SCIENCE OF SLOW-TO-FAST EARTHQUAKES

"Science of Slow-to-Fast Earthquakes" is a joint research project by researchers from across Japan and follows the "Science of Slow Earthquakes" project.

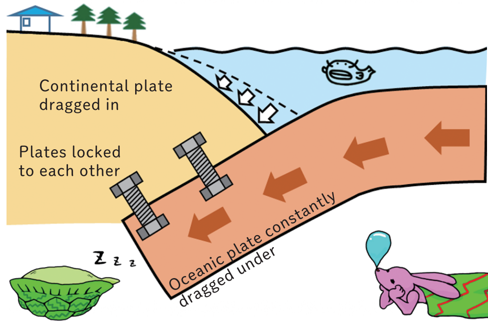
We aim to establish a comprehensive understanding of earthquakes through collaborative research across various fields of earth science and the introduction of new research methods.

Science of Slow-to-Fast Earthquakes
Grant-in-Aid for Transformative Research Areas (A)
Principal Investigator: Satoshi IDE (The University of Tokyo)

What is a Slow Earthquake?

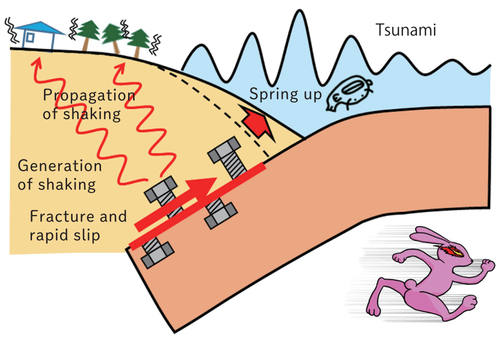
An earthquake is a subsurface fault slip. Whereas an ordinary earthquake involves rapid slip, a slow earthquake is slow slip that causes little shaking. Such slow earthquakes have been detected worldwide.

①Plate boundary in itsordinary state



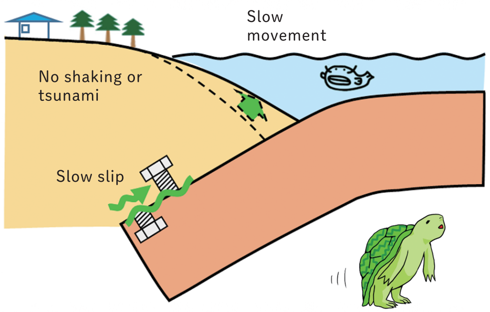
①During subduction of an oceanic plate, the continental plate is dragged in, and strain builds up

②Big (fast) earthquake



②When strains build up to a particular limit, rapid slip occurs on the fault, and shaking and tsunamis are generated

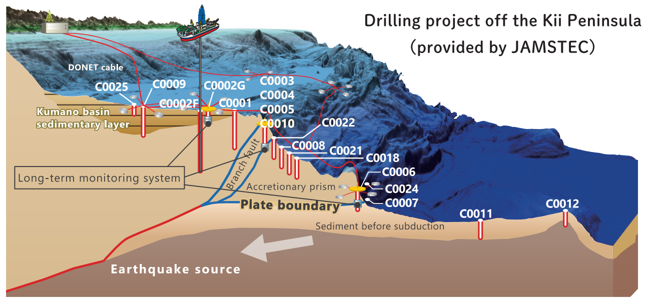
③Slow earthquake



③Slow earthquakes also occur when strain builds up to a particular limit. However, slip occurs slowly, and no shaking or tsunami occurs

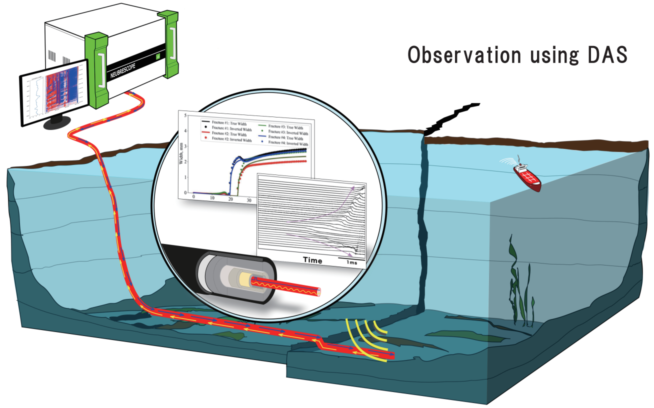
Various Research Methods

Earthquakes are an important focus of investigation in the fields of geology and geophysics. The mechanism of fault slip is governed by equations of physics, and chemical knowledge is essential for studying fault materials. Researchers from various fields collaborate to understand slow and fast earthquakes. For example, we have drilled boreholes (wells) off the Kii Peninsula to acquire materials used for estimating the conditions of fracture and slip via laboratory experiments. These conditions are further used for computer simulations to reproduce earthquakes.



Drilling project off the Kii Peninsula (provided by JAMSTEC)

Methods for studying earthquakes continue to advance. Recently, machine learning (artificial intelligence) methods have been applied to big data of earthquakes. New measurement methods are also being developed, such as DAS, which transforms a single optical fiber cable for communication into 10,000 seismometers.



Observation using DAS

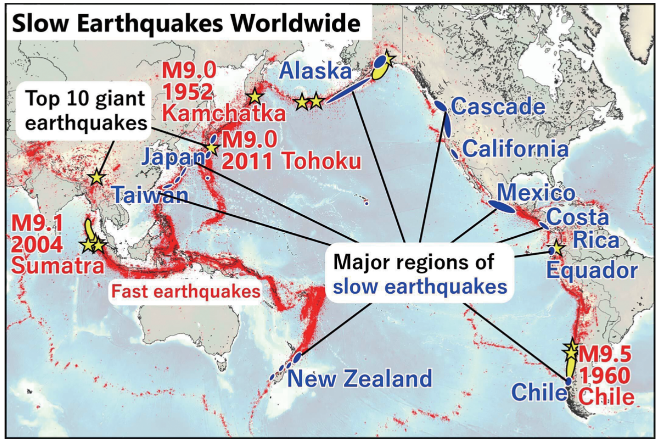
Slow and Fast Earthquakes

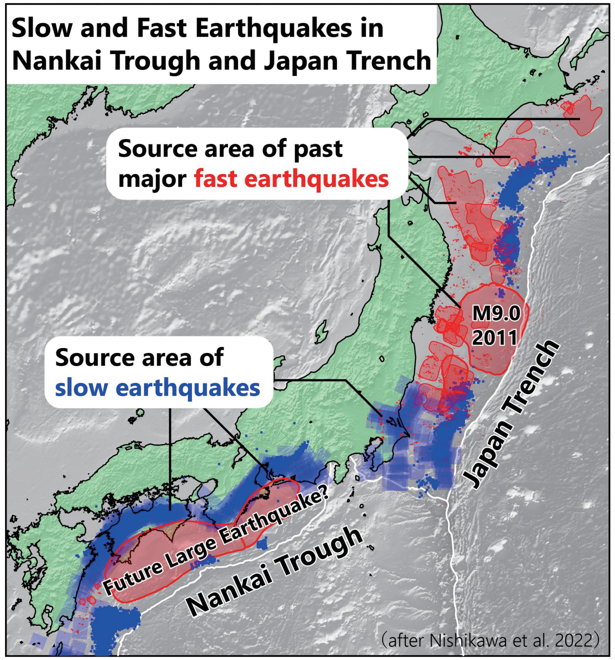
When an earthquake occurs, an underground fault is fractured with rapid shear slip to cause strong seismic shaking. However, a fault may slip slowly, without strong shaking. These **slow earthquakes** were first discovered during the early twenty-first century. The table below summarizes the differences between the two types of earthquake. In this project, we are investigating the relationship between slow and fast (ordinary) earthquakes.

	Fast Earthquake	Slow Earthquake
Mechanism	Shear slip on fault (common)	
Max. Size (Length)	Magnitude 9.5 (1000km)	Magnitude 7.5 (500km)
Max. Shaking	~1G (gravity)	~0.000001G (cannot be felt)
Duration	<5 minutes	Seconds to years
Expansion Speed	Faster than sound and bullet	Turtle walking to human running speed

Locations

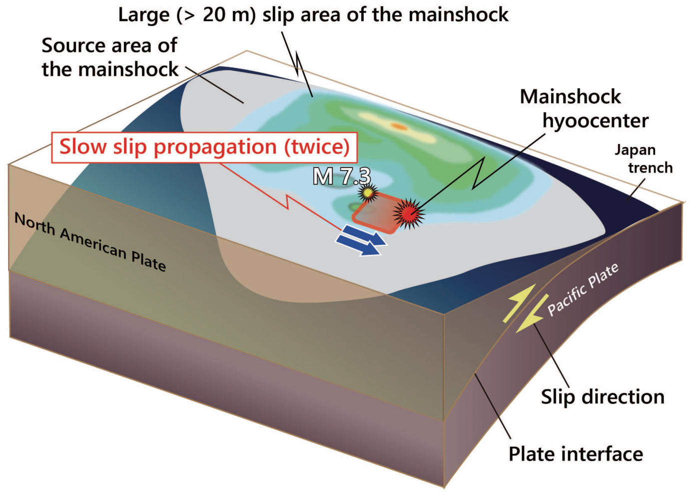
The driving force of both slow and fast earthquakes is the movement of tectonic plates. Therefore, these earthquakes occur near plate boundaries (see figure below). Around Japan, earthquakes occur frequently in subduction zones, such as the Nankai Trough and the Japan Trench (see figure to the right).





Earthquake Forecasting and Slow Earthquakes

Unfortunately, It is currently impossible to predict the occurrence of earthquakes with the level of accuracy required to issue warnings for giant earthquakes. However, probabilistic forecasting that includes uncertainty, producing forecasts involving the likely size of an earthquake (e.g., M > 7.5) and the associated time frame (e.g., within a few decades) are realistic. Our goal is to reduce the uncertainty and increase the power of future forecasting through a more accurate understanding of the physical phenomena involved. For example, preparatory processes must occur before a large earthquake and are probably related to slow earthquakes. During the 2011 Tohoku-Oki, Japan, earthquake, slow slip (a slow earthquake) occurred twice along the plate boundary, days or weeks before the M9 earthquake. The question is, how often do these slow slip phenomena occur?



Earthquake and Volcano Hazards Observation and Research Program

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