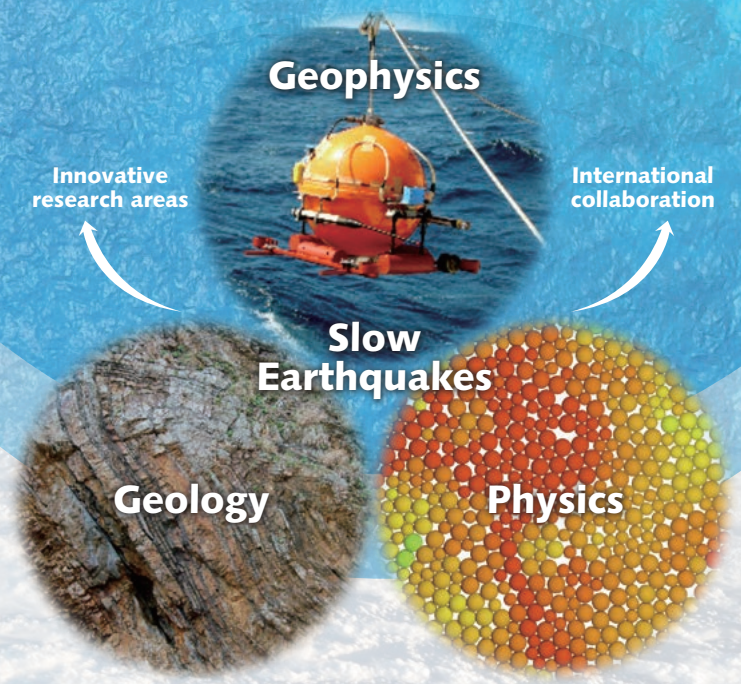
Science of Slow Earthquakes



"Science of Slow Earthquakes" is a five-year collaborative project conducted by researchers in Japan.

It aims to reveal a new type of seismic phenomena defined as "slow earthquakes" from a new multidisciplinary perspective incorporating geophysics, geology, and non-equilibrium physics.

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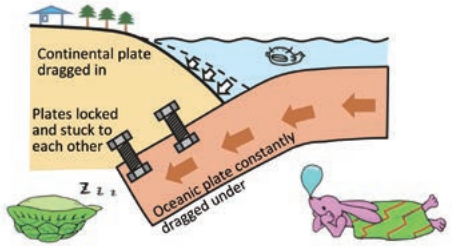
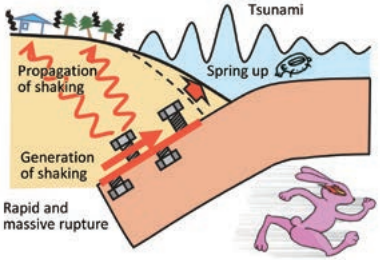
Earthquake Research Institute, The University of Tokyo

What Is a Slow Earthquake?

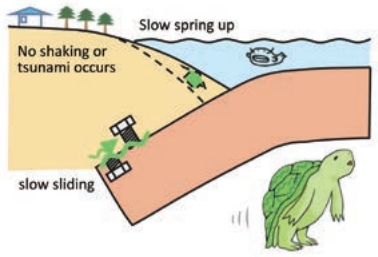
An earthquake is a subterranean fault slip. While a regular earthquake is a quick slip, a slow earthquake is a slow slip causing little tremble on the ground surface. Such slow earthquakes have been detected worldwide.



① Plate boundary in its ordinary state
While the plates are stuck, the continental plate is dragged in, and strains build up



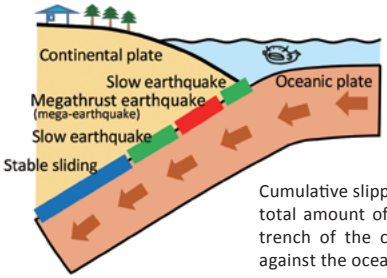
② Big earthquake (Regular earthquake)
When strains build up to the limits, a rapid slide occurs on the fault plane, at which point, shaking and tsunamis are generated.



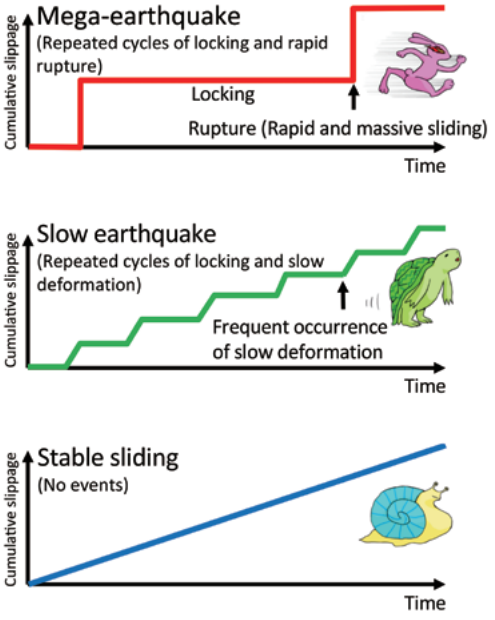
③ Slow earthquake
Slow earthquakes occur when strains build up to the limits, just as with ordinary earthquakes.
However, the slides are slow due to the fault properties. Hence, no shaking or tsunami occurs.

Frequently Occurring Slow Earthquakes

A plate boundary was formerly thought to be divided into two areas: a megathrust area, where a locked zone makes a massive slip once in several hundred years; and a stable sliding area, where constant slips prevent the accumulation of strains. The slow earthquake area, later found in between these two areas, has intermediate properties of the two. Strains that accumulate in this area are released to cause slow earthquakes more frequently than megathrust earthquakes.



Cumulative slippage = total amount of slip toward the trench of the continental plate against the oceanic plate



Types of Slow Earthquakes

Slow earthquakes exhibit a wide range of slowness. Slow slip events (SSEs), either long-term with a duration of six months to several years or short-term with a duration of several days, are observed as a deformation of the Earth, whereas low-frequency tremors and very-low-frequency (VLF) earthquakes produce weak trembles and are detected by a seismograph.

These slow earthquakes occur in deep and shallow areas of the locked zone called asperities and have been mostly detected through land observation. Meanwhile, recent oceanic observation has provided more details about shallow slow earthquakes.

Our next goal is to directly detect SSEs that are expected to occur in shallow areas as the Earth deformations.

	Characteristic duration time	Deep side	Shallow side
Geodetic	0.5–5 years	Long-term SSE	Undetected (?)
Geodetic	2–6 days	Short-term SSE	
Seismic	10–100 seconds	Deep VLF	Shallow VLF
Seismic	2–8 Hz	Deep low-frequency tremor	Shallow low-frequency tremor

Deep ETS
(Episodic tremor and slip)

Shallow ETS?

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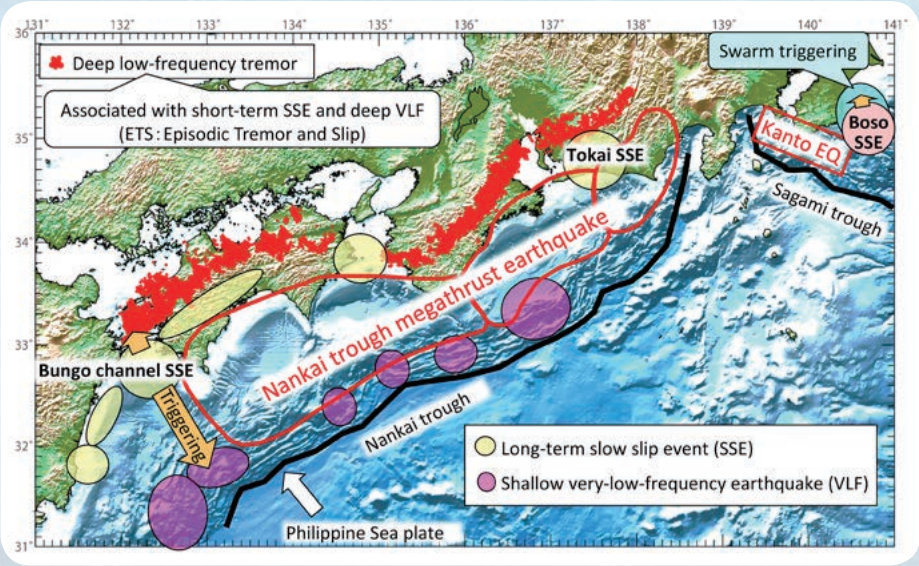
Slow Earthquakes Surrounding the Focal Area of the Nankai Trough Megathrust Earthquakes

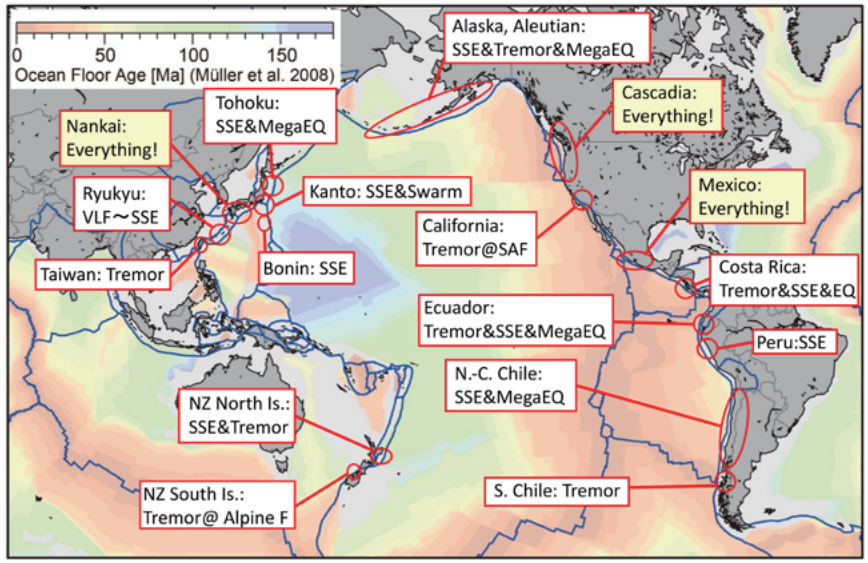


Slow earthquakes were first found around the year 2000 in the surrounding areas of the Nankai Trough Megathrust earthquake focal region, and various types of slow earthquakes have been observed ever since.

Adjacent slow earthquakes have a mutual impact on each other. In the Bungo Channel located in between Shikoku and Kyushu, for example, long-term SSEs have stimulated low-frequency tremors and shallow very-low-frequency (VLF) activities in the surrounding areas.

Similarly, slow earthquakes may have an impact on the occurrence of adjacent megathrust earthquakes.

Slow Earthquakes Occurring Worldwide



Since slow earthquakes were first discovered in southwest Japan, various others have been subsequently detected in plate subduction zones around the Pacific Rim.

Slow earthquake activities in each subduction zones differ in patterns such as the combination of phenomena included or intervals of occurrence.

These differences may arise from the environment surrounding the subduction plates. Thus, slow earthquakes have been attracting global attention as a new indicator to characterize subduction patterns.