Earthquake Research Institute,
The University of Tokyo

Ocean Hemisphere Research Center: Hitoshi Kawakatsu

Deployment of the Pacific Array has begun!

The Pacific Array, which consists of a number of stations equipped with broadband seismometers and electromagnetic meters, is being deployed on the seafloor of the Pacific Ocean to explore subsurface structure down to the asthenosphere. The arrays will be moved to different locations at 1 to 2 year intervals with the aim of covering a wide area of the Pacific Ocean in about ten years.

Professor Hitoshi Kawakatsu of the Ocean Hemispheric Research Center, one of the key member of the observation project, discusses the background of the Pacific Array and its objectives as follows.

Deployment of the array on the oldest seafloor of the Pacific Ocean

"Although there have been calls for building seismic monitoring networks in areas of the Pacific Ocean seafloor that are not currently being monitored, methods have never been substantively discussed due to the difficulties involved. However, with the advent of broadband seismic exploration has enabled to use arrays to effectively monitor vast areas of the Pacific Ocean. Thus, we developed this observation plan named the Pacific Array," explains Professor Kawakatsu.

In November 2018, an array was installed jointly with South Korea and observations initiated at a site called "Oldest-1" (Figure 3). As the name suggests, this is the oldest seafloor in the Pacific Ocean. Professor Kawakatsu says that "the subseafloor structure should have a record of the mantle flow at the time of the creation of Pacific Ocean plate 10 million years ago. We would like to read that record." When there is flow within the mantel, the minerals become aligned, and the speed of seismic waves increases in the direction of flow. It is anticipated that observations by the Oldest-1 array will make it possible to visualize the flow of the lithosphere and the asthenosphere. The observation data will be made available to researchers around the world after a certain period. A US group also installed an array in May 2018, and the installation of a another array is scheduled. Research groups in Taiwan, China, and Germany have expressed interest in conducting joint observations with Japan. If a wide area of the Pacific Ocean can be covered, it will be possible to understand how subseafloor structure differs with seafloor age. We expect that this will elucidate both mantle dynamics over the past 180 million years and the physical mechanisms of plate movement.

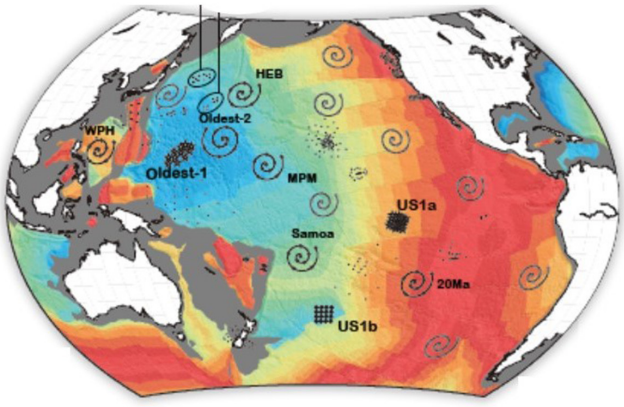
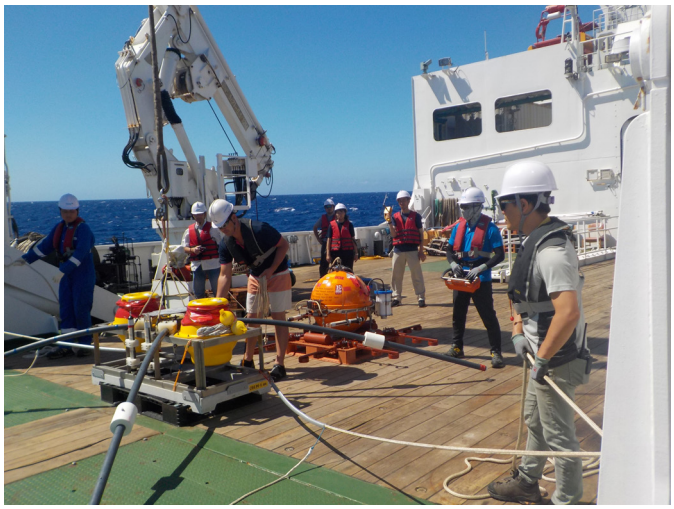


Figure 1 Pacific Array Location Map.
An "Array of Arrays" is a new observation concept involving a two-stage array, with the Pacific Array being the aggregate of the observations by individual arrays. In the figure, individual arrays are represented by spirals. Japan installed Oldest-1 on the oldest seafloor in November 2018. The installation of arrays at Oldest-2, HEB, 20Ma, Samoa, and MPM in collaboration with South Korea, Taiwan, Germany, and others is being planned. The US installed US1a in May 2018 and is planning to install US1b. The small black points represent existing seafloor movement observation points, while the colors show the age of the seafloor. The most recent information on the Pacific Array is available at : http://eri-ndc.eri.u-tokyo. ac.jp/pacificArray/.



Photograph of OBS.

Investigating the Earth through Math

"Models" based on theories and "data" obtained by observations are the two wheels driving science, and it is the comparison of these two that produces new knowledge. The scales of model-based simulations and observation data is steadily increasing. The development of new algorithms that can be used to conduct large-scale simulations and analyze big data is necessary.

Associate Professor Hiromichi Nagao of the Research Center for Computational Earth Science comments as follows.

Innovative Data Assimilation

"We create mathematical theories and algorithms that are fundamental to simulation and data analysis." As simulations progress, discrepancies with data observed in the real world occur, and these discrepancies increase. "Data assimilation is a method for resolving such discrepancies between simulation results and real world data. Observation data is input during the simulation, and the simulation is corrected to match the real world. Data assimilation has resulted in substantial improvement in the performance of simulations. However, still some problems remain. As such, I am developing new algorithms to solve problems with data assimilation."

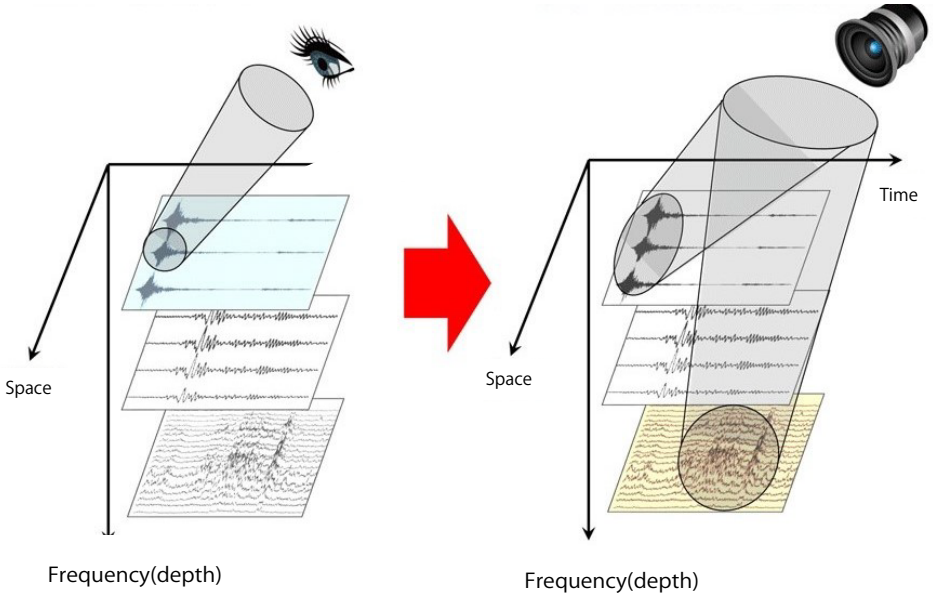
If the uncertainty of predictions can be assessed; we will be able to determine what types and how much data is required to achieve the necessary precision for predictions. Another great advantage of having such an ability is that it will facilitate recommendations regarding the design of observations and experiments, including what types of observations and experiments should be performed in what locations. The new data assimilation methods being developed by Professor Nagao and colleagues are anticipated to be applicable also to fields other than meteorology and seismology.

Intelligent Seismic Wave Analysis Method

Capable of auto-focusing on appropriate spatiotemporal and frequency bands based on a flexible model and, thus, is capable of detecting a wide range of seismic phenomena and hypocenter determination.

Conventional Seismic Analysis Methods

Require manual selection of spatiotemporal and frequency bands or selection based on rigid models and, thus, are only capable of capturing classical seismic phenomena.



Integrated Research Project on Seismic and Tsunami Hazards Around the Sea of Japan

The strong shocks and tsunami caused by the 2011 Tohoku earthquake produced great damage over a wide area of Japan, and highlighted the pressing need to reconsider earthquake and tsunami damage assessments as well as disaster prevention measures. The Sea of Japan-side of Japan is no exception. Professor Hiroshi Sato discusses the eight-year Sea of Japan Earthquake and Tsunami Project that began in 2013.

Pacific Ocean and Sea of Japan Tsunamis are Different

On the Sea of Japan side, tsunami-causing earthquakes occur in the upper plate carrying northeastern and southwestern Japan. As the distances from hypocenters to the Japan coast are short, tsunamis reach the coast quickly. There is no sufficient time to wait for an evacuation alert, and people must evacuate immediately if they feel a strong shock.

Urgent Need to Determine Location and Types of the Earthquake Source Faults

One method for investigating Subsurface structure is the seismic reflection survey. Seismic waves are artificially generated, and the waves that are reflected at strata or fault boundaries and other locations where physical properties change are received. Subsurface structure can be understood from the strength of reflected waves and the time it takes for reflected waves to return. In addition to investigation of coastal and offshore areas, the project carried out an integrated ocean and land exploration of the crustal structure along transects from the ocean to land. These investigations have revealed the detailed subsurface structure on the Sea of Japan side (Figure 2).

Based on the results of the survey, existing geological and geophysical data, historical records of earthquakes and tsunamis, and surveys of tsunami deposits, etc., we have been able to derive the location, length, width, inclination, etc. of source faults and build a fault model. Using this fault model, we calculated the occurrence of earthquakes and tsunamis and estimated strong ground motion and tsunami wave heights. These predictions of strong ground motion and tsunamis are provided to the national and local governments for the use in damage estimation.

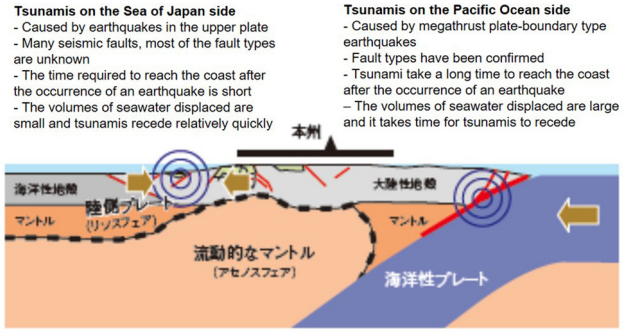


Figure 1
Characteristics of tsunamis on the Pacific Ocean side and the Sea of Japan side

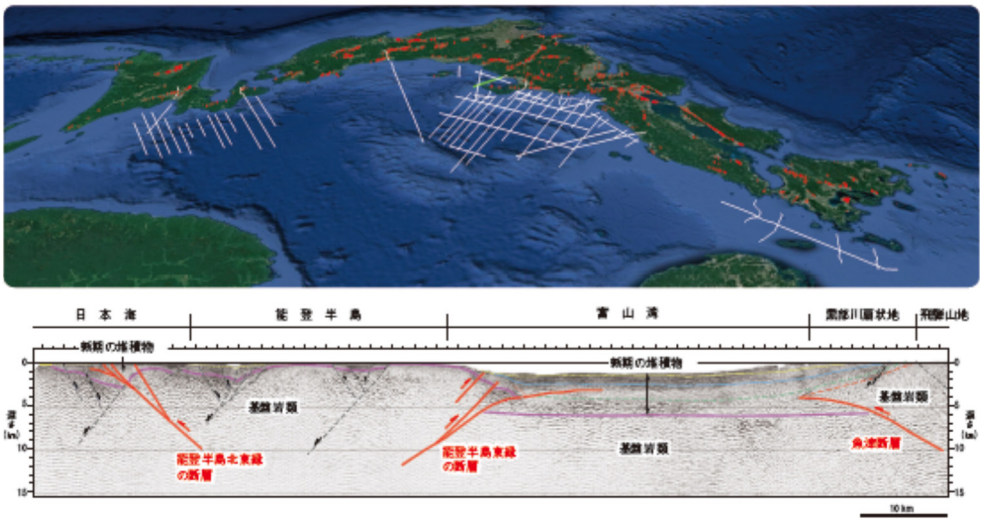


Figure 2 subsurface structure exploration by this project.
In addition to investigation of coastal and offshore areas, an integrated ocean and land exploration of the crustal structure was conducted along transects from the ocean to land (upper figure). This investigation generated location and fault type data necessary for constructing a fault model. The white lines are the transects for the investigation conducted by JAMSTEC and ERI. The red lines are active faults on land. The bottom figure shows the results of an exploration by Associate Professor Tatsuya Ishiyama et al. of the subsurface structure crossing the Toyama Trough (green line in upper figure).

Visiting Program for researchers at Earthquake Research Institute

G: Geoffrey Abers (Professor, Cornell University, USA)

JP: Jean-Pierre Vilotte (Professor, IPGP, France)

V: Vukobratovic, Vladimir (Assistant Professor, University of Novi Sad, Serbia)

We offer a unique opportunity for researchers worldwide to stay for collaborative research, from a few weeks to one year at the Earthquake Research Institute, the University of Tokyo. On Feb. 19th 2020, three current visitors talked to us about their experiences at ERI.

Facilitator: Masa Kinoshita, Head of International Office

Q. What is the topic of your research here, and why did you choose ERI?

V: A visit to ERI gives me a unique opportunity to access a huge amount of data from instrumented buildings, which helps me to expand the research from my Ph.D. thesis in 2015. My four-month stay is greatly supported by Dr. Kusunoki, through regular meetings and discussions.

JP: I am working on new statistical data analysis of slow earthquakes activity in active subduction zones from seismic geodetic observations. ERI is one the most knowledgeable place in the world for slow earthquakes research. With Professor Obara, we have been collaborating and exchanging students and post-docs through the long-standing collaboration between ERI and IPGP.

G: I chose ERI to stay for my sabbatical because I knew this is the best place as seismologist to study partial melting in deep earth through seismic observation. There are only two labs in the world that make relevant measurements at seismic frequencies. I have known Dr. Takei and her post-docs for ten years, but this is our first opportunity to collaborate.

Q. What is your impression about research environment here?

V: I have perfect communication with my host and cooperative colleagues. Our collaboration exceeded the expected level.

JP: I found here a unique opportunity to exchange and leverage scientific understanding and thinking behind slow earthquake observations. This requires time and cannot be easily gained otherwise. The ERI environment allows working on complicated issues benefitting from interaction with disciplines other than Earth Sciences.

G: ERI has perhaps the biggest collection of expert seismologists. It is valuable to talk with them, especially about research that bridges complicated experiments and observations. Language barriers exist between English and Japanese, and between seismologists and experimentalists. However, there is much time in this environment to allow complicated issues to be discussed. It is hard to find the place like this.

Q. What do you think about our visiting program?

G: There are a lot of programs for young post-docs or Ph.D. students, while not many for senior researchers.

V: This is a special kind of academic freedom, without typical every-day duties. I find that it is very important and beneficial to spend time like this, especially for young researchers.

JP: It is a unique opportunity at a senior research level. Beyond language barriers, I enjoyed the wide spectrum of seminars that allow discovering young researchers. The visiting program helps building up and nourishing scientific collaborations at different levels in a long-term perspective.

Masa Kinoshita, Head of International Office

Long-term visiting program for professors / post-docs

- Term: 4 - 12 months between April 1, 2021 and March 31, 2022
- Application Deadline: August 16, 2020

Short-term visiting program for researchers

- Term: Up to 3 months between April 1, 2021 and March 31, 2022
- Application deadline: Fall 2020

For more information:International Research Promotion Office http://www.eri.u-tokyoac.jp/kokusai/english/index.html