating signatures and deformation mechanisms associated with fast slip. In addition, I visited the Alpine Paleomagnetic Laboratory and discussed fault magnetism with Dr. Claudio Robustelli Test (University of Turin), focusing on how the rheological properties of fault rocks are reflected in their magnetic fabrics.

During our research trip, we were each able to launch new collaborative projects. We intend to apply the experience gained during this visit to our future research. Finally, we express our deep gratitude to the Science of Slow-to-Fast Earthquakes project for supporting our overseas research.

Advancing post-expedition research related to Japan Trench drilling through an overseas research fellowship

Rina Fukuchi, Graduate School of Education, Naruto University of Education

From 24 July to 16 August 2025 I made an overseas research visit to Heriot-Watt University in Edinburgh, UK (Photographs 1 and 2). The host of this stay was Dr. Amy Gough, with whom I collaborated as part of the same sedimentology group during International Ocean Drilling Program (IODP) Expedition 405. The objective of the visit was to advance post-cruise studies related to the earthquake fault zone drilled in the Japan Trench.

During the stay, I worked mainly on the observation, description, discussion, and writing paper drafts, and also held a mini-workshop with Dr. Uisdean Nicholson (Heriot-Watt University; also a member of the expedition), Dr. Marianne Conin (University of Lorraine, France), Dr. Rebecca Robertson (Durham University; currently at Cardiff University, UK), and Dr. Maria Jose Jurado (Geosciences Barcelona, Spain; online). We exchanged datasets, including mineral quantification, cation exchange capacity analyses, and oxygen isotope measurements, and discussed the behavior of fluids within the sediments on the subduction margin, with particular emphasis on the roles of clay minerals and basalt as potential sources. Through the integration of our respective datasets, we refined the direction of future collaborative research and publication.

In addition, I participated in a geological field excursion with university members. At Siccar Point, we observed Hutton's famous unconformity, and around Barns Ness we examined representative Carboniferous stratigraphy (Photographs 3 and 4).

Despite the duration of only ~3 weeks, the stay enabled deeper scientific discussion, field-based observations, and a strong foundation for future international collaboration. I would like to express my sincere appreciation to everyone who supported this opportunity.


1.Entrance to Heriot-Watt University.


2.Group photo with participants of the mini workshop


3.Unconformity at Siccar Point

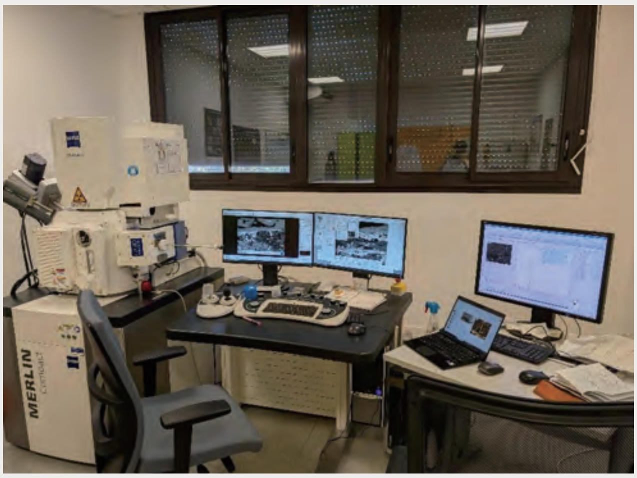

4.Root traces in limestone, White Sands Beach.

Report from a research stay at the University of Orléans, France

Yusuke Shimura, Geological Survey of Japan, AIST

From 29 May to 30 July 2025 I made an overseas research visit to the University of Orléans in France. The visit was facilitated by Prof. Hugues Raimbourg and marked the beginning of our collaborative research. He visited Japan to conduct a presentation as an invited speaker at the science of slow-to-fast earthquakes session of JpGU2025. Prior to this overseas research, we conducted a joint survey, focusing on faults in the Sanbagawa and Shimanto belts on the Kii Peninsula. In Orléans, we performed scanning electron microscope observations of the collected fault rocks and chemical mapping using an electron probe microanalyzer and cathodoluminescence imaging. Having focused primarily on geological structures at the meso- to macro-scale in the past, I gained valuable insights into the interpretation of microstructures and the aspects of such microstructures to prioritize. Furthermore, he strongly encouraged sketching, which I learned allows for a broad view of microstructures and their connections to larger scales.

This overseas research visit allowed me to dedicate myself wholeheartedly to a single research theme, much like during my time at graduate school, and proved highly meaningful. I intend to continue discussions with Prof. Raimbourg to prepare the results for publication and aim for ongoing collaborative research in the future.



Fault observations using a scanning electron microscope.

Joint Research Meeting

Hirosaki 03 : Joint Research Meeting of the A03 and B03 Groups

Yoshihiro Kaneko, Graduate School of Science, Kyoto University

The A03 and B03 groups have so far held their research meetings separately; however, this time we organized a joint meeting to strengthen discussion, collaboration, and interaction. The meeting, called "Hirosaki 03," was named after the fact that both groups are "03." It was held in a retreat format from 6 to 9 February 2025 at Hotel Apple Land in Hirakawa City, Aomori Prefecture. A total of 44 people attended, with 42 oral presentations, including 21 by students, which resulted in a lively and engaging atmosphere throughout. As the meeting brought together Group A03, which focuses on observation-based research, and Group B03, which engages mainly in modeling, we allocated ample time for questions and answers in consideration of the different research approaches. This provided a valuable opportunity for both groups to deepen their understanding of each other's work. The retreat setting also encouraged interaction beyond the sessions, with active conversations during meals, in the hot spring, and in the lobby. As the days went on, more questions came from students, showing the value of a format that allows for ample discussion time. There was also active interaction among young researchers, and we hope that this kind of gathering will help spark new projects in the future.

Group photograph in front of Hotel Apple Land

Lecture Event

Lecture at the Nanki Kumano Geopark Centre

Chuki Hongo, Wakayama Prefectural Nanki Kumano Geopark Centre

Group A02 held its third public lecture in collaboration with the Nanki Kumano Geopark. On 14 January 2025, Dr. Asuka Yamaguchi of Group A02 delivered a talk titled "Seafloor Deformation in the Source Area of Earthquakes" at the Nanki Kumano Geopark Centre, located on Cape Shionomisaki, the southernmost point on Honshu. The lecture highlighted the importance of research cruises and presented results from drilling surveys in the Nankai Trough earthquake zone, as well as the geology and geomorphology of the Shionomisaki Submarine Canyon and seafloor faulting observed during the 2024 Noto Peninsula Earthquake. Participants gained rare insights into research vessels and the seafloor through photographs and videos. During the Q&A session, lively questions (including whether large earthquakes can be predicted following slow-slip events) reflected strong public interest and expectations for future research. The lecture was held in person and was also interpreted in sign language and with note-taking support, and was co-hosted by the Wakayama Prefectural Nanki Kumano Geopark Centre and the Science Slow-to-Fast Earthquakes project.

Lecture at the Nanki Kumano Geopark Centre

T-Petit

Investigating the Mystery of Petit-Spot Volcanic Activity: IODP^3 Expedition 502

Ayumu Miyakawa, Geological Survey of Japan, AIST

In fall 2025, Expedition 502 of the International Ocean Drilling Programme (IODP^3) will take place on the outer rise of the Japan Trench. The seafloor in this area is the Pacific Plate just before it subducts, and the sediment layers found here are unusually thin. One recently identified cause of these thin sediments is the small-scale volcanic activity known as petit-spots.

Petit-spots are a type of volcanic activity in which alkaline, CO2-rich basaltic magma from the deep mantle erupts due to flexure as the plate bends prior to subduction. This type of volcanic activity was only discovered in the 2000s and is distinct from traditional plate-boundary volcanism and hotspots.

The main objective of Expedition 502 is to drill petit-spots directly and verify the existence and distribution of petit-spot volcanic activity under the seabed. If these volcanic features are widespread and voluminous, they could have a significant impact on earthquakes, volcanic activity, and even global geochemical cycles, especially the carbon cycle. For example, differences in sediment thickness in the source region of the 2011 Tohoku-Oki earthquake may be linked to the occurrence of earthquakes and the scale of tsunamis. Furthermore, basalt from petit-spots intruding the sediment layer may influence earthquake mechanisms and slip propagation. In addition, petit-spot volcanoes release large amounts of CO2, which could play a significant role in the carbon cycle and the composition of the Earth's atmosphere. Previously considered small and limited, petit-spots could offer new perspectives on Earth's evolution and climate change if their distribution and activity have been underestimated.

This drilling expedition, which will depart from Sendai in Miyagi Prefecture, will be the first to use the research vessel *Chikyu* under the new IODP^3 framework and will last about one month. The research team will collect sediments and underlying basalt directly, and will date the samples and analyze their chemical composition and physical properties. Co-chiefs and onboard researchers from this project will aim to comprehensively describe petit-spot volcanic activity and its effects on earthquakes, volcanism, and the geochemical cycles of the Earth.

Chikyu at Sendai Port, Japan

Award

Minister of Education, Culture, Sports, Science and Technology Award for Young Scientists in the Field of Science and Technology
Keisuke Yoshida (A03 Co-investigator Tohoku University)

The 6th Nishida Prize of JpGU
Saeko Kita (A02 Co-investigator Building Research Institute)
Yoshihiro Kaneko (B03 Co-investigator Kyoto University)

2025 Young Scientist Award of the Seismological Society of Japan
Yuji Itoh (B01 Co-investigator The University of Tokyo)
Daisuke Sato (B03 Co-investigator JAMSTEC)

2025 Research Paper Award of the Seismological Society of Japan
Shunsuke Takemura, Yohei Hamada, Hanaya Okuda, Yutaro Okada, Takeshi Akuhara, Akemi Noda, Takeshi Tonegawa (B02, A01, A01, B02, A02, B03, A02 Co-investigator The University of Tokyo, JAMSTEC, JAMSTEC, Tohoku University, The University of Tokyo, Ministry of Education, Culture, Sports, Science and Technology, JAMSTEC)
Makoto Naoi (A01 Co-investigator Hokkaido University)

2024 Editor's Citation for Excellence in Refereeing, Outstanding Service to the Authors and Readers of JGR : Solid Earth, American Geophysical Union
Keisuke Yoshida (A03 Co-investigator Tohoku University)

Top Viewed Article, Geophysical Research Letters
Aitaro Kato (B02 Co-investigator The University of Tokyo)
Keisuke Yoshida (A03 Co-investigator Tohoku University)

Top Viewed Article, Journal of Geophysical Research: Solid Earth
Keisuke Yoshida (A03 Co-investigator Tohoku University)

Outstanding Student Presentation Award of JpGU 2025
Manato Akishiba (A02 student Kochi University)
Seiya Yano (B03 student The University of Tokyo)
Kazuma Nakakoji (B01 student The University of Tokyo)
Takashi Nishizawa (B02 student Kyoto University)
Reiju Norisugi (B03 student Kyoto University)
Rintaro Enomoto (B03 student Kyoto University)

Outstanding Student Presentation Award of the 132nd annual meeting of the Geological Society of Japan
Ryoto Toda (A02 student Tohoku University/The University of Tokyo)
Fuka Takuwa (A02 student The University of Tokyo)
Kei Takahashi (A02 student The University of Tokyo)
Ryoto Toda (A02 student Tohoku University/The University of Tokyo)
Suzuka Yagi (A01 student Hiroshima University)
Yuto Yamasaki (A03 student Tsukuba University)
Shota Komagino (A03 student Tsukuba University)
Kotaro Kubota (A02 student Tsukuba University)

Seto Prize of the Geodetic Society of Japan (Research Startup)
Yuto Yoshizumi (B01 student The University of Tokyo)

Seto Prize of the Geodetic Society of Japan (Publishing Support)
Yuto Yoshizumi (B01 student The University of Tokyo)
Yuji Kikuchi (B02 student Shizuoka University)

Slow-to-Fast Earthquakes SNS

Website Facebook X

Publication of Slow-to-Fast Earthquake Leaflet

In 2022, we created a leaflet in both Japanese and English to introduce slow and fast earthquakes. In 2023, we also prepared the Spanish version for the self-invited workshop in Mexico, 2024. The pdf version is available on the Slow-to-Fast Earthquakes website. For the printed copies, please contact us from the Contact Form on the website.

Upcoming Events

JpGU-AGU Joint Meeting 2026
Date: May 24 (Sun.)-29 (Fri.), 2026
Hybrid (in-person & online), Venue: MAKUHARI MESSE, Chiba

The 88th Fujihara Seminar: Reconstruction of Earthquake Science with Slow Earthquake
Date: Sep. 16(Wed.)-18 (Fri.), 2026
Venue: Grand Hotel New Oji, Tomakomai city, Hokkaido

【Cover photos】
(Left)International Joint Workshop on Slow-to-Fast Earthquakes 2025
(Upper right) AOGS 2025
(Lower right)Self-invited workshop on SF Earthquakes Science in Chile

Grant-in-Aid for Transformative Research Areas (A)
SCIENCE OF SLOW-TO-FAST EARTHQUAKES
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