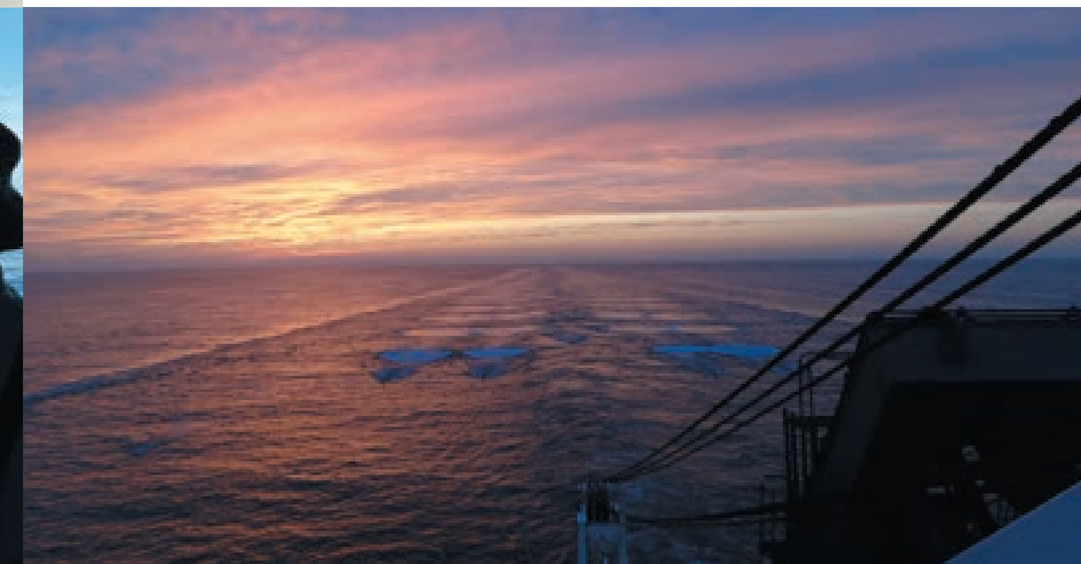
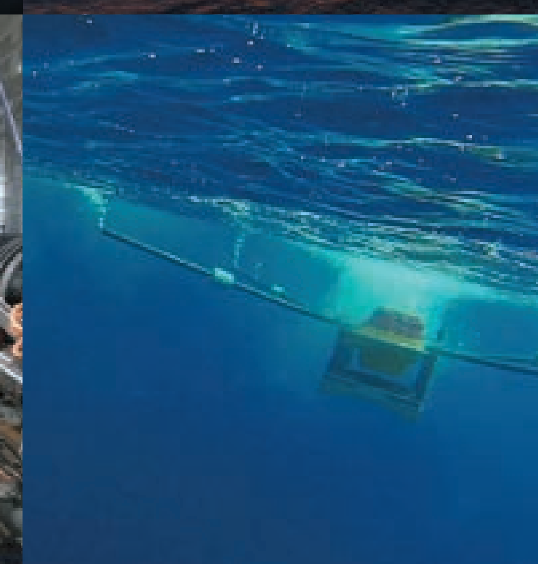
JAMSTEC
Japan Agency for Marine-Earth Science and Technology

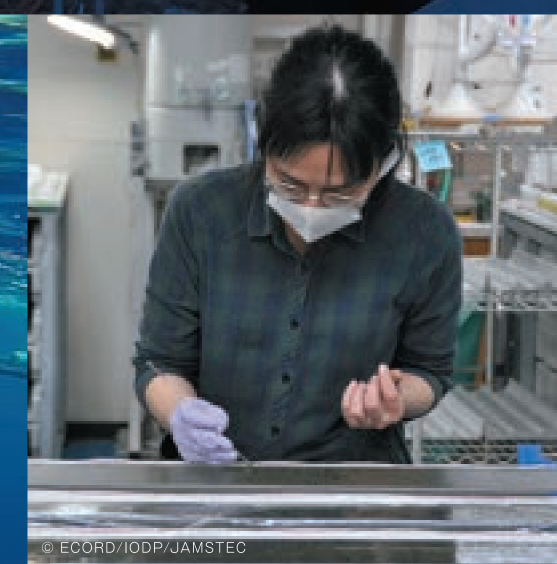
Japanese title written by Shosen Tabata 2024.4


# Research Institute for Marine Geodynamics

海域地震火山部門

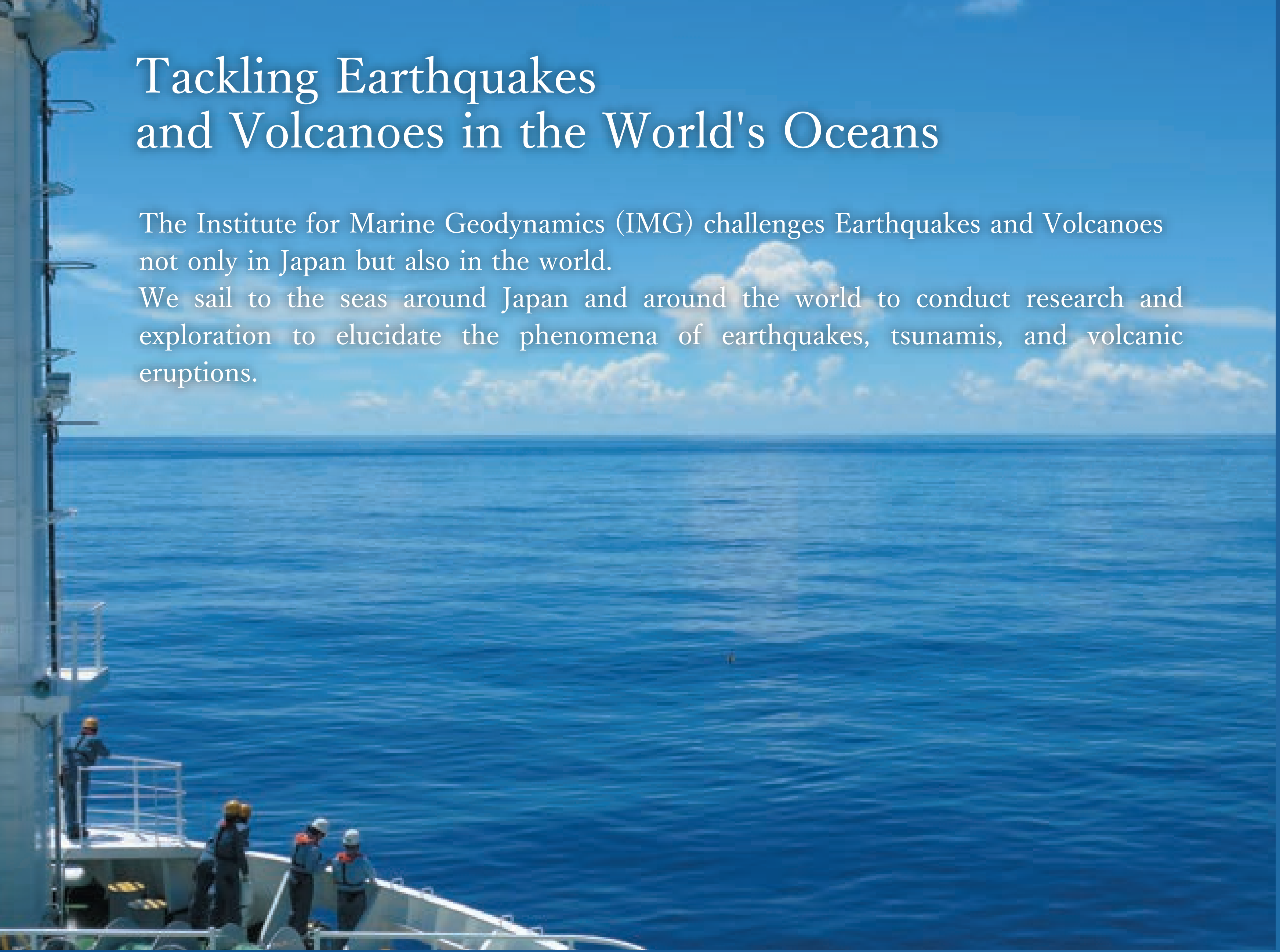




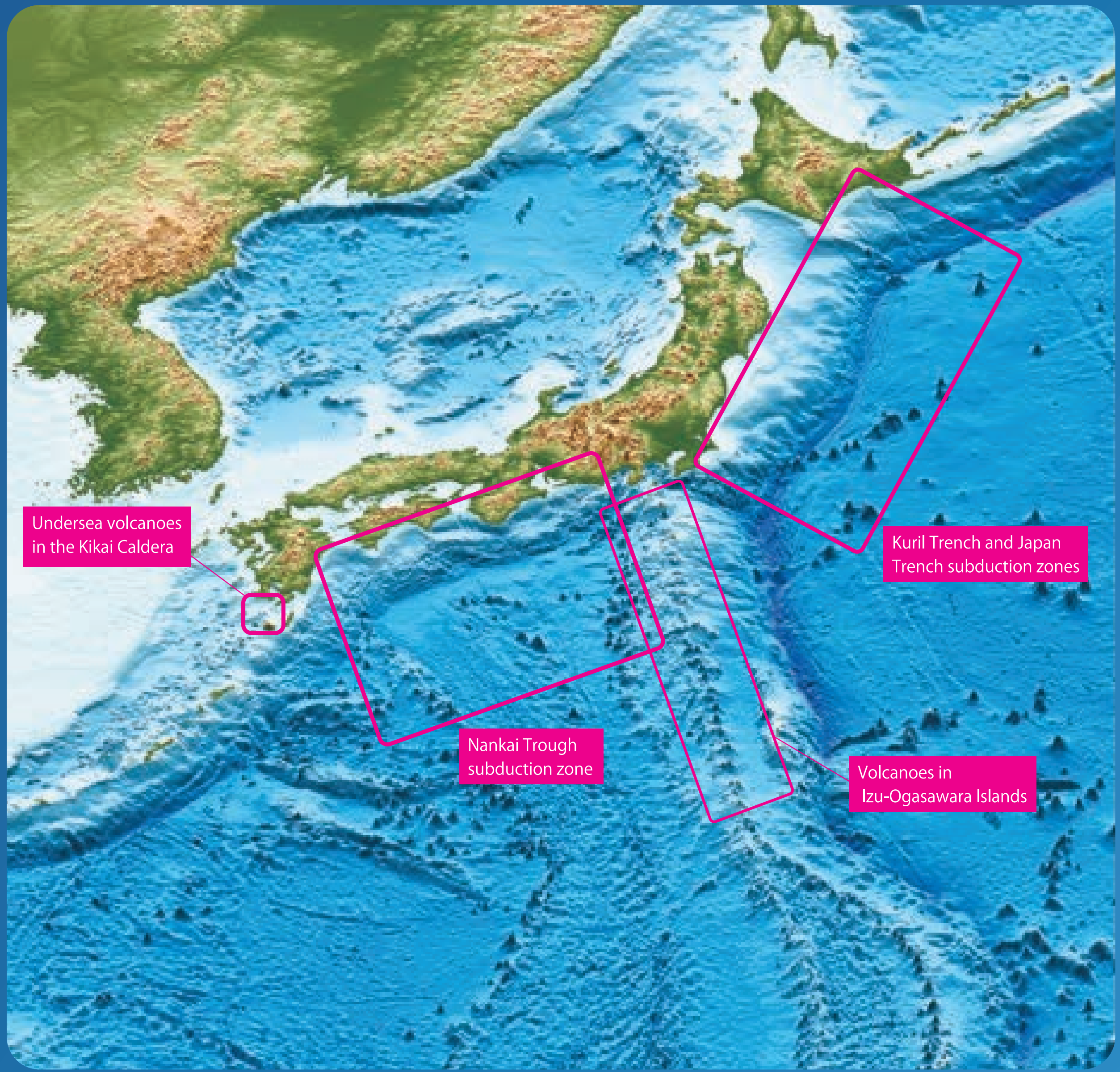


# Tackling Earthquakes and Volcanoes in the World's Oceans

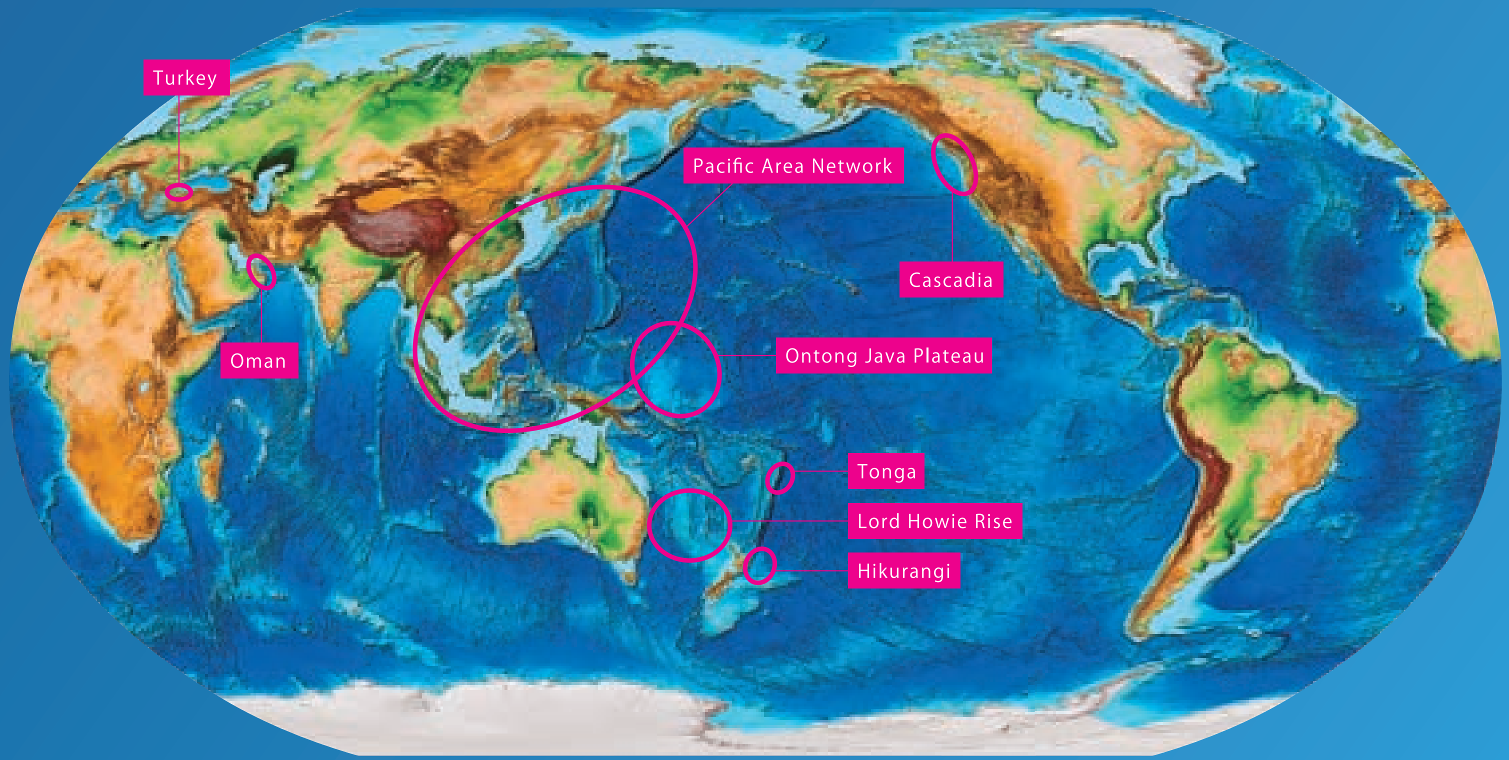
The Institute for Marine Geodynamics (IMG) challenges Earthquakes and Volcanoes not only in Japan but also in the world.
We sail to the seas around Japan and around the world to conduct research and exploration to elucidate the phenomena of earthquakes, tsunamis, and volcanic eruptions.



## Main Research Areas:




| | | |
|---|---|---|
| JAPAN | Kuril Trench | We investigate crustal structure, seismic activities, and deformation processes to elucidate the megathrust earthquakes in this subduction zone. |
| | Japan Trench | We investigate crustal structure, seismic activities, and deformation processes to elucidate the megathrust earthquakes, such as the 2011 Tohoku earthquake. |
| | Nankai Trough | We investigate crustal structure by extensive seismic exploration and observe crustal activities by developing monitoring system to elucidate and forecast the preparation, rupture and deformation processes of the megathrust earthquakes. |
| | Kikai Caldera | We conduct structural exploration and collection and analysis of volcanic ejecta to investigate the conditions leading to past eruptive activities and understand the potential damage that the volcano may pose to society in the future. |
| | Izu-Ogasawara Islands | We study the processes leading to eruptions and investigate the transition in eruptive activity by analyzing ejecta samples and conducting structural exploration. |
| WORLD | Turkey | We conduct seafloor seismic observations in the Marmara Sea to study the geometry of faults that pass beneath the seafloor and the actual state of seismic activity. |
| | Oman | We study the crust-mantle boundary by examining the largest oceanic lithosphere (ophiolites) exposure on land. |
| | Pacific Area Network | We conduct geophysical observations to contribute to the early detection of earthquakes and to tsunami forecasting in the western Pacific region. |
| | Ontong Java Plateau | We conduct comprehensive research on the formation and origin of the largest oceanic volcanic edifice on Earth. |
| | Tonga | We conduct research on the eruption process of submarine volcanoes using pumice and other materials ejected during volcanic eruptions. |
| | Lord Howie Rise | We investigate the crustal structure and crustal deformation to understand the mechanism of continental breakup. |
| | Hikurangi | We examine the crustal structure and crustal deformation of a mega seismic zone to explore the earthquake generation processes caused by crustal deformation. |
| | Cascadia | We investigate the effects of seamount subduction on earthquake generation zones. |




Medley, P. R., CIRES, University of Colorado at Boulder, 2009
http://www.ngdc.noaa.gov/mgg/global/global.html
Accessed 05.08.2022

# Elucidating the occurrence and processes of earthquakes and volcanic activities in marine areas for disaster mitigation

The Institute for Marine Geodynamics (IMG) conducts large-scale research and observation using JAMSTEC-owned research vessels and observation equipment to elucidate the occurrence of and circumstances affecting earthquakes and volcanic activities. In addition, highly accurate numerical simulations are conducted to predict the future trends of these activities. These data and information are provided to the government and related organizations to mitigate disasters.

**Shigeaki Ono**

Director-General, Research Institute for Marine Geodynamics (IMG)

We are committed to learn about the past, present, and future of the living Earth and explore the relationship between Earth activities and human society.

Sub-seafloor structural exploration

Wave Glider, an unmanned vehicle that observes seafloor crustal deformation

Volcanic eruption at Nishinoshima

## Three centers that make up the Institute for Marine Geodynamics (IMG)

### Subduction Dynamics Research Center (SDR)

We conduct extensive marine controlled-source seismic surveys and earthquake observations to reveal the subseafloor structure in subduction seismogenic zones, especially focusing on the detailed geometry and physical properties of the megathrust plate boundary fault. We also apply submarine paleoseismology using seafloor sediment samples to reveal the prehistoric huge earthquakes and tsunami in subduction zones. Based on these activities, we will contribute to a better understanding of the subduction seismogenic zones.

Director of Center: **Gou Fujie**
Specialty: Marine Seismology

Most of the devastating earthquakes, such as the 2011 Tohoku earthquake, occur beneath the seafloor. To clarify the detailed nature of such seismogenic zone, in-situ observations where the earthquakes occur are indispensable. We challenge to understand the past, present, and future state of seismogenic zones based on marine geophysical and geological surveys and observations.

### Research and Development Center for Earthquake and Tsunami Forecasting (FEAT)

Most of the rupture areas of huge earthquakes with magnitudes of over 8 extend beneath the seafloor. The mission of our center is to develop technologies for real-time monitoring of crustal and seawater movements on the seafloor, and to make maximum use of these observation data to develop and implement a system for forecasting earthquakes and tsunamis. Our goal is to understand crustal deformation during the pre-, co-, and post-seismic periods, as well as tsunami and other phenomena that occur as a result of earthquakes, seafloor landslides, and so on.

Director of Center: **Takane Hori**
Specialty: Earthquake Forecasting

We have been developing a system to comprehend the past and present occurrences of phenomena that cause earthquakes to be able to forecast future events. When an earthquake occurs in the future, I hope that people will say, "I knew it will happen there, and I am glad we prepared for it in advance."

### Volcanoes and Earth's Interior Research Center (VERC)

Earth is a continuously changing planet and volcanoes play a major part in shaping both its land and marine landscapes. The dynamic activity of volcanoes is an awesome sight, yet, we often suffer from disasters caused by them. Ultimately, the energy of volcanic activities is supplied from the Earth's interior. Our center is aiming to develop an integrated understanding of volcanoes and Earth's interior, and making the best use of this knowledge for the benefit of our society.

Director of Center: **Shigeaki Ono**
Specialty: Science of Earth's interior

Compared with volcanoes on land, there are many unsolved problems with oceanic volcanoes. Those who are interested in facing the challenges this last frontier of volcanology, oceanic volcanoes, are welcome to join us at JAMSTEC.

## Subduction Dynamics Research Center (SDR)

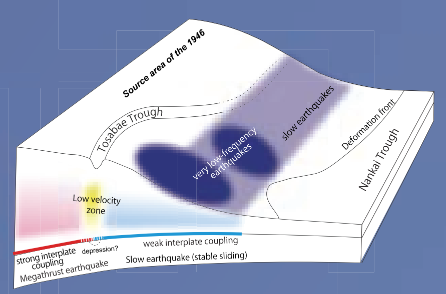
# Toward understanding the seismogenic zones from marine geophysical and geological surveys and observations

We conduct extensive marine controlled-source seismic surveys and seafloor seismic observations to reveal the three-dimensional structures of the subduction seismogenic zones, and conduct submarine paleoseimology using marine sediment samples to reveal the prehistoric record of the devastating earthquakes and tsunamis.

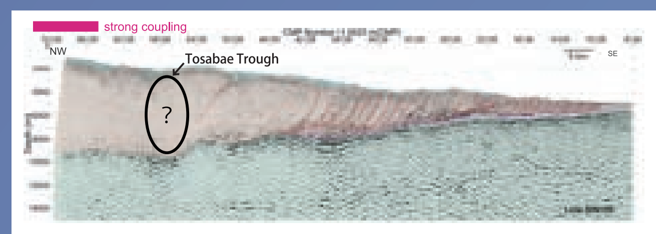
## Visualization of seismogenic zones

In the subduction seismogenic zones, both the normal earthquakes, that cause strong ground motion, and the so-called slow earthquakes, that cause almost no ground shaking, occur along the plate boundary fault. The conditions that discriminate the generation of the normal earthquakes and slow earthquakes are still poorly understood. Clarifying these conditions is key to understanding the generation mechanism of various earthquake along the plate boundary fault.

The Subduction Dynamics Research Center (SDR) conducts extensive marine controlled-source seismic surveys and seafloor seismic observations to better understand the subduction seismogenic zones. One of the primary research objectives is revealing the conditions that discriminate the occurrence of the normal and of the slow earthquakes. Recently, we confirmed that slow earthquakes occur along the plate boundary fault where many small seamounts are subducting. In addition, we found a narrow low seismic velocity zone, suggesting highly fractured zone, within the overlying plate between the areas of the normal earthquakes and of the slow earthquakes, suggesting that the structural evolution of the overlying plate is closely related to the seismic activities along the plate boundary faults. We will further investigate the physical properties of the low velocity zone to better understand the causes that discriminate the areas of the normal earthquakes and of the slow earthquakes, and the mechanism that enables the devastating plate boundary earthquakes.



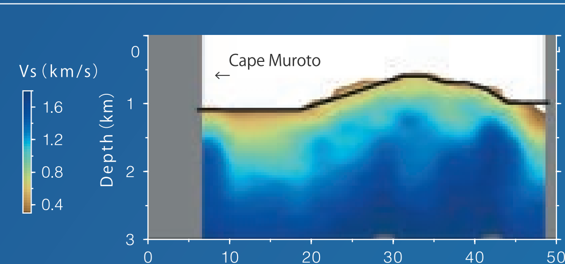

Schematic illustration of the subduction seismogenic zone of the Central Nankai Trough, showing a low velocity zone exists within the overlying plate between the areas of the megathrust earthquakes (strong interplate coupling) and of the slow earthquakes (weak interplate coupling).




Seismic cross-section of the Central Nankai Trough. A low velocity zone exists beneath the Tosabae Trough.

## Challenges for Monitoring subseafloor structural changes

Long-term Submarine seismic observation has many difficulties, such as the cost of the installation and the constant power supply. However, the recent development of new observation technology that uses submarine fiber-optic cables, which are commonly used for telephone and Internet communications, as sensors to detect ground motion is bringing significant innovation to submarine seismic observations. Research and Development Center for Earthquake and Tsunami Forecasting(FEAT) succeeded in developing a seismic monitoring system that uses an existing seafloor cable several tens of kilometers long off Cape Muroto. The monitoring system is equivalent to a dense and permanent array of the ocean bottom seismometers installed at several meter intervals.




S-wave velocity structure estimated by the ambient noise analysis observed through the fiber-optic cable off Cape Muroto.

We, Subduction Dynamics Research Center (SDR), processed the ambient noise of the data obtained through the fiber optic cable off Cape Muroto and have succeeded in extracting various seismic waves propagating under the seafloor. In addition, we have developed a new technique to visualize the complicated geological structure beneath the seafloor using the seismic waves extracted from the ambient noise observed by the fiber-optic cable. These new observation and analysis techniques have the potential to detect changes in the subseafloor structure under the existing fiber-optic cables. We will advance our observation and data analysis techniques to monitor the minute changes that occur in the subduction seismogenic zones.

## Paleoseismology: Exploring prehistoric giant earthquake and tsunami

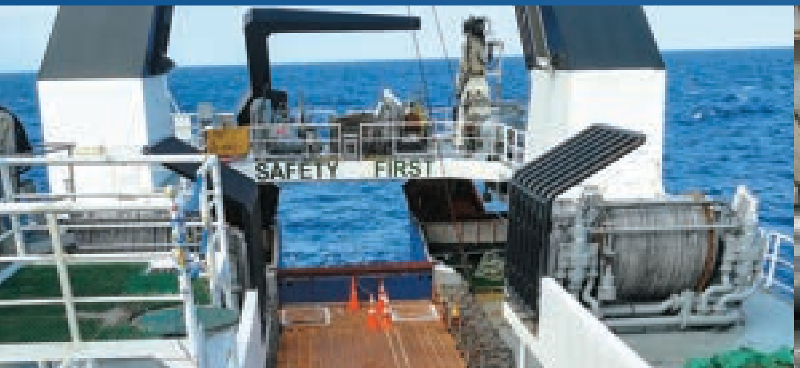
The 2011 Tohoku earthquake was the largest earthquake instrumentally recorded in Japan and caused a devastating tsunami. A large tsunami inundation similar to the 2011 Tohoku earthquake is recorded in historical documents, but the recurrence of such devastating earthquakes and tsunamis is poorly understood. Marine paleoseismology, a study of prehistoric giant earthquakes and tsunamis based on the traces left by these events, is key to understanding the geohazard and risk posed by long-recurrence earthquakes.

When the seafloor is strongly shaken by earthquakes, the sediments suspended by the strong ground motion move down the slope like an avalanche, reaching the deep seafloor and depositing there, forming a layer called "turbidites". Since the turbidites layers are the traces of past earthquakes and tsunamis, the seafloor sediments sampled by coring are the key to paleoseismology. The distribution of the turbidites show the extent of strong ground motion at the seafloor.

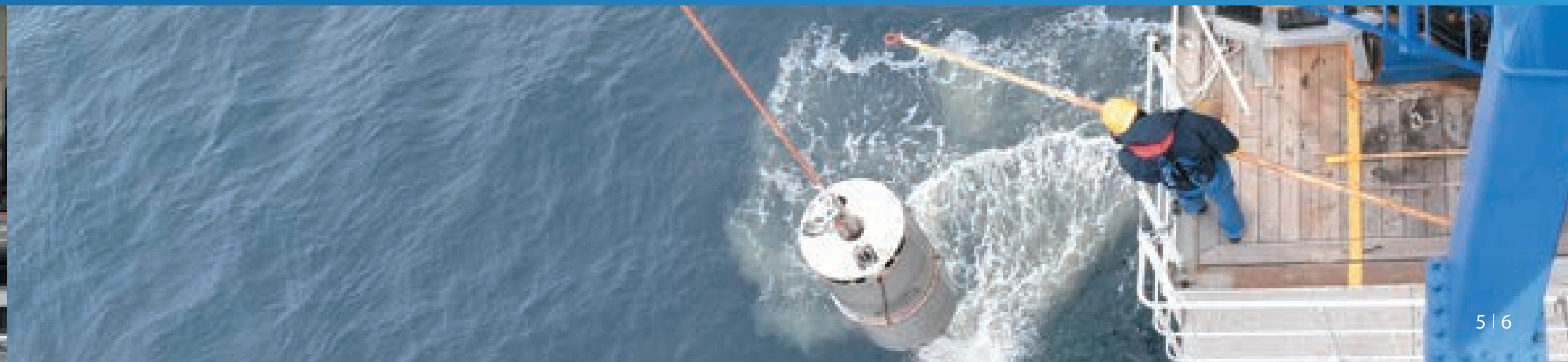
In the Japan Trench, we succeeded in determining the extent of the strong ground motion from the paleoearthquake that occurred more than 1000 years ago, based on the sediment samples taken from the seafloor. In the Nankai Trough, we found many turbidite layers in the sediment cores, but some of them may not be related to strong ground motion. Therefore, we will develop a method to distinguish the cause of the turbidite layer formation and will reveal the historical occurrence of earthquakes and tsunamis in this area.

We will continue to conduct deep seafloor surveys and core sampling, and reconstruct earthquake occurrence records up to tens of thousands of years in the past, mainly in the Nankai Trough, Japan Trench, and Kuril Trench areas.


**X-ray CT images of a core sample taken from the Nankai Trough.**
The images show repeated appearance of turbidites (white bands).





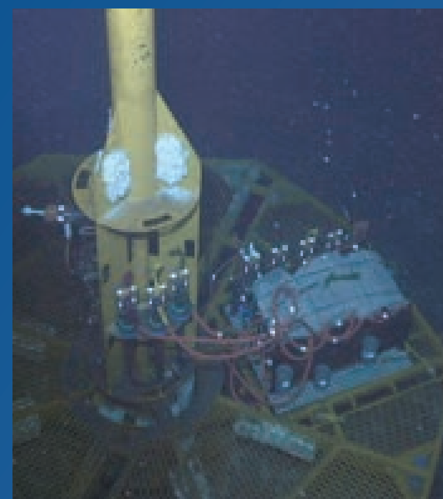


# Continuous Seafloor Crustal Deformation Monitoring and Earthquake/Tsunami Forecasts

Development of seafloor observation equipment to observe crustal deformation and methods to monitor and forecast earthquake activities.

## Continuous Real-Time Monitoring of Seafloor Crustal Deformations

The Research and Development Center for Earthquake and Tsunami Forecasting (FEAT) is developing a continuous real-time wide-area monitoring system for seafloor crustal deformations around the Nankai Trough in order to predict earthquakes and tsunamis.
JAMSTEC installed seismographs and water-pressure gauges at 51 sites on the seafloor around the rupture areas of the Nankai and Tonankai Earthquakes. These are then connected to the land stations via seafloor cables for conducting continuous real-time earthquake and tsunami monitoring with the "Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET)*1.
Borehole measurements are effective to monitor the seafloor crustal deformation at a higher precision. JAMSTEC has been conducting drilling studies offshore of Kii Peninsula using the Deep-sea Scientific Drilling Vessel CHIKYU to install these systems. Currently, 3 long-term borehole monitoring systems have been installed in boreholes several hundred meters below the seafloor and continuous real-time crustal deformation monitoring is achieved by connecting with DONET. In the near future, we plan to install similar observation systems in boreholes several hundred meters below the seafloor at 3 sites in the area west of the Kii-Channel, which will be connected to the seafloor cable observation systems, such as DONET, using CHIKYU.



Seafloor observatory at a borehole constructed by using CHIKYU

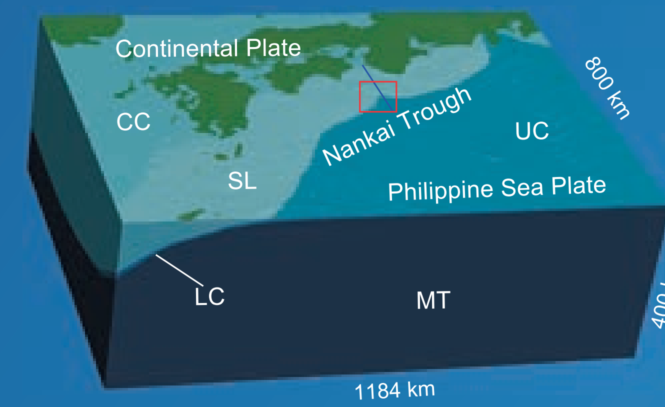
In addition, we have been using the Research Vessel KAIMEI's Giant Piston Corer to drill boreholes ~20m below the seafloor for installing seafloor crustal deformation observation equipment and laying the optical fibers for broadband observation of strain on the earth's crust. We are expanding our continuous real-time crustal deformation observation network by connecting these equipment to the DONET.

*1 Now the DONET is managed by the National Research Institute for Earth Science and Disaster Resilience.

## Near-future Predictions of the state of Seismogenic Zone

By analyzing seafloor and terrestrial crustal deformation data with the models that reflect subsurface structure and physical property estimated by the Subduction Dynamics Research Center, we aim to comprehend the current conditions of fault locking/slipping, estimate the stress distribution on the fault and fault strength, and predict near-future fault locking/slipping behavior. On the shallow and deep plate interface in the Nankai Trough, "slow slips" of several centimeters/week to tens of centimeters/month occur. We focus on the slow slips because they will inform us of the change in the potential for the generation of a large earthquake. Although slow slips are not unusual, some remarkable situations where the area of slow slips overlaps the source areas of the large earthquakes, or the area continually expands after magnitude 6-7 earthquakes, can occur.

In these unusual situations, the possibility of a huge earthquake is thought to be higher than normal. Thus, we aim to detect unusual locking/slipping conditions by collecting data from seafloor crustal deformation monitoring systems. It is known that huge earthquakes occurred successively along the Nankai Trough, for instance, the Nankai earthquakes that occurred 1.5 days and two years after the Tokai and Tonankai earthquakes. Once a large earthquake occurs, we will estimate the unruptured area and will predict the size and rupture area of the forthcoming earthquake and associated tsunami. Moreover, after the first earthquake, the slow slip area expands into its surroundings, leading to successive earthquakes. We advance research and development to monitor and predict these slow slips and to provide information regarding future earthquakes.

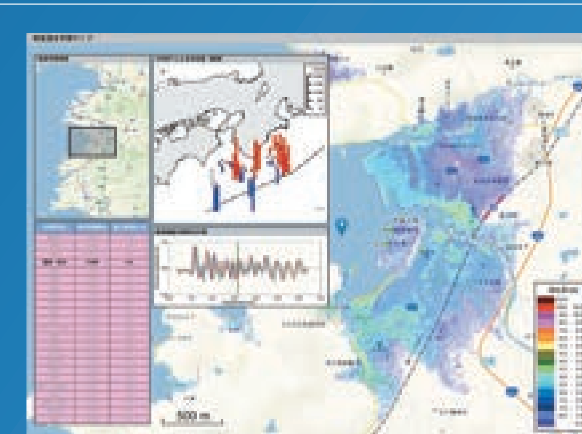



**A finite element model reflecting heterogeneous underground structure**

Conventional earthquake cycle simulations to reproduce the occurrence intervals and patterns of earthquakes utilized simple subsurface structure model. In the future, we aim to understand the current state of the seismogenic zone and predict near-future conditions by utilizing both subsurface structural survey data and seafloor crustal deformation data.

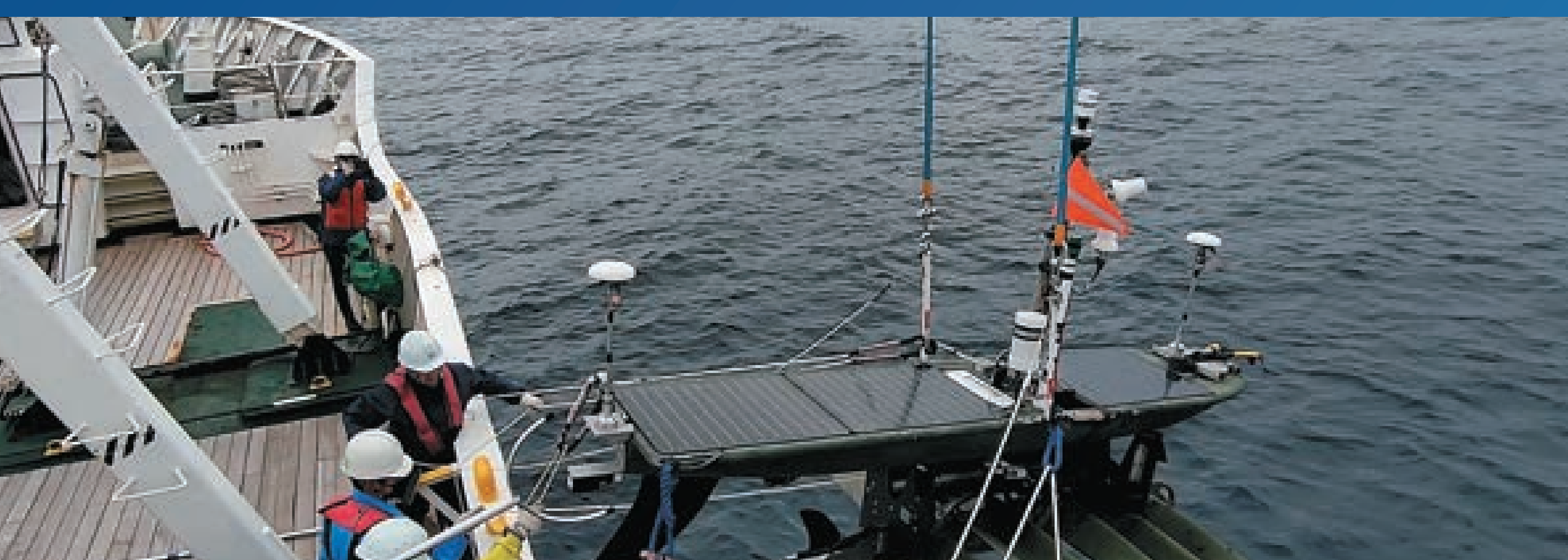
## A Tsunami Prediction System that takes Storm Surges and Submarine Landslides into Account

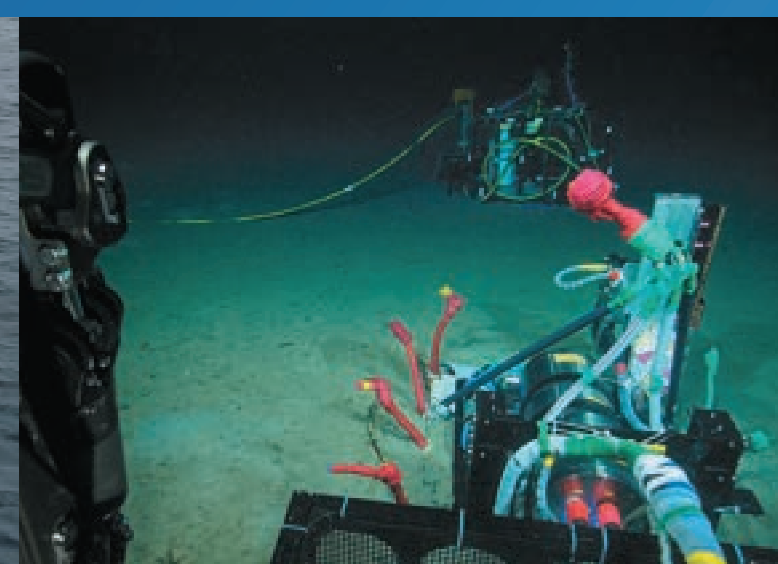
JAMSTEC has built a real-time tsunami forecasting system using DONET, and this system has already been introduced in Wakayama, Mie, and Kagawa prefectures, Chubu Electric Power Co., Inc, and Kagawa University, in collaboration with the National Research Institute for Earth Science and Disaster Prevention, which is managing the DONET. The real-time tsunami forecasting system uses observed offshore water pressure data from DONET, as well as coastal tsunami height and the timing and breadth of flooding, to transmit real-time information that is useful for disaster prevention. However, DONET water pressure gauge readings are not only high during tsunamis but also during storm surges due to typhoons. Like earthquakes, submarine landslides in a comparatively small area have been known to cause large tsunamis. Thus, we are continuing to improve the real-time tsunami forecasting system by distinguishing between storm surges and tsunamis, as well as improving our ability to predict tsunamis induced by landslides.

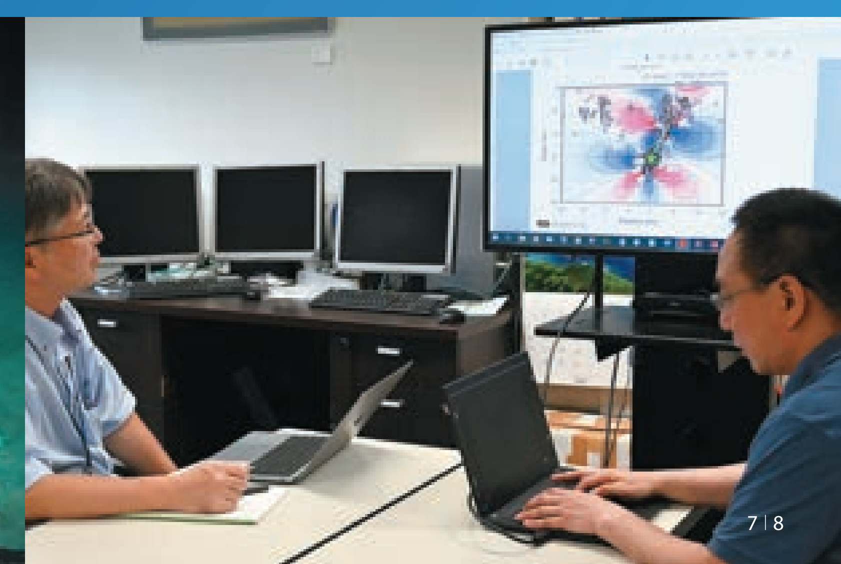


**Real-time tsunami forecasting system based on the seafloor pressure monitoring.**

Forecasts of tsunami arrival time, wave height, inundation depth and inundation area in the targeted area is updated every second.







## Volcanoes and Earth's Interior Research Center (VERC)

# Developing an integrated understanding of volcanic activity and the Earth's interior

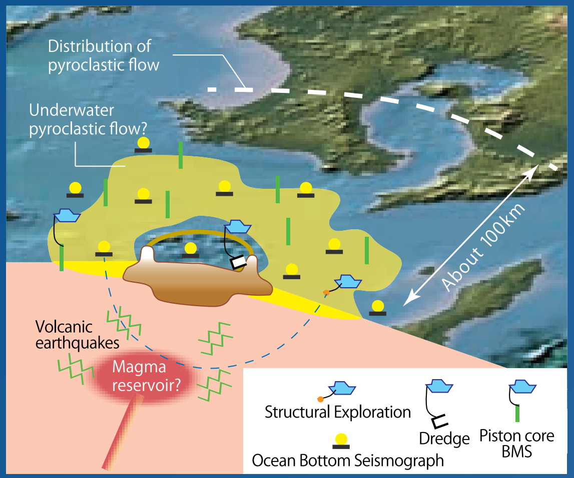
Our center is advancing our understanding of present and past activities of volcanic islands and submarine volcanoes by conducting seafloor surveys and analyzing erupted materials from offshore volcanoes. We are also elucidating the internal dynamics of Earth as the key for generating volcanoes.

## Exploring the present state of oceanic volcanoes

Studies on oceanic volcanoes, such as submarine volcanoes and volcanic islands, is far behind those on volcanoes located on land. Consequently, there are concerns that unexpected eruptions of oceanic volcanoes could occur and induce larger disasters. Thus, the Volcanoes and Earth's Interior Research Center is advancing research aimed at understanding the occurrence of oceanic volcano eruptions, evaluating their impacts for global environment, and reducing disasters.

We are deploying a high-density array of ocean bottom seismographs (OBS) in Kikai Caldera located on seafloor south of Kagoshima. We are observing earthquakes for a year, and we will then use these observations to investigate the subseafloor structure at 10-100 km depth. If a magma reservoir exists at this location, our data is expected to capture it. In order to monitor the present conditions of several oceanic volcanoes, we installed water-pressure gauges capable of measuring the vertical movements of seafloor, and ocean bottom electro-magnetometers (OBEM) that are sensitive to subseafloor temperature. To communicate with the OBEM in the seafloor, we are developing an unmanned data acquisition system in collaboration with Kobe University and the Earthquake Research Institute of the University of Tokyo.

While the present state of volcanoes can be monitored from geophysical observations, reconstructing the past histories of eruptions of these volcanoes is also important for predicting possible future activities. Volcanic rocks and ash distributed on seafloor around oceanic volcanoes should provide records of their eruption history. We are therefore surveying seafloors such as around the Kikai Caldera and the Izu-Ogasawara Arc to collect volcanic materials by using research vessels. Petrological and geochemical analyses are performed on the collected rocks and sediments to elucidate past eruptions and variation of volcanic activities.




**Ongoing surveys at Kikai Caldera**

Kikai Caldera experienced huge eruptions in the past. We are exploring the structure by various methods and reconstructing the eruption history.


**Drifted pumice erupted from Fukutoku-Oka-no-Ba, 2021**

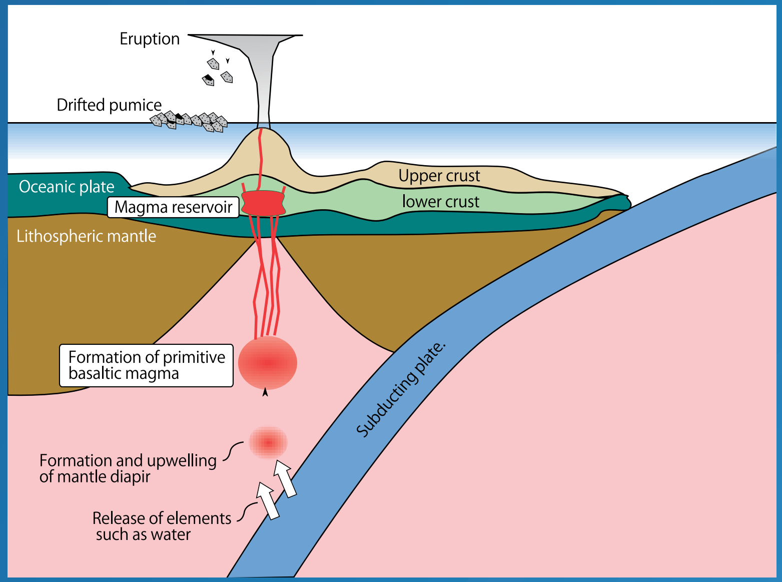
We are exploring the mechanism of eruption by analyzing these samples.

## Studying Earth's interior to explain why volcanoes are located where they are

In order to predict future volcanic activities based on scientific knowledge, it is also necessary to understand phenomena occurring inside the Earth. Volcanism on and around Japan is induced by the subduction of tectonic plates. The key factor for generating magmas in a subduction zone is the transport of water to the deeper part and its subsequent release from the subducted plate. Because the melting temperature of mantle rock is significantly lowered by the presence of water, magmas are generated above the subducted plate and then move to crustal reservoirs beneath volcanoes.

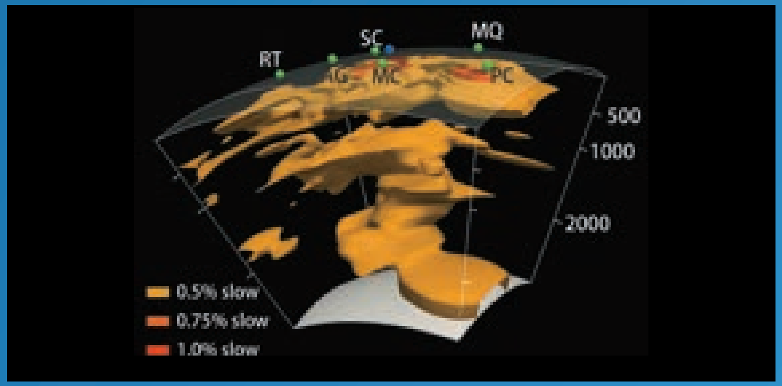
The type of magma tends to vary depending on the distance from the trench. There is a hypothesis that this variation is caused by the expected compositional difference of water, which depends on the depth of release. Previous JAMSTEC surveys and subsequent geochemical studies confirmed that the type of magma varies from north to south along the Izu-Ogasawara Trench. A possible cause of this phenomenon was suggested to be the variation of crustal thickness and, consequently, the difference in the depths where magmas are generated.

What is the nature of tectonic plates and how they are generated, moving, and subducting, are still significant open questions in Earth science. We will also continue drilling surveys under the IODP (International Ocean Discovery Program) using our Deep-sea Scientific Drilling Vessel CHIKYU to confront these challenging questions. We will be able to answer the question why specific types of volcanoes are located at certain regions of the Earth in the near future.




**Schematic view of volcano formation in a subduction zone**

Supply of water from subducted plate lowers the melting temperature of mantle rock. Partial melts of mantle rocks generate magma that ascends to the surface and collects to form a reservoir beneath volcanoes. Consequently, volcanic eruption occurs.




**Upwelling flow of mantle beneath hot spot volcanoes**

Structure of mantle beneath French Polynesia in the South Pacific derived from seismic tomography.

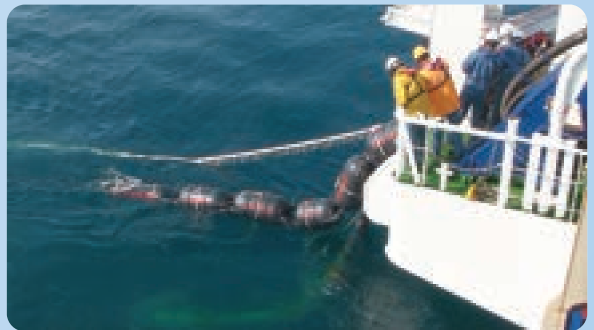
# Marine surveys and observations

## Investigation of the subduction seismogenic zones

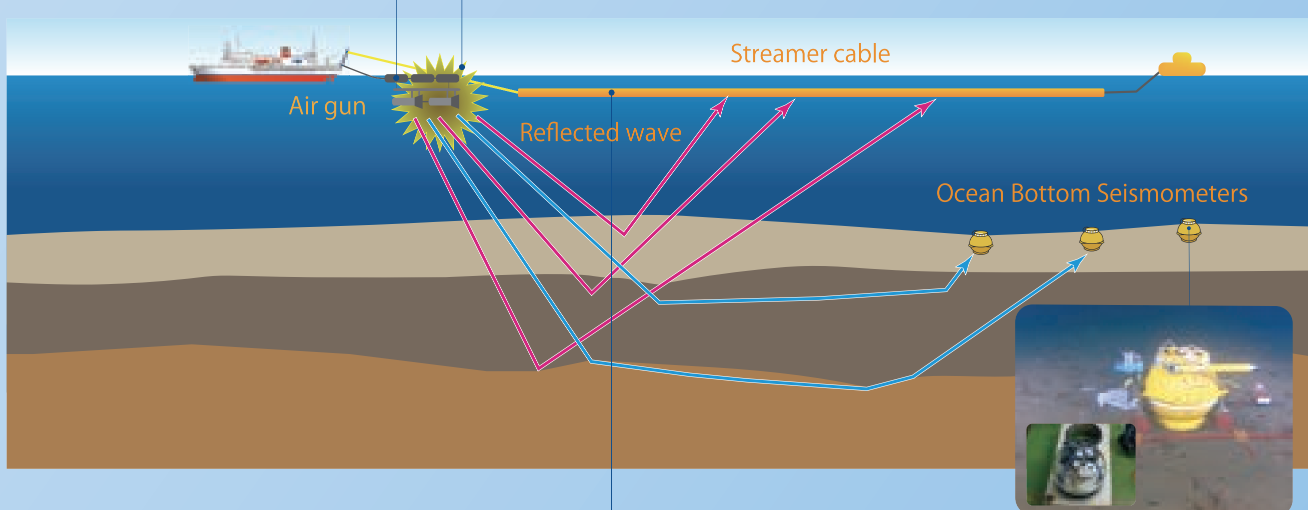
Main research areas:
Nankai Trough, Japan Trench, Kuril Trench

**In the controlled-source seismic survey, the Research Vessel KAIMEI tows an air-gun array to emit the acoustic waves (seismic waves) and a hydrophone streamer cable, a long cable implementing many hydrophones, to record the seismic waves emitted from the air-gun array. In addition, ocean bottom seismometers (OBSs) are deployed in advance to record the air-gun signals. The analysis of these seismic data reveals the detailed subseafloor structure.**

Deployment of an air-gun array into the sea from the stern. The black ovals are floats and the air-guns are suspended 10 meters below the float.

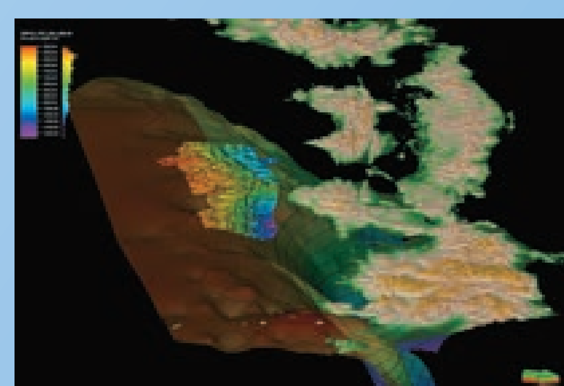


High-pressure air is released into the ocean at a regular interval from the air-gun array.




Ocean Bottom Seismometers (OBS).
A seismograph (sensor) is implemented in a pressure proof glass sphere within the yellow cover (hard hat).

A hydrophone streamer cable. A number of hydrophones are placed every few meters. The cable length depends on the situation and can be more than 6km.



The surface of the Philippine Sea plate subducting into the Nankai Trough modelled by marine controlled-source seismic surveys.

## Ocean drilling to reveal past large earthquakes and tsunami events recorded in submarine sediments

Main research areas: Nankai Trough, Japan Trench, Kuril Trench

**We collect submarine sediments using the Deep-sea Scientific Drilling Vessel CHIKYU and the Research Vessel KAIMEI. Based on sampled data, we reveal the historical earthquakes and tsunamis.**

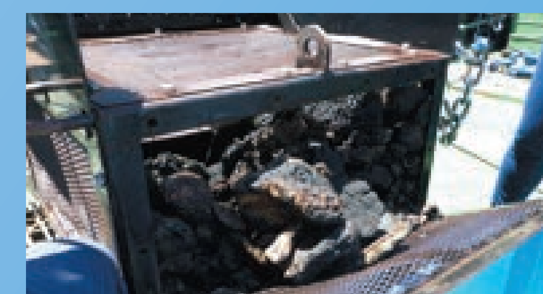
(left) A Research Vessel KAIMEI. (right) The sampled sediments.

The sediment samples (core) collected at a depth of 4,332m off Cape Muroto in the Nankai Trough. Several turbidite layers (the blackish layers), which are traces of the past large earthquakes, can be recognized. We are investigating the historical megathrust earthquakes and tsunamis based on these sediment samples.

## Collecting rock samples from seafloor

Main research areas: Kikai Caldera, Nishinoshima, Fukutoku-Oka-no-Ba

**Erupted rocks and ash remain on the seafloor around oceanic volcanoes. They are collected by a huge basket called "dredger" trawling from a research vessel. We can explore the mechanism of eruption by analyzing these samples.**



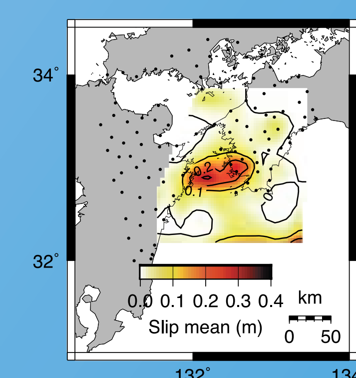
Dredged rocks
These are dense rocks erupted from Fukutoku-Oka-no-Ba. We can obtain further information on eruption mechanism by comparing them with light pumice that drifted and were recovered from the sea surface.

## Forecasting by using supercomputers

Representative target regions: Nankai Trough, Japan Trench

**The High-Performance Computing on the supercomputer based on the observation and synthesized data enables us to simulate past earthquakes and forecast future earthquakes.**

The Earth Simulator (ES)
The ES is used for research in various fields, including the field of marine geosciences such as geodynamics.




Slip distribution for the slow slip in the Bungo Channel estimated by means of a new analysis method that simultaneously processes many earth models, taking advantage of the computational capabilities of the Earth Simulator. As a result, the spatial extent of the slip area is smaller than that of the conventional method, and the relationship with other slow earthquakes can be reasonably explained.

# The Research Institute for Marine Geodynamics (IMG): Interview with the Director-General

What are the characteristics of JAMSTEC's research on marine earthquakes and volcanoes, and how can the research results be used to solve social problems in the event of a disaster? We also asked Shigeaki Ono, director of the division, about his expectations for the next generation of young people.

**Q** Please tell us about the main characteristics of JAMSTEC's research on marine earthquakes and volcanoes. There are many universities and national research institutes that study earthquakes and volcanoes and the disasters they cause. What is the difference between JAMSTEC and those other research institutes?

**A** JAMSTEC's goal is to obtain "scientific knowledge" about earthquakes, tsunamis, and volcanic eruption phenomena. We then disseminate this information and use it to help build a disaster-resilient city and nation. Our mission is particularly important in the area of "obtaining scientific knowledge.

JAMSTEC is a research institute for the "ocean," so one thing that clearly differentiates us from other research institutes is that we can explore the ocean. We use our own tools, observation vessels, and exploration equipment to investigate what is happening there, and we ensure the maximum use of the data we obtained. I think the most unique aspect of JAMSTEC is that we are conducting research and development to understand earthquakes and volcanic eruptions in the marine realm.

**Q** If so, do you consider JAMSTEC-owned vessels and originally developed tools to be the most distinctive features of JAMSTEC?

**A** We do not believe that vessel ownership or availability of tools are the only features. What is important is that every researcher has the ability to make the best use of the existing tools and the ingenuity to create new ones to solve the scientific problems that we face. This is what makes us unique.

**Q** There are many types of earthquakes, such as earthquakes directly under the Tokyo metropolitan area and trench earthquakes, etc. What are the targets of your research at JAMSTEC?

**A** We target earthquakes and volcanic activities that occur in the "oceans" or offshore. Our specific research targets are trench earthquakes and associated tsunamis, as well as large volcanic eruptions in the oceans, that have a large impact on social activities. We are unique in the world in that we focus on trench earthquakes, tsunamis, and offshore volcanic activities.

**Q** We would like to ask you about the perspective of social implementation. I think it will be very important to see how the research of the Research Institution for Marine Geodynamics (IMG) is specifically useful to society and our daily lives. In the future, I believe that collaboration between the Research Institution for Marine Geodynamics (IMG) and the private sector will increase. What benefits and advantages will the private sector gain from this collaboration?

**A** There are two aspects. First, from the viewpoint of the continuity of corporate activities in the event of a disaster, the scientific knowledge and data we disseminate or the systems we develop will be used for preliminary assessment of damage, and we believe that the predicted transition information immediately after a major earthquake can also be used for business planning after the disaster. The second is the new way of utilizing various corporate infrastructure facilities in terms of earthquake and tsunami monitoring and early detection. Due to recent technological innovations, sensors that were originally installed for purposes other than earthquake observation are now being used as tools to detect earthquakes and tsunamis. In some cases, they can provide an order of magnitude more information than conventional observation networks. It may be possible to create new business opportunities by taking advantage of this kind of technology.

**Q** Finally, what would you like to convey to the youth of the next generation?

**A** As someone who lives in earthquake-prone and volcano-laden country like Japan, I hope that more children will become interested in questions like "what is this planet we live on" and "why do these things (earthquakes, tsunamis, volcanic eruptions) happen? To this end, we would like to convey to high school and junior high school students, and possibly elementary school students, the wonders of what is happening inside the Earth and the fun of unraveling these marvels. We actually had opportunities to discuss with high school students and examine their research together, and we will continuously have such activities in the future.