Understanding Earthquakes

The Headquarters for
Earthquake Research Promotion

Introduction

This booklet is written to help people better understand earthquakes. In preparing this booklet a great deal of data and information has been provided by many institutions and researchers. We are extremely grateful to them.

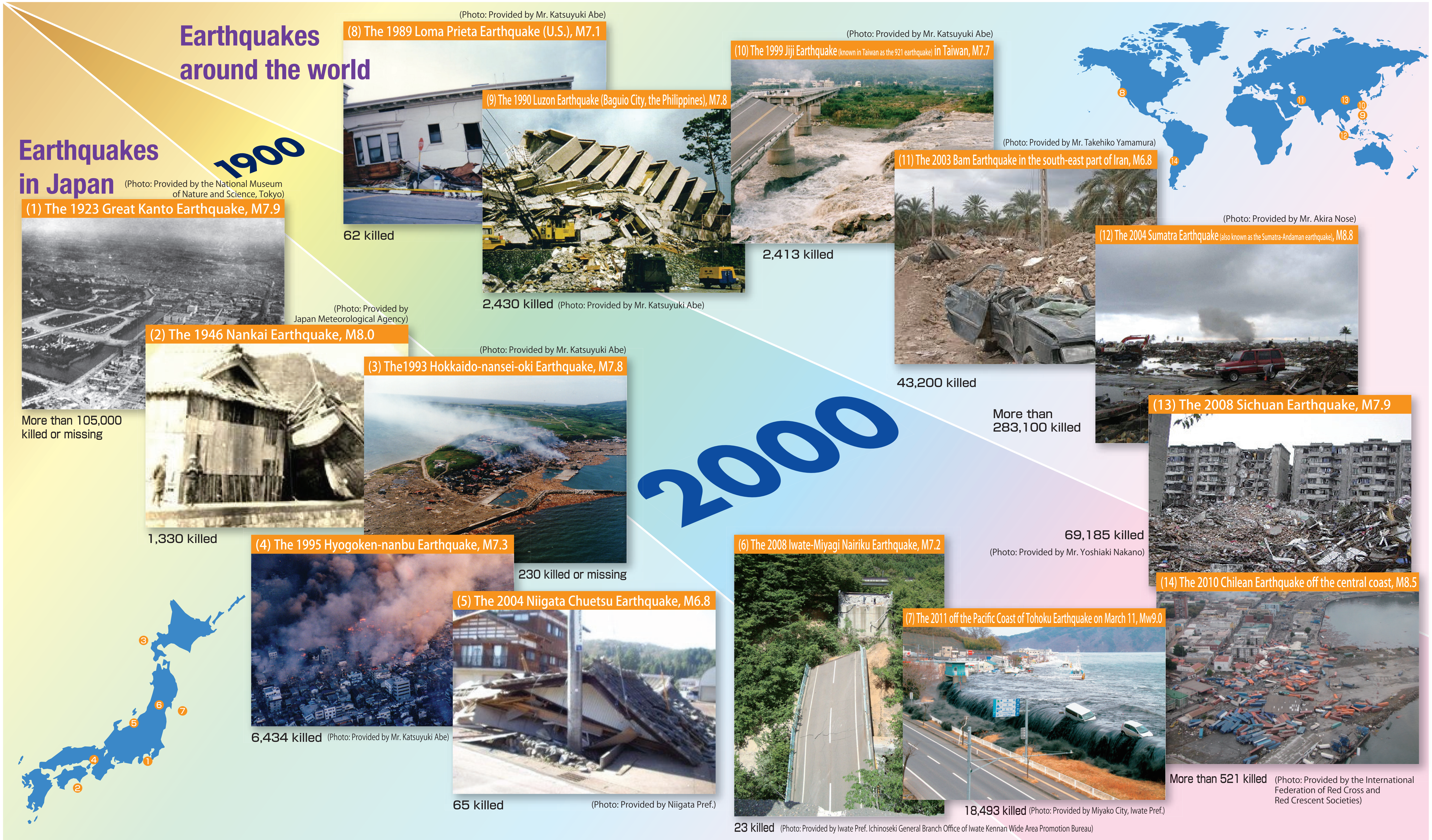
Q & A

Supporting Section

Supplementary Material Section

Recent earthquakes in Japan and around the world

The huge earthquake that occurred off Sumatra Island, Indonesia in 2004 caused an enormous tsunami. The tsunami caused tremendous damages to the countries facing the Indian Ocean. Large earthquakes like this that inflict serious damage occur repeatedly around the world. Living in Japan, one of the world's most earthquake-prone countries, we should never forget that we have also suffered severe damage from many earthquakes. These include the Hyogoken-nanbu Earthquake (The Great Hanshin-Awaji Earthquake Disaster) in 1995 and the off the Pacific Coast of Tohoku Earthquake (The Great East Japan Earthquake Disaster) in 2011.

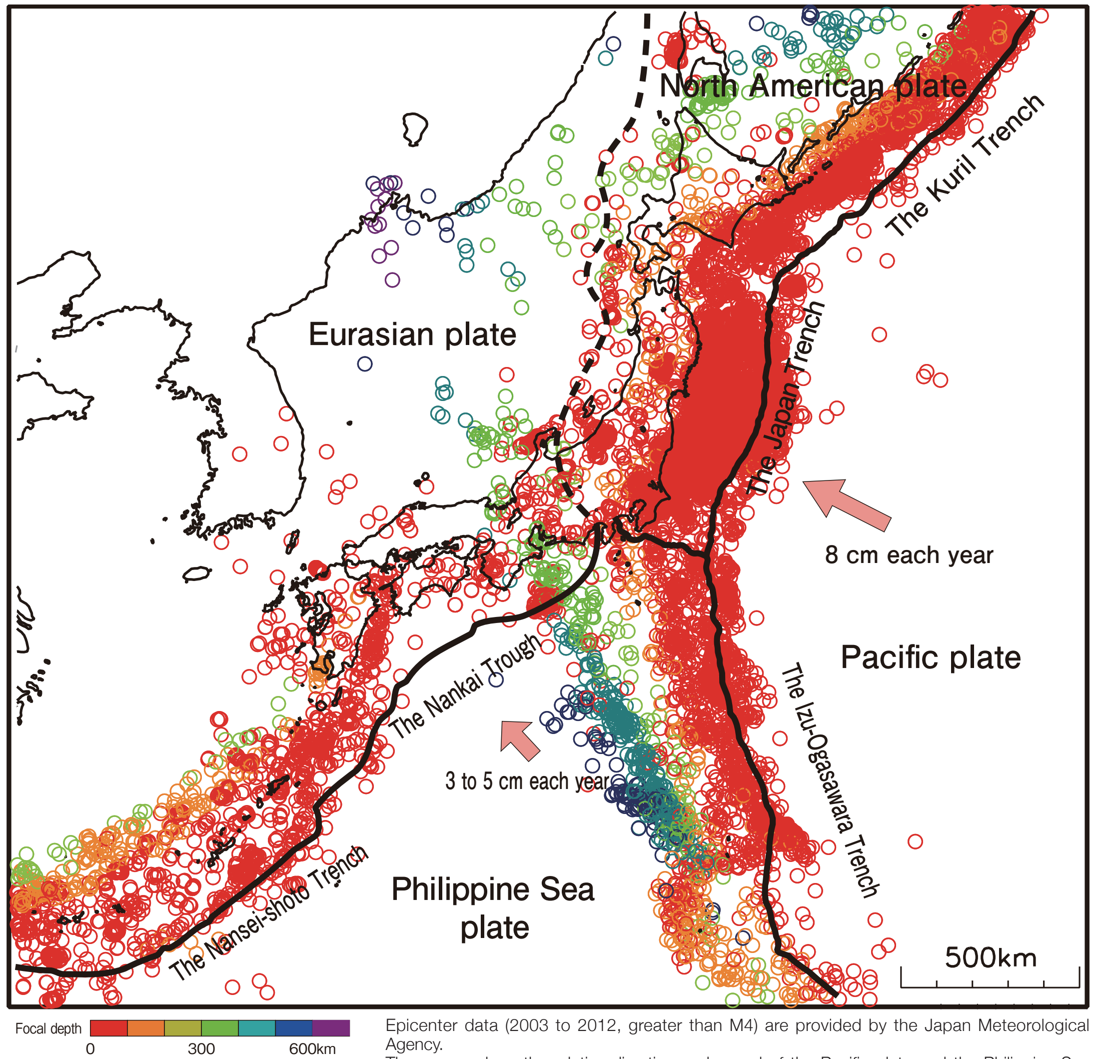


Q1 Why do we have so many earthquakes in Japan?

That is because Japan is situated on the plate boundaries, an area where large strains are accumulated.

The surface of the earth is covered with more than a dozen huge plates (plate-like masses of rock). The plates move in different directions at a speed of several centimeters per year (plate motion). Looking at things on a large scale, most earthquakes occur in the belt-like zones along the plate boundaries. It is said that Japan has been struck by approximately ten percent of the world's earthquakes. This is despite its small area, being less than one percent of the world's total land area.

Tremendous forces are applied by plate motion to the inside of the underground rock masses near the plate boundaries. Over many years a vast amount of energy builds up inside the rock masses as a strain and accordingly stress is accumulated. If a rock mass fractures due to the accumulated stress, an earthquake occurs. Japan is situated along the boundaries of four plates. The large strain energy accumulated in the rock masses therefore cause many earthquakes to be generated. However this doesn't only apply to the type of earthquakes that occur near the plate boundaries. Earthquakes that occur inland are also thought to be the result of accumulated strain in continental plates.



Epicenter data (2003 to 2012, greater than M4) are provided by the Japan Meteorological Agency.
The arrows show the relative direction and speed of the Pacific plate and the Philippine Sea plate to the Eurasian plate, respectively.
The thick solid lines show the plate boundaries. The dashed line shows unclear plate boundaries.

○ shows the locations of epicenters. The color shows the depth of each hypocenter. You can see that the earthquakes are concentrated along the areas near plate boundaries.

Q2 How do earthquakes occur?

Earthquakes occur when stressed underground rock masses rapidly move in opposite directions to each other along a certain plane (a fault plane). This movement is called fault movement (or faulting).

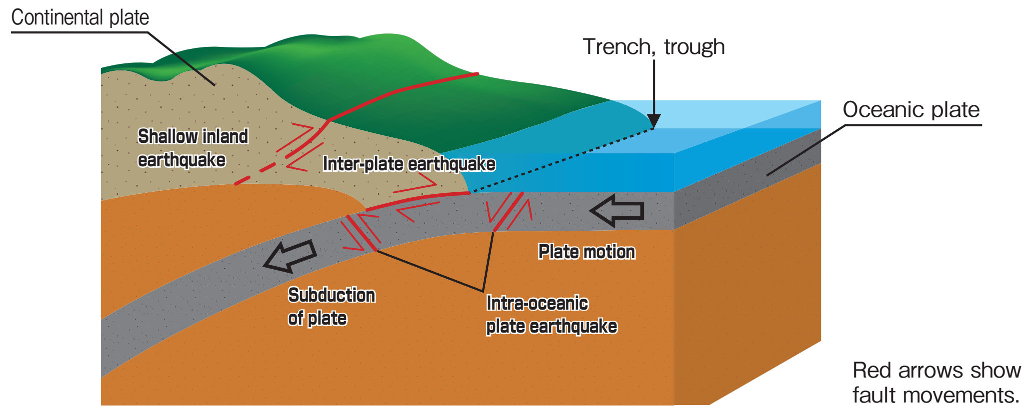
Along the Japan Trench and the Nankai Trough on the Pacific side of Japan, oceanic plates are continuously moving under the continental plates (subduction). At the same time, the continental plates are being dragged inland.

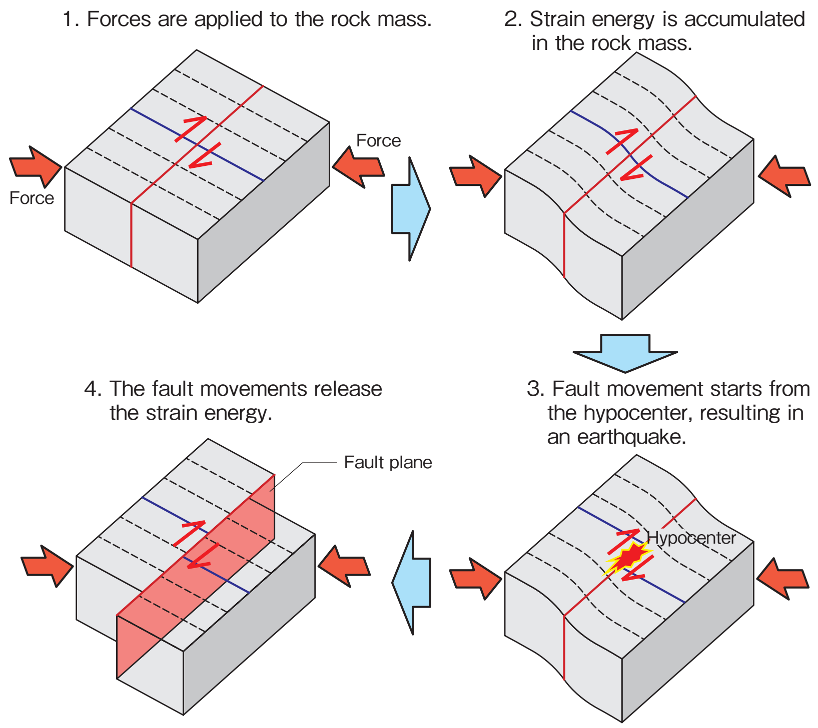
The subduction of an oceanic plate stresses rock masses around the plate boundary. When the accumulated stress exceeds its limit, a fault movement occurs. This leads the continental plate to rapidly jump up. This movement is a type of earthquake called an inter-plate earthquake.

On the other hand, earthquakes can occur in oceanic plates. The stress accumulated inside the oceanic plate generates a fault movement in the plate; this also causes an earthquake. This type of earthquake is called an intra-oceanic plate earthquake.

In continental plates, indirect forces from plate motion accumulate strain energy. Fault movements occur to release this strain energy in the continental plate. They occur at depths of up to 20 km from the ground surface. When a large-scale fault movement occurs in a continental plate, a fault displacement may develop on or near the ground surface.

The Headquarters for Earthquake Research Promotion calls earthquakes that occur along or around a plate boundary related to a trench or trough a "subduction zone (trench type) earthquake". It also calls earthquakes that occur at the shallow section of a continental plate a "shallow inland earthquake."



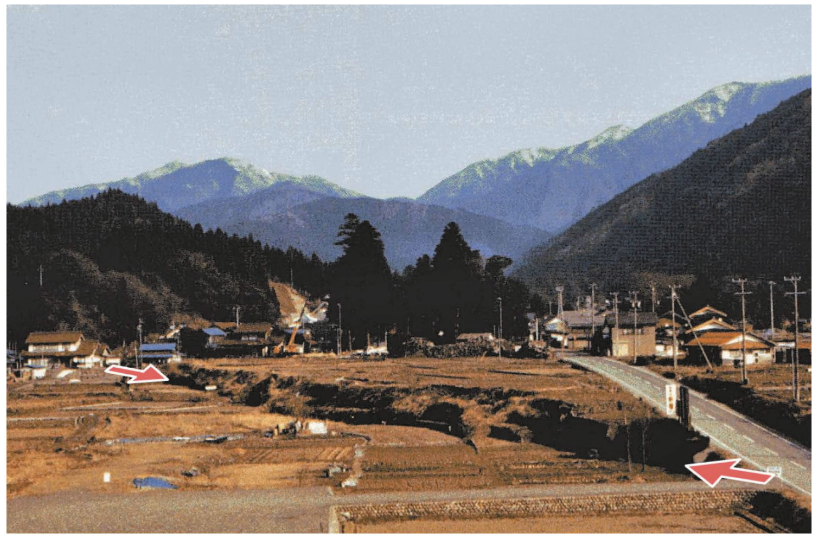


Earthquakes occur as fault movements. A fault movement is a phenomenon that involves two adjacent rock masses moving in opposite directions to each other along a certain plane (a fault plane). The energy of strain accumulated by plate motion in the rock mass is released in the form of a seismic wave. This is due to abrupt faulting.

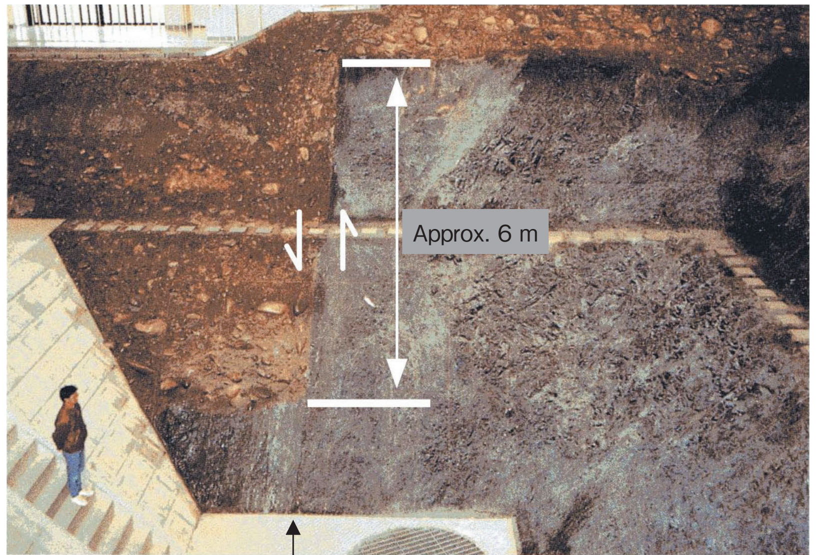
Q3 What is an active fault?

An active fault is a fault that has repeatedly experienced fault movements in the past and is still deemed to be a source fault of future earthquakes.

If a large earthquake occurs inside a continental plate, the fault displacement can reach the ground surface and deform geological layers and geographical features. The deformations caused by repetitive fault movements such as these form characteristic geographies. These can include dislocations along mountain ridges, dislocations along valley faults, and continuous cliff formations. By surveying these characteristic geographies through aerial photography, it is presumed that approximately 2,000 active faults currently exist in Japan. Excavating active faults is useful for estimating the probability of fault activity in the future. By undertaking the excavations, we can find out the scale and interval of earthquakes in the past.



The fault cliff that was formed as a result of the fault movements that occurred during the Nobi Earthquake in 1891 (shown by the arrows). In this earthquake, a total of 80 km of surface fault rupture emerged along the Nobi Fault. Active faults show that form such a characteristic geography have occurred repeatedly in the past.



Fault

Dislocation of geological layers generated by the Nobi Earthquake (the Neodani Fault).
A vertical displacement of approximately 6 m can be observed. Past fault activities can be clarified by examining the dislocation of layers such as this one.

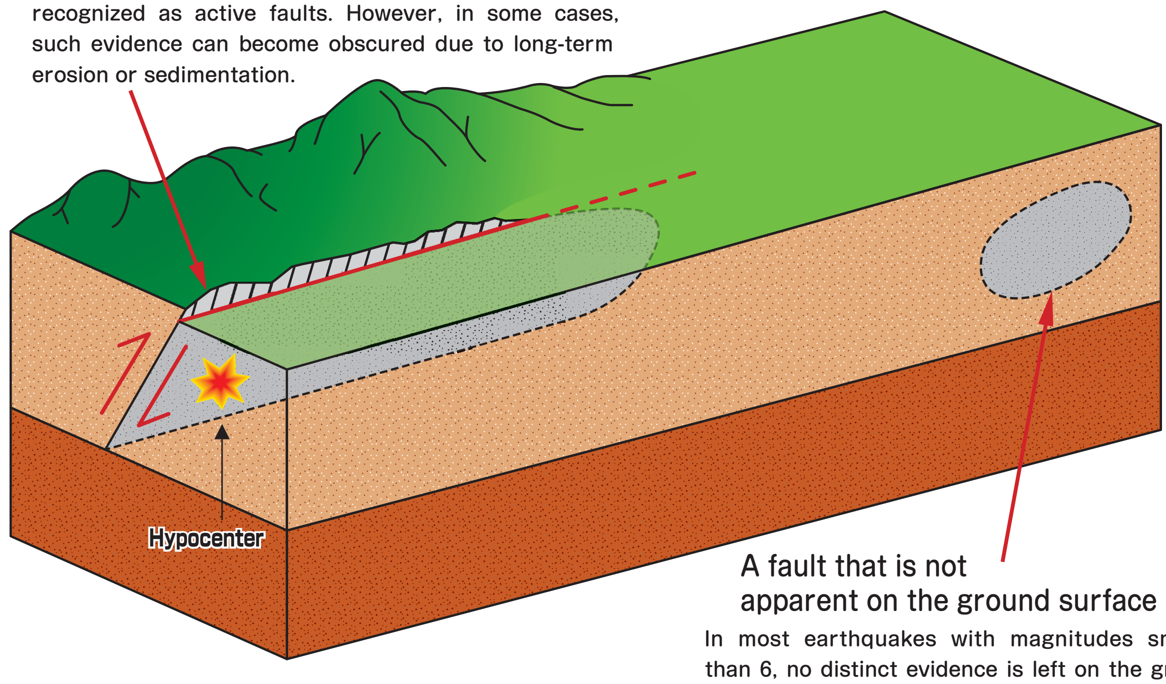
(Photo: Provided by the Education Committee of Motosu City)

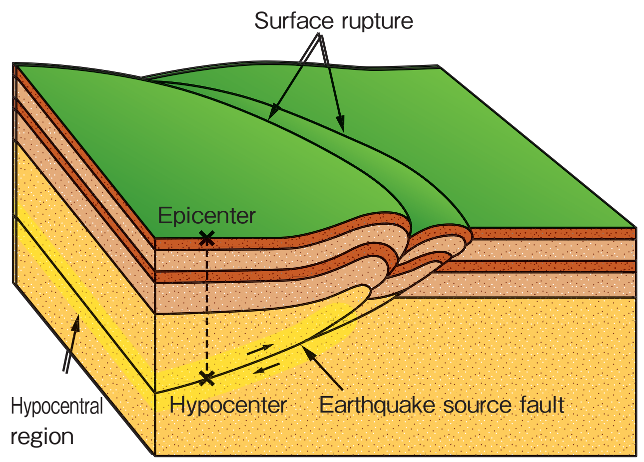
Q4 Do earthquakes not happen in places where there are no active faults?

Earthquakes can occur where no active faults have been recognized.

If the magnitude of the earthquake is small, the displacement of the causal fault does not always show up on the ground surface. Even if the fault displacement reaches the ground surface, sometimes such evidence of the fault activity is removed by erosion or sedimentation over a long period of time. Therefore, even in places where no apparent active faults have been presently found, active faults may still exist and cause earthquakes in the future.

Detailed investigations of underground areas and geography may lead to detection of such underground faults.





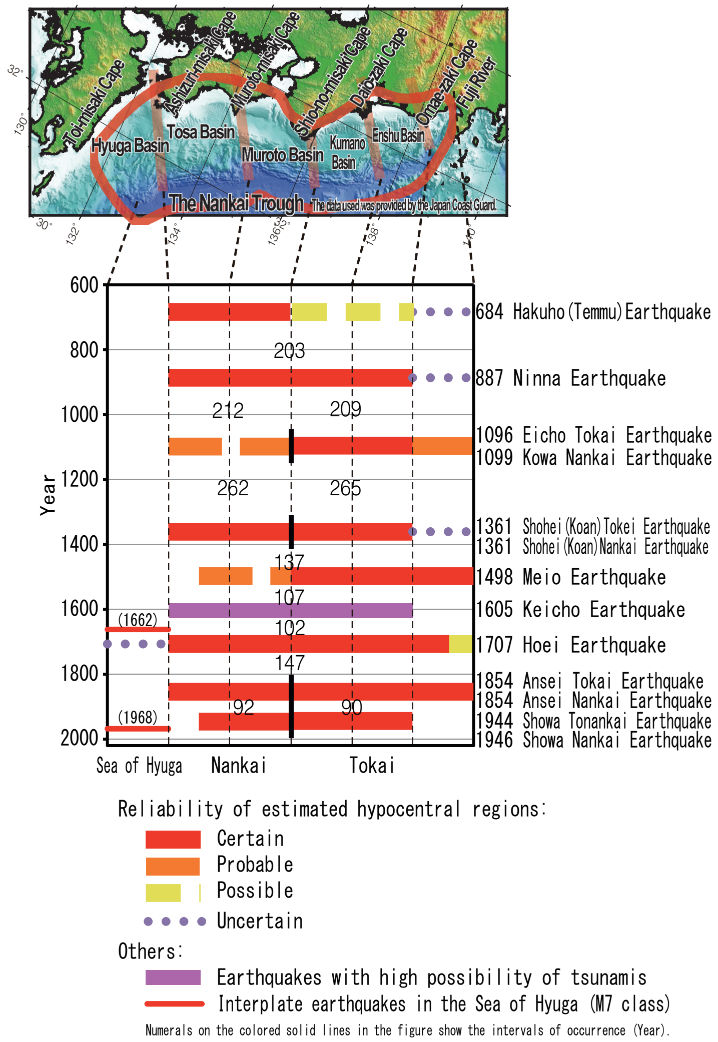
Underground faults that have caused earthquakes are called “earthquake source faults.” The dislocations that reached the ground surface as a result of faulting are called “earthquake surface faults (earthquake faults).”

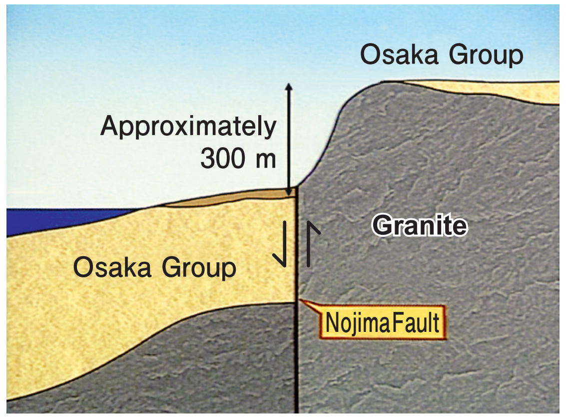
Q5 Do earthquakes occur repeatedly at the same places?

Large-scale earthquakes tend to occur repeatedly at the same place over a long period of time.

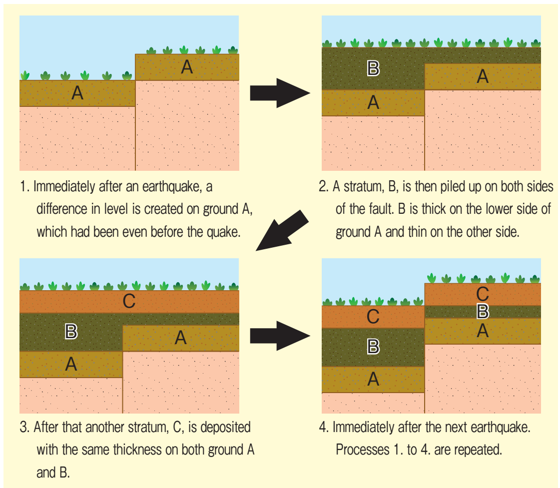
In Japan, it is well known that there are many active faults and places where large-scale subduction zone earthquakes repeat all over the country.

Large-scale earthquakes have a tendency of "happening repeatedly at the same place as in the past." For example, records show that at the Nankai Trough, where subduction zone earthquakes occur, large-scale earthquakes have been happening repeatedly. The investigation of active faults shows that large-scale inland earthquakes also have repeated at the same fault as in the past.





During the Hyogoken-nanbu earthquake, which caused the Great Hanshin-Awaji Earthquake Disaster, the Nojima Fault in Awaji Island moved. The Osaka Group, which had accumulated several million years ago, was displaced along the Nojima fault by more than 300 m.



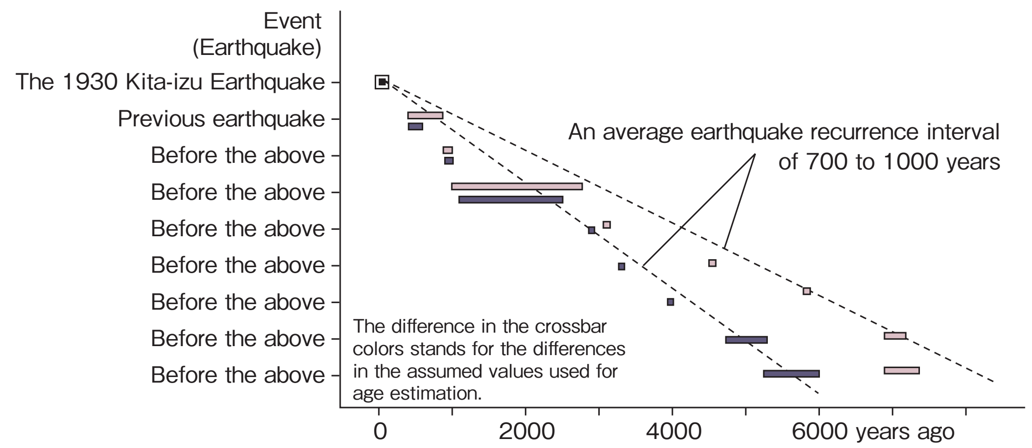
Such geological formations are found by excavating active faults. They reveal that the faults moved repeatedly in the past.

Q6 How often do large earthquakes occur?

The intervals of subduction zone earthquakes, which occur near plate boundaries, range from several decades to several hundreds of years. On the other hand, the intervals of active fault earthquakes, which occur at inland active faults, range from a thousand to tens of thousands of years.

Subduction zone earthquakes, which occur near plate boundaries, occur at intervals ranging from decades to several hundreds of years on average. This is a relatively short period. Inland active fault earthquakes, on the other hand, occur at intervals ranging from a thousand to tens of thousands of years. This is quite a long period compared with the human life-span. These intervals differ from fault to fault, because they depend on the speed of strain that is accumulated in the rock mass by plate motion. They also depend on the strength of the rock mass against strain. However, earthquakes that are caused by individual active faults have almost the same size and recurrence intervals.

Taking all the earthquakes in Japan that inflicted major damage over the past 200 years, the average recurrence interval is 20 years for subduction zone earthquakes and 10 years for shallow inland earthquakes.



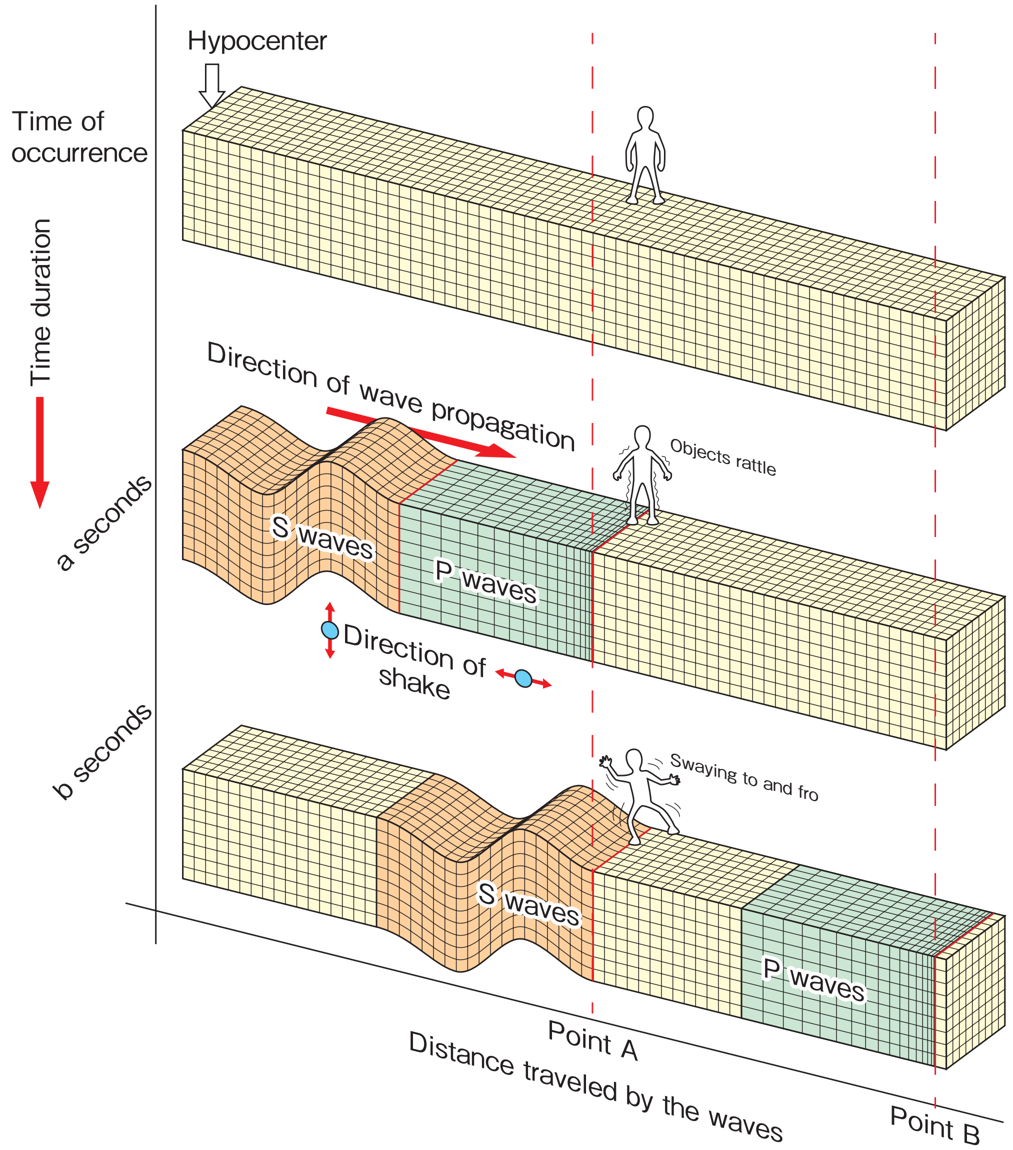
The trench excavation survey at the Tanna Fault indicates that the Tanna Fault moved nine times in the past, with an average interval of 700 of 1000 years. (The history of the fault activity was obtained by the Tanna Fault Excavation Survey and Research Group in 1983.)

Q7 How do seismic waves travel?

Part of the earthquake energy travels in the form of waves (seismic waves).

When the underground rock mass is broken and a fault moves, part of the energy propagates in all directions as seismic waves. Typical seismic waves contain two different types of waves: P waves and S waves. P waves are the propagation of density change. The direction of P waves' shake is the same as the direction of their propagation. S waves are the propagation of shear deformation. The direction of S waves' shake is perpendicular to the direction of their propagation. According to the direction of their shake, P waves and S waves are called "longitudinal waves" and "transverse waves," respectively. P waves travel faster than S waves. That is why when an earthquake occurs first the ground rattles due to the arrival of P waves. After this the ground slowly sways a little bit due to the arrival of S waves. Additionally, if an earthquake occurs in a distant place (especially if the hypocenter is shallow) large and slow swaying can occur after the ground shake by P waves and S waves. Those waves are called surface waves and travel only on or near the surface of the ground. They are able to reach distant places.

P waves stand for primary waves, which means they come first. S waves stand for secondary waves, which means they come second.

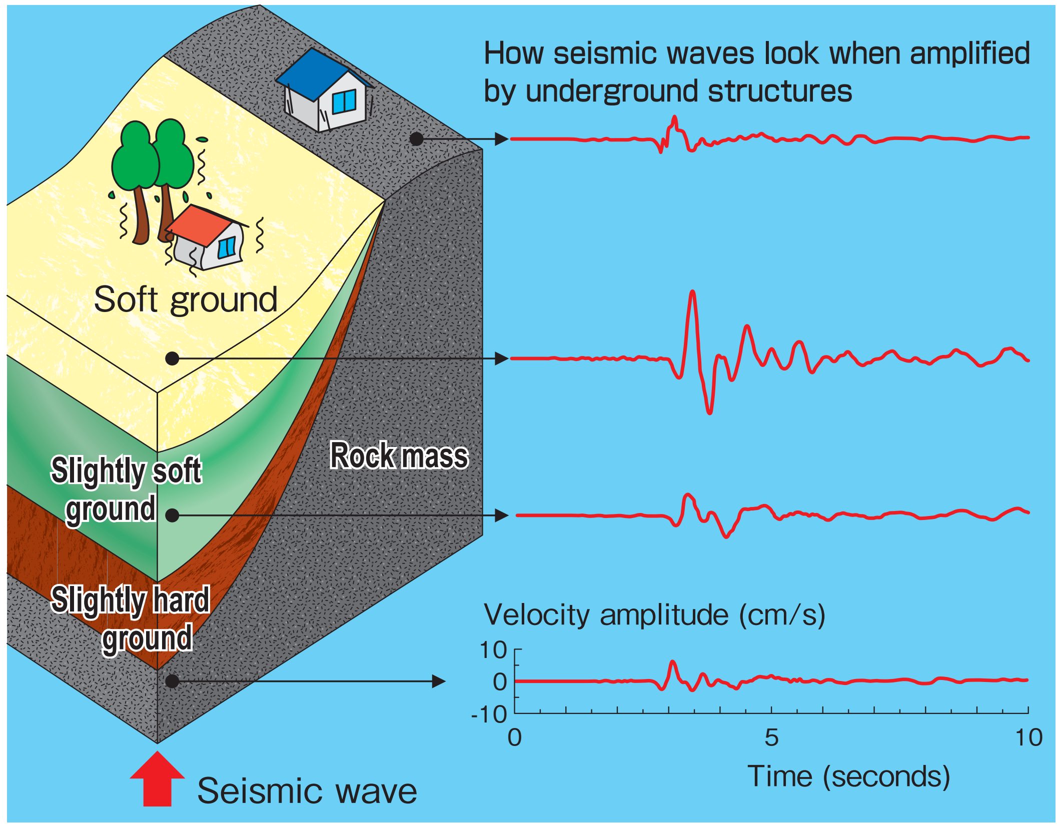


Q8 In what place does the ground shake the strongest?

The softer the ground is, the stronger the ground shakes.

How strongly the ground shakes at the surface depends largely on the structure of deep ground near the surface. Generally, the ground shakes more strongly at surfaces where the soil near the surface is soft, compared to ground where the soil near the surface is hard. Furthermore, sometime deep portions of ground also make the ground shake more strongly. This happens because seismic waves increase their strength when they propagate from hard rock mass to soft soil. They also increase their strength when the deflected waves and reflected waves overlap.

The underground structures near the surface can be estimated from geographical features to some extent. The deep ground structures can also be known through boring investigations or studies using artificial earthquakes.



Earthquake near Hakone on Aug. 5, 1990 (M5.1)
In the figure, underground structures such as rock mass and soft ground are simply illustrated. The earthquake data (waveforms) shown in the figure are actual records. The ground shakes approximately three times as strongly on the soft ground than it does on the hard rock. The ground shakes for a longer amount of time on the soft ground than it does on the hard ground. (This figure based on a figure by Mr. Kazuyoshi Kudo)

Q9 How long does the ground shake for?

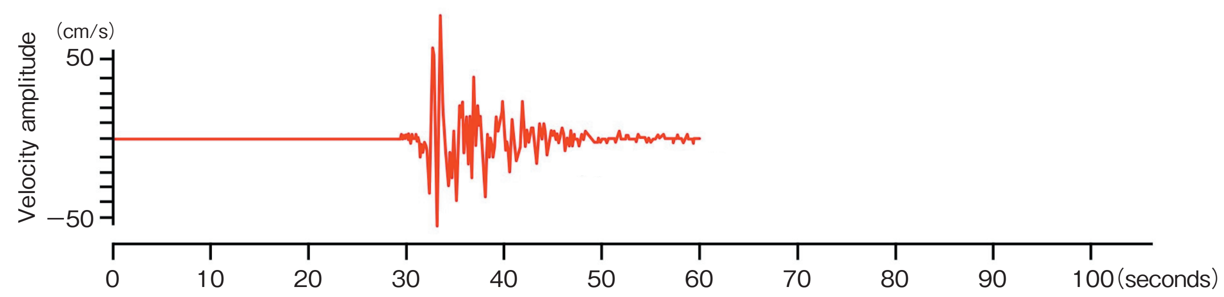
The duration of large shakes in the large-scale earthquakes that occur near Japan is thought to be generally one minute at the longest. The intensity of shake depends on the scale of the earthquake, the location of hypocenter, and the condition of the ground.

Generally, the larger that the earthquake source fault is, the duration of large shakes in the earthquakes that occur near Japan generally becomes longer. For example, in the 1995 Hyogoken-nanbu Earthquake the length and breadth of the earthquake source fault was several dozen kilometers. Subsequently, the duration of strong shakes lasted more than a dozen seconds.

On the other hand, during the 2011 off the Pacific Coast of Tohoku Earthquake both the length and breadth of the earthquake source fault were as large as several hundred kilometers. Subsequently, strong shakes lasted more than 3 minutes in some areas. On the other hand, for example, during the 2003 Tokachi-oki Earthquake shakes have lasted for long periods of time, even if the earthquake source fault is not so large. In cases involving long periods of ground motion, slow swaying motions may continue even after large shakes.

The magnitude of shake (seismic intensity) at a given location depends on the scale of the earthquake itself (earthquake magnitude), it also relies on its position relative to the hypocenter and the underground soil structure. In the case of shallow inland earthquakes, strong shakes can come in the vicinity of the hypocenter and inflict severe damages even if the scale of the earthquake is relatively small.

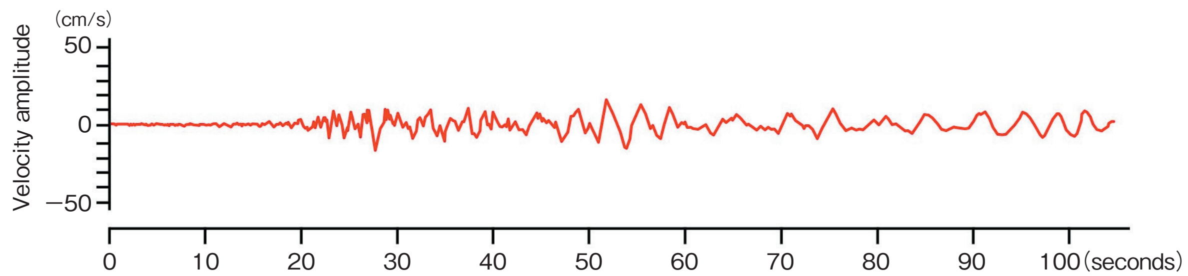
The 1995 Hyogoken-nanbu Earthquake (Chuo-Ku, Kobe City)



The 1995 Hyogoken-nanbu Earthquake: a large shake lasted for more than a dozen seconds in Kobe City. During this time an extremely large shake lasted for 4 or 5 seconds.

(Data taken from the Japan Meteorological Agency website)

The 2003 Tokachi-oki Earthquake (Tomakomai City)



The 2003 Tokachi-oki Earthquake: long-period ground motions were observed in Tomakomai City, where the sway continued for nearly 3 minutes.

*In the figure, a part exceeding 100 seconds is cut off.

(Data taken from the Japan Meteorological Agency website)

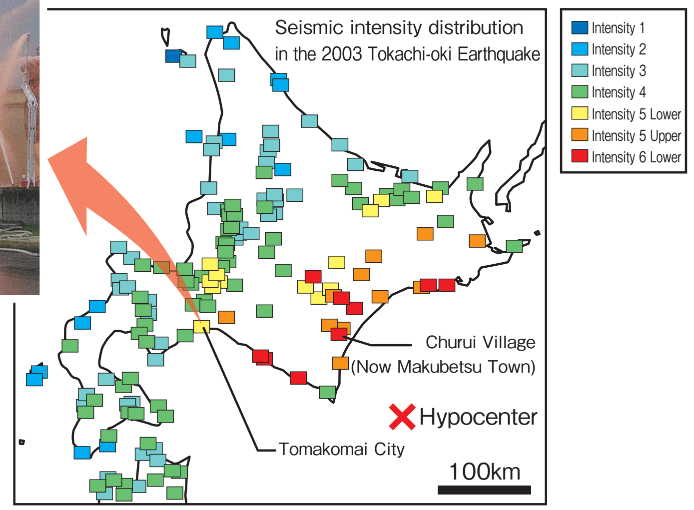
Q10 What is "long-period ground motion"?

It means a relatively slow swaying motion during earthquake shake.

When a relatively large-scale earthquake occurs, unlike ordinary earthquakes that have short shake periods, they occasionally cause slow swaying ground motions that last for a long period of time. The period can range from several seconds to more than a dozen seconds. Such ground motions are called "long-period ground motions". Long-period ground motion can travel to places very distant from the hypocenter. Strong swaying motions can even be observed in places that are quite far from the hypocenter. This is one of the features of long-period ground motion.

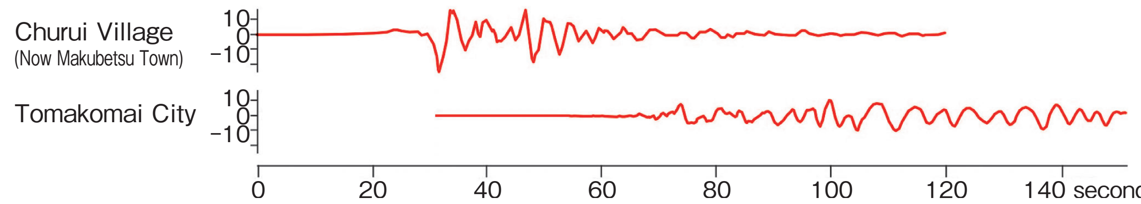
(Photo provided by the Fire and Disaster Management Agency)

In this earthquake at Tomakomai Harbor, which was 200 km or more away from the hypocenter, a long-period ground motion caused the oil in storage tanks to slosh about. This caused the tanks to rupture, leading to fire.



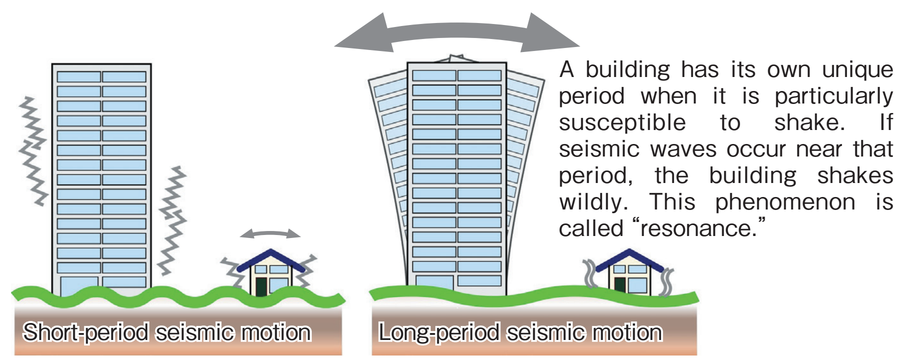
(Data taken from the Japan Meteorological Agency website)

North-south shake (cm)



From the seismographic data it can be seen that the swaying motion continued for a long time in Tomakomai, even though it was very far from the hypocenter.

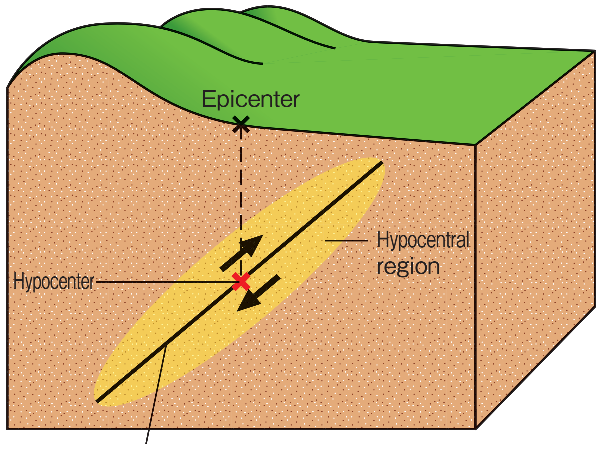
Large structures tend to resonate with long-period ground motions. It is now known that during the 1923 Great Kanto Earthquake, there were large tremors with periods of more than 5 seconds. However these long-period ground motions did not attract much attention at the time. This was because back then there were not many large structures in Tokyo. However, nowadays ultra-high-rise buildings and large-scale bridges have been constructed in various part of Japan. Structures like these tend to resonate with ground motions that have periods exceeding several seconds. There are therefore fears that long-period ground motions will affect those structures. On the other hand, low-rise buildings tend resonate with short-period ground motions.



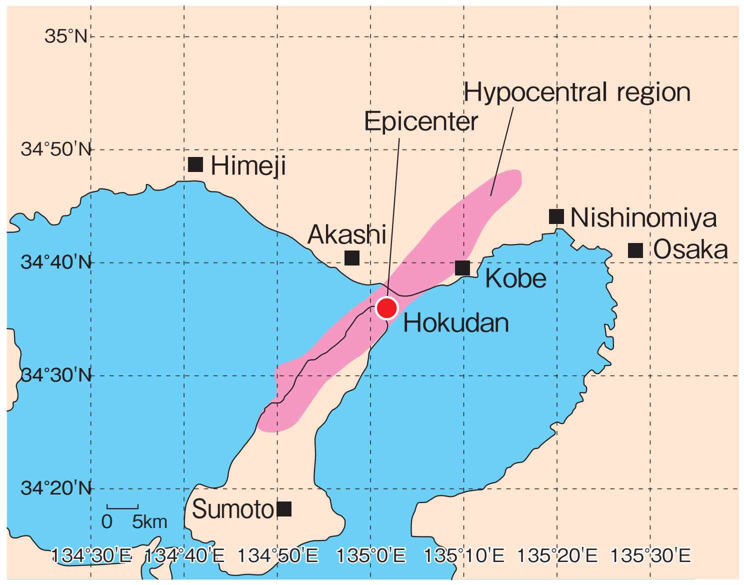
Q11 What are the hypocenter, epicenter and hypocentral areas?

The point where the fracture started is called the hypocenter. An epicenter is the point on the ground surface directly above the hypocenter. Hypocentral regions are regions where fractures have spread due to faulting.

Enormous forces are acting on the underground rock masses. When the forces become too great for the rock masses to bear, they fracture. This induces an earthquake. A hypocenter is the point where the fracturing has started. An epicenter is the point on the ground surface directly above the hypocenter. The fracture, which started at the hypocenter, spreads to the surrounding region and stops at a certain distance. This expanded region is called the hypocentral region. It is in this region that the vast energy of earthquakes is generated.



Pattern diagram showing the relation between hypocenters, epicenters and hypocentral regions



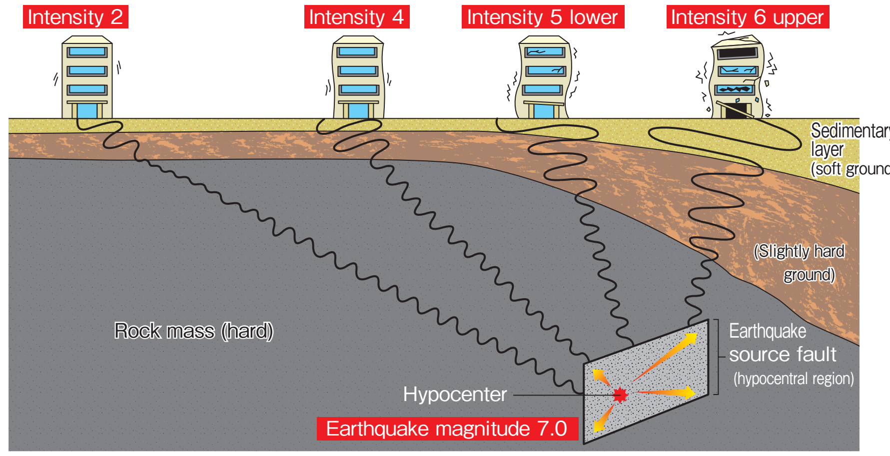
Epicenter of the 1995 Hyogoken-nanbu Earthquake (M7.3) and ground surface projection of its hypocentral region

Q12 Are seismic intensity and earthquake magnitude different?

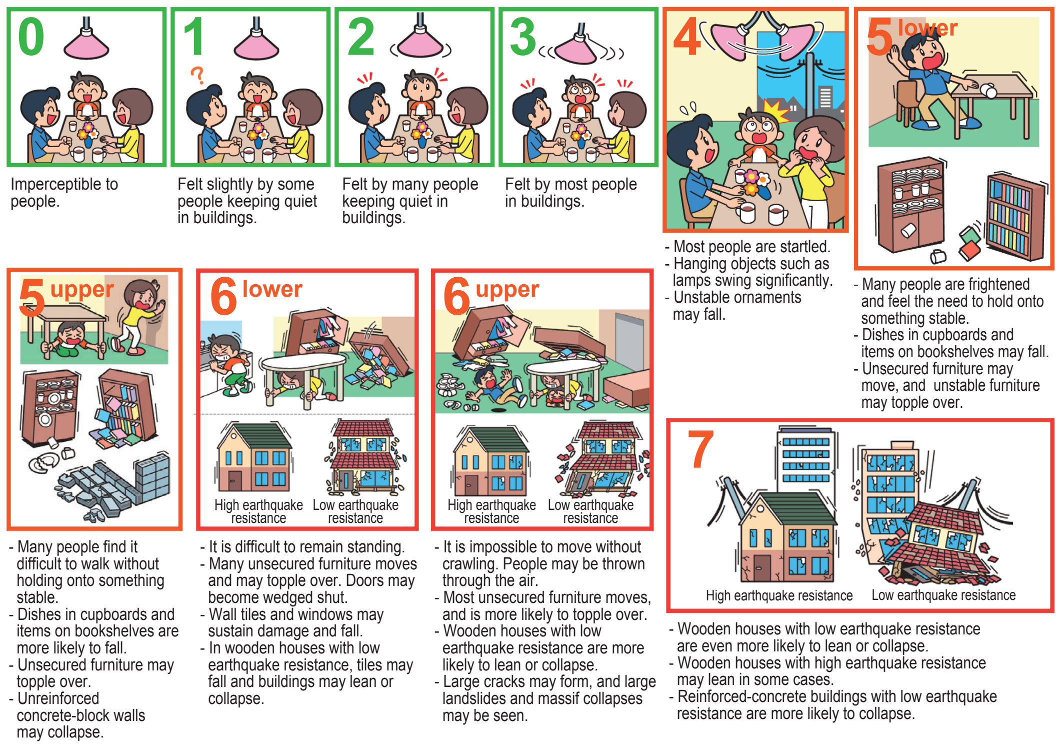
Intensity is the greatness of the shake observed at the location and earthquake magnitude is the greatness of the earthquake itself.

Intensity is a measure of the shake at a particular location. When an earthquake occurs, the seismic waves propagate in every direction. Since the behavior of the wave propagation differs depending on the distance from the hypocenter and ground condition, the strength of shake differs with location. The strength is measured at various locations to define the intensity at each place.

Earthquake magnitude, on the other hand, is a measure of how great the actual fault movement that occurred at a hypocentral region is. The scale of an earthquake (earthquake magnitude) depends on the size of the fault plane and amount of displacement. By using the maximum amplitude on equipment such as a seismograph, earthquake magnitude can be seen as an indirect expression of the energy unleashed by seismic waves caused as a result of faulting.



Earthquake magnitude, which represents the scale of faulting, only provides one reading for earthquakes. However, the intensity, which represents the strength of shake at different locations, varies with the location. The figure shows that shake movements are larger when the hypocenter is nearer and the ground is softer.



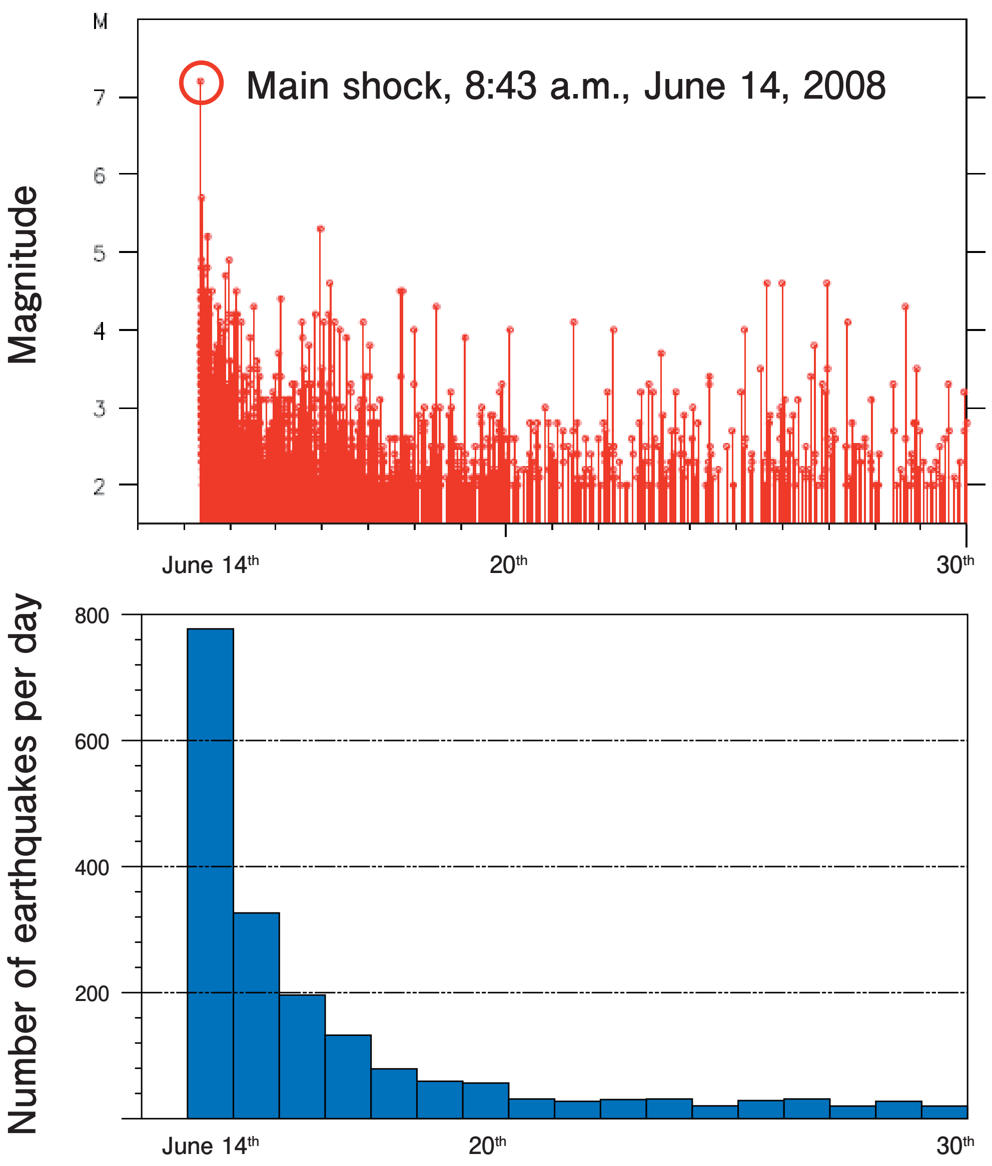
Q13 What are "main shocks" and "aftershocks"?

A main shock is the largest earthquake in a sequence. Smaller earthquakes that repeatedly occur afterward are aftershocks.

When large earthquakes occur, many small earthquakes often occur afterward. The largest earthquake is called the main shock and the subsequent smaller earthquakes are called aftershocks.

The magnitude of aftershocks varies but the largest of them is called the largest aftershock. Generally the magnitude of the largest aftershock is smaller by 1 or more than the main shock. It is known that aftershocks frequently occur immediately after the main shock. However, their rate declines as time elapses. It is also known that if the magnitude of the main shock is large, it takes a longer amount of time for the aftershocks to die down.

Example of "main shock – aftershock" type earthquake activity
(the Iwate-Miyagi Nairiku Earthquake on June 14, 2008)



(Hypocenters with magnitudes of 2.0 or greater, provided by the Japan Meteorological Agency)

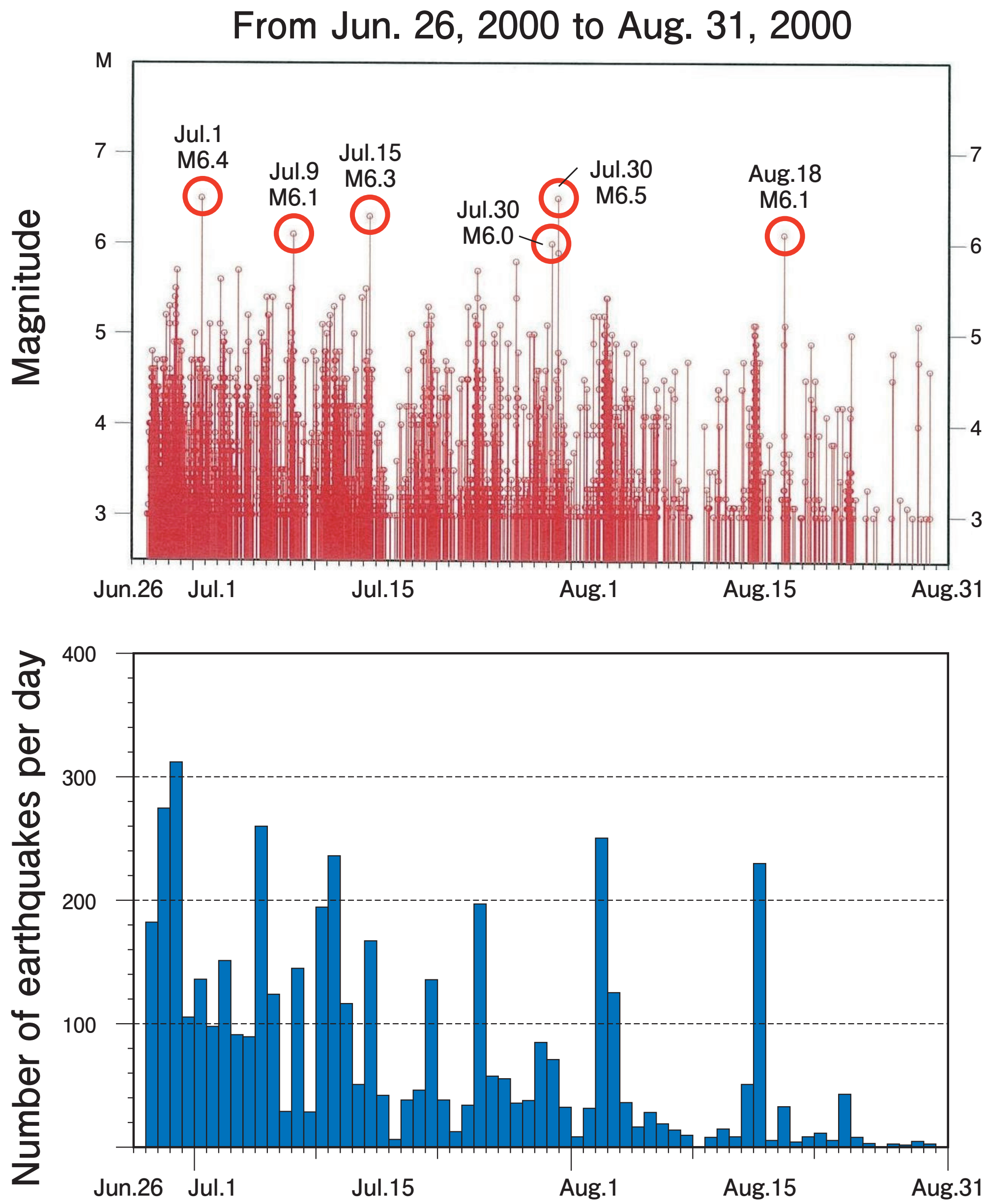
Q14 What are "earthquake swarms"?

Earthquake swarms are sequences of earthquakes in which similar size earthquakes occur in a relatively small area in a concentrated manner.

Sometimes similar size earthquakes occur in a concentrated manner in a relatively small area. This happens for a certain period of time and then they calm down. Such earthquakes are called earthquake swarms. What makes earthquake swarms distinctive is that they occur many times, their hypocenters are shallow, and they are quite small. However, sometimes medium-sized earthquake swarms with magnitudes of 5 to 6 occur.

The 1965 Matsushiro Earthquake Swarm, the 1978 Izu Hanto Toho-oki Earthquake Swarm, and the 2000 Izu Shoto Earthquake Swarm are famous in Japan. It is assumed that earthquake swarms are somehow related to the underground movement of fluids, such as magma. It is assumed from crustal deformation data that the 2000 Izu Shoto Earthquake Swarm occurred when plate-shaped magma intruded into the rock mass.

Example of "swarm type" earthquake activities
(The 2000 Izu Shoto Earthquake Swarm)



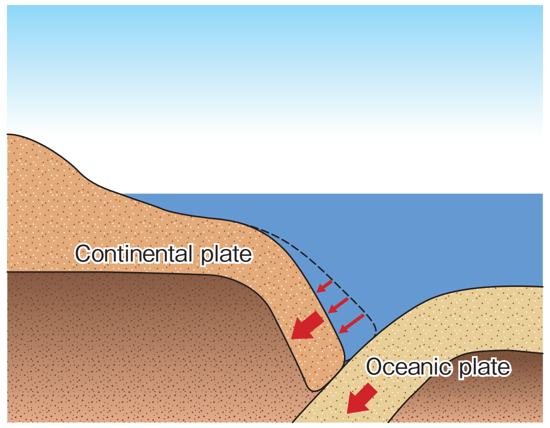
(Hypocenters with a magnitude of 3 or greater, provided by the Japan Meteorological Agency)

Q15 How are tsunamis generated?

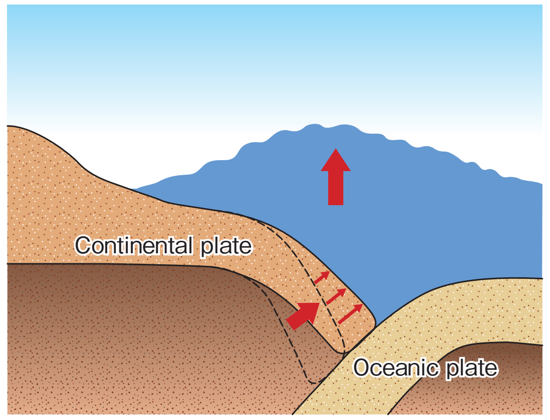
If large crustal deformation occurs under the sea as a result of an earthquake, it moves the overlying mass of seawater and generates a tsunami.

When large earthquakes occur in the ocean, large crustal deformation occurs on the seafloor. Due to the crustal deformation, the overlying seawater rises and falls. This fluctuation of seawater creates a tsunami. Tsunamis are generated not only by earthquakes under the ocean, but also by submarine volcanic eruptions, seafloor landslides, or large collapses near the shore.

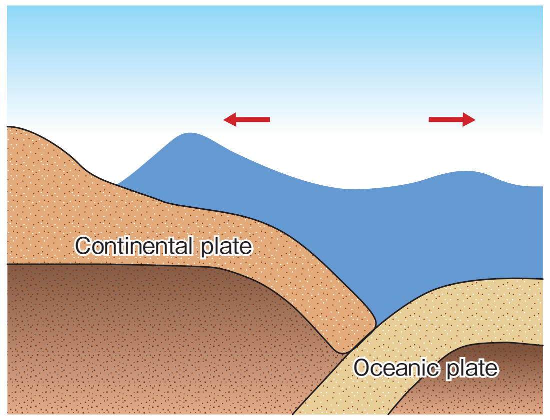
Tsunamis characteristically decrease their velocity and increase their height rapidly as they approach land and the depth of the sea decreases. The velocity, although it may be slower near land, is still nearly 40 km/h in areas where water depth is approximately 10 m. The height of a tsunami doesn't only depend on how great the earthquake was, but also on the topography of the seabed and the geographical shape of the coastline. Tsunamis can become much higher due to the shape of a particular bay or cape.



Oceanic plates slowly sink under continental plate over decades or hundreds of years. Strain accumulates when the end of a continental plate is dragged in downward.



When the strain exceeds a certain limit, the end of the continental plate jumps up (an earthquake occurs). When this happens, large volumes of seawater rise and fall.

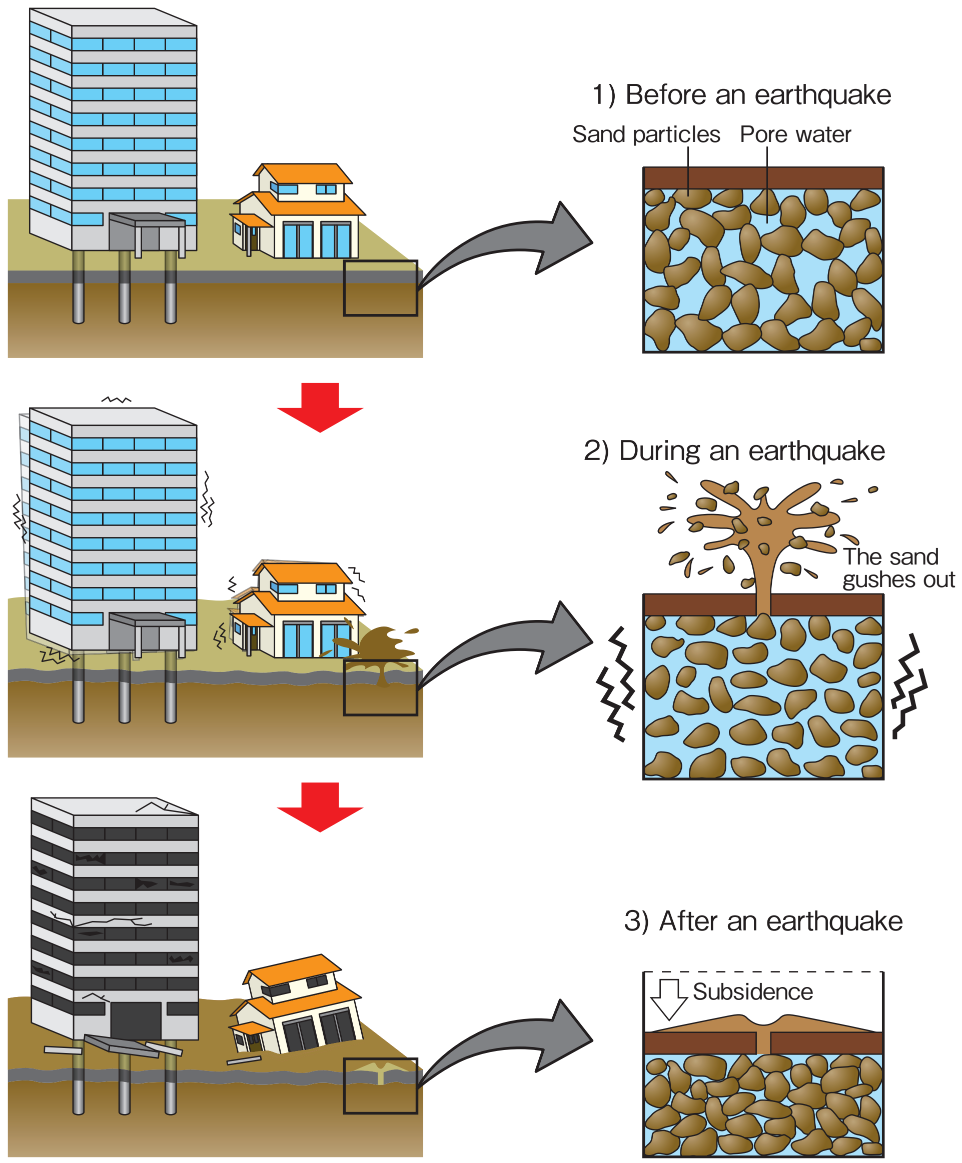


A tsunami is generated, which then advances toward land.

Q16 What is "liquefaction"?

Liquefaction is a phenomenon where, due to the shaking of an earthquake, soil with high water content becomes like liquid.

Soil on low land or reclaimed land contains a lot of water (pore water). In soil such as this, sandy particles are holding each other together. With their water-filled pores, they stay stable. When a strong shake is applied by an earthquake, this system is destroyed. When this happens, the water pressure between the sandy particles increases. This turns the ground into a muddy, water-like state. The muddy water tries to support the load from above. However, if there are fissures or weak parts in the ground surface, the water becomes unable to support the load. This causes muddy water to erupt to the surface. Liquefaction can cause various types of damage. In addition to ground subsidence, it can cause ground-based tanks or manholes to float, and buildings and other structures to lean or collapse.



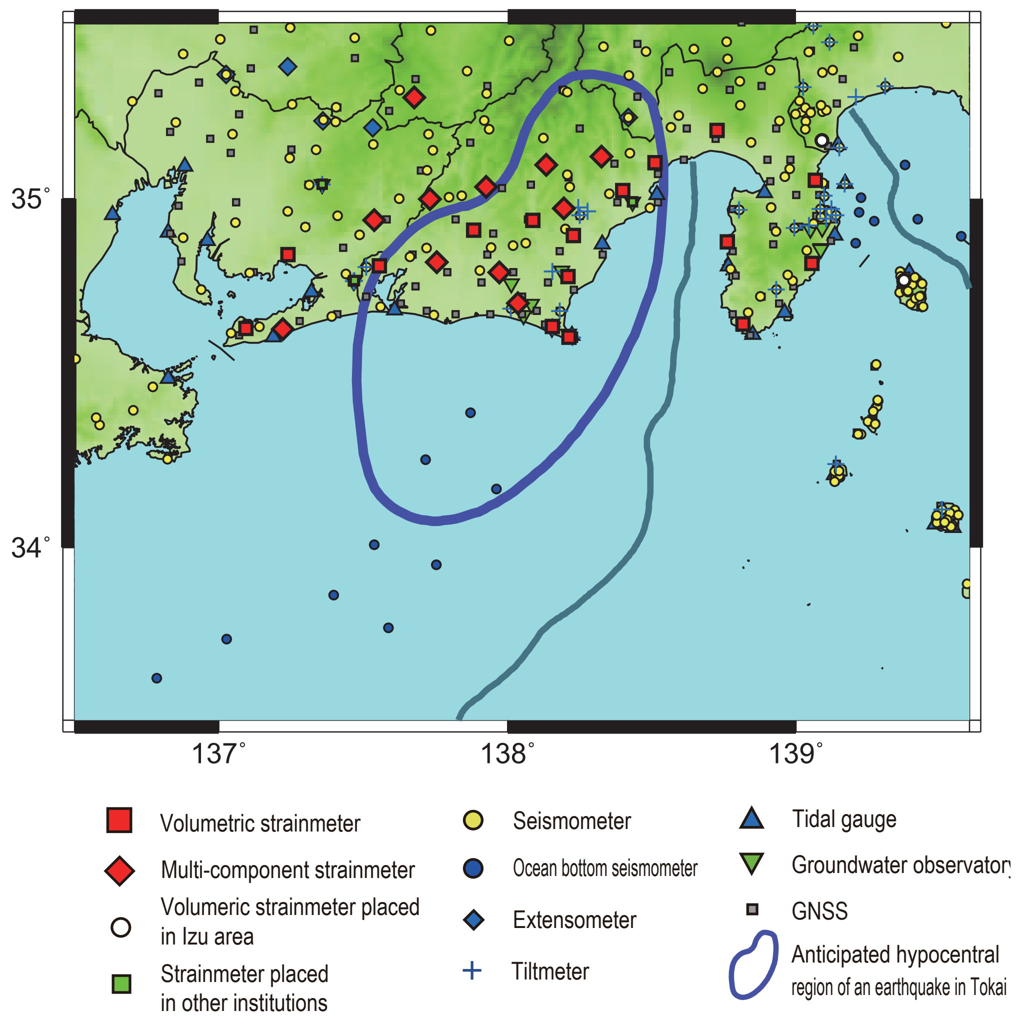
Q17 Is it possible to predict earthquakes?

Generally speaking, it is difficult to predict the occurrence of earthquakes.

Earthquake prediction means to predict "when, where an earthquake will occur, as well as how big it will be, before its occurrence based on scientific grounds." Earthquake prediction is generally considered to be difficult with present science and technology, even if limited to large-scale earthquakes.

It is thought that a large-scale earthquake could occur at any time in Tokai. This is a conclusion drawn from the history of repeated large earthquakes. About half of the hypocentral regions of past earthquakes were underground and inland. Therefore, it is thought that earthquake prediction might be possible by developing highly accurate observation networks for capturing earthquake precursors and monitoring the obtained data. Arrangements for monitoring and information sharing are now in place.

However, there are still many unknown factors when it comes to the occurrence processes of an earthquake in Tokai. In some cases, earthquake precursors are too obscure to detect, or even if they are detected there is sometimes no time to release the information before the earthquake occurs. Therefore, preparing measures for disaster prevention is also a necessary step that must be taken to guard against sudden earthquake strikes.



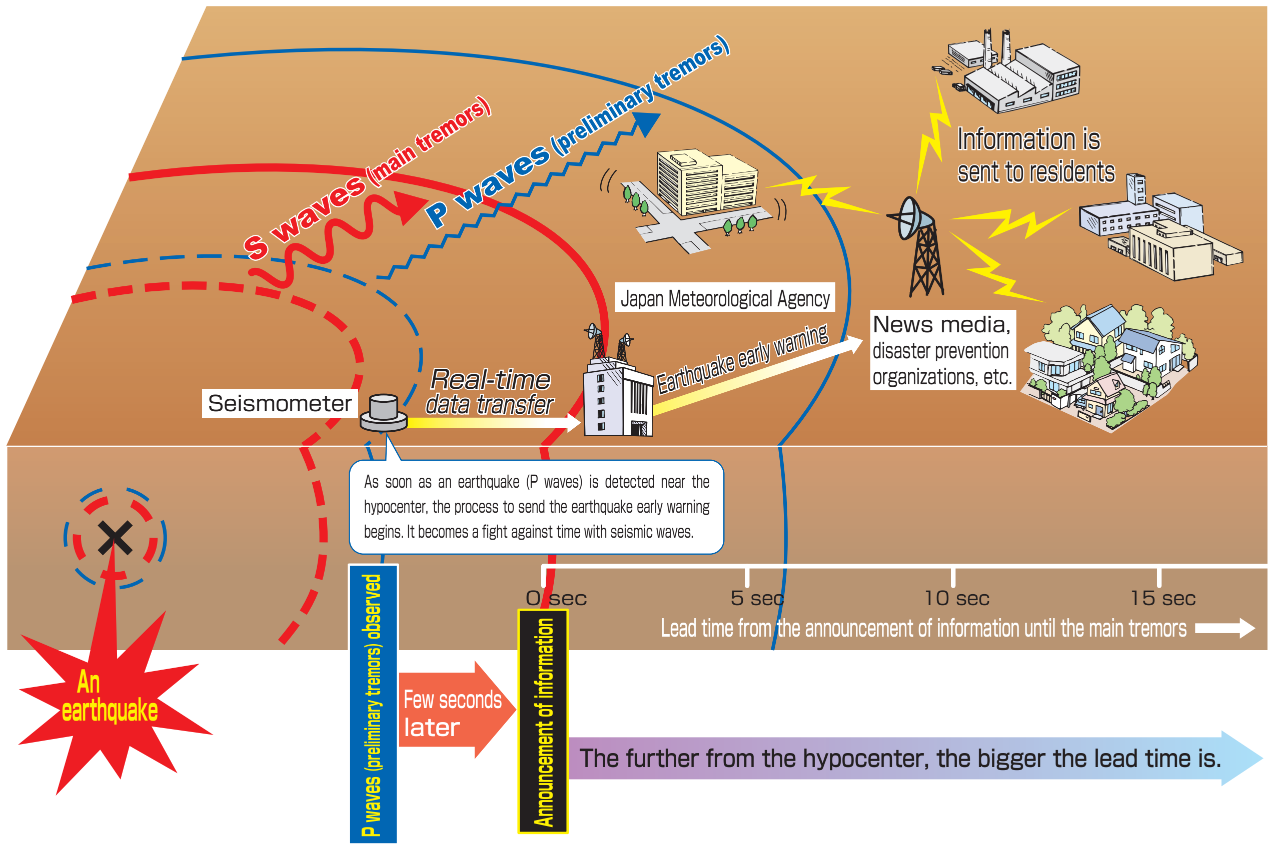
Anticipated hypocentral region of an earthquake in Tokai and the crustal deformation observation network (Figure from the Japan Meteorological Agency website)

Q18 What is an "earthquake early warning"?

An earthquake early warning is an information announcement about the occurrence of an earthquake before the actual main shake arrives. The information is obtained from the characteristic seismic waves.

Seismic waves have P waves (preliminary tremors), which have a large propagating velocity, and S waves (main tremors), which are slower. Damage due to earthquake shaking is mainly caused by the S waves. Real-time analysis of the hypocenter location and strength of the earthquake (magnitude) are now possible immediately after the occurrence of an earthquake, thanks to the progress in seismology and information processing technology. This can be done with just the arrival data of P waves near the hypocenter. Once the hypocenter and the magnitude of the earthquake are determined, it is possible to estimate the seismic intensity at a given location.

This is the system that is currently maintained all over the country to transfer information regarding analyzed and predicted hypocenters, earthquake magnitudes and seismic intensity before the arrival of S waves. It is known as the "earthquake early warning" system and the information is provided by the Japan Meteorological Agency through formats such as TV. It is expected that disaster prevention organizations, transportation facilities, public facilities, and others will be able to respond to the warning and prevent or minimize the earthquake damages before the S waves arrive. However, if the hypocenter is close, it becomes impossible to cope with the S waves before they arrive. It is therefore important to keep the differences between P waves and S waves in mind.



- The earthquake early warning system catches earthquakes (P waves and preliminary tremors) near their hypocenter and automatically calculates their location, magnitude, and estimated seismic intensity. The result is notified swiftly, ranging from several seconds to several dozen seconds, before the strong shaking (S waves and main tremors) arrives.
- However, for locations near the hypocenter, sometimes there is no warning time to prepare for strong shaking.

(Taken from a leaflet published by the Japan Meteorological Agency)

Supporting Section Part 1 Government Efforts

Ⅰ. General Overview of the Headquarters for Earthquake Research Promotion

The Great Hanshin-Awaji Earthquake Disaster on January 17, 1995 killed 6,434 people and destroyed over 100,000 buildings. This was the worst damage that Japan had suffered since the end of World War II. It also brought to light a number of problems in the national earthquake disaster prevention measures at the time.

Based on these problems, the Special Measure Law on Earthquake Disaster Prevention was enacted by legislators in July 1995. It was designed to promote a comprehensive national policy on earthquake disaster prevention.

The law recognized that the national system had failed to sufficiently communicate and apply the results of earthquake research to general public and disaster prevention organizations. As a result, the Headquarters for Earthquake Research Promotion was established in accordance with this law as a special governmental organization attached to the Prime Minister's Office (it now belongs to the Ministry of Education, Culture, Sports, Science and Technology). It was established in order to clarify the systems of responsibility regarding earthquake research that is directly connected to government policy. It manages this in an integrated fashion with a governmental capacity.

1. The basic objectives and roles of the Headquarters for Earthquake Research Promotion

□ Basic objectives

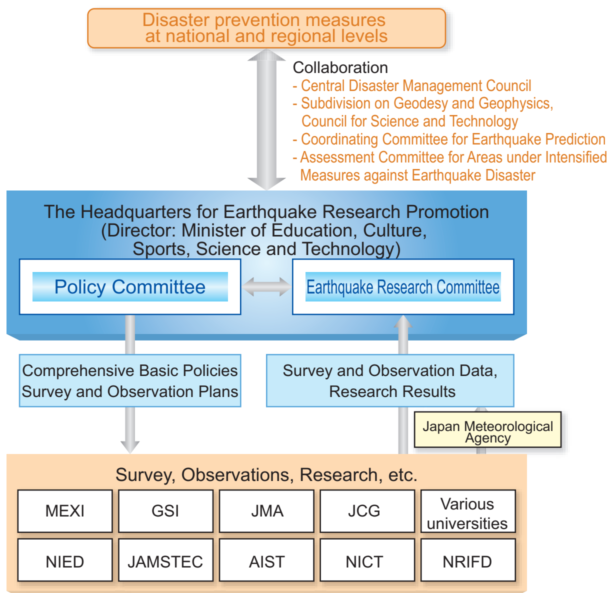
To promote research of earthquakes in order to strengthen earthquake disaster prevention measures, especially for the reduction of damages from earthquake.

□ Roles

1. Planning of comprehensive and basic policies
2. Coordination of budgets and other administrative work with related governmental organizations
3. Establishment of comprehensive survey and observation plans
4. Collection, arrangement, analyses, and comprehensive evaluation of survey results by related governmental organizations, universities, etc.
5. Publication based on the above evaluations

2. Composition of the Headquarters for Earthquake Research Promotion

The Headquarters for Earthquake Research Promotion consists of a director (the Minister of Education, Culture, Sports, Science and Technology) and staff members (such as the vice ministers of related ministries and agencies). Underneath them are the "Policy Committee" and the "Earthquake Research Committee," composed of staff from related government offices and academia.



MEXI: Ministry of Education, Culture, Sports, Science and Technology
GSI: Geospatial Information Authority of Japan
JMA: Japan Meteorological Agency
JCG: Japan Coast Guard
NIED: National Research Institute for Earth Science and Disaster Prevention
JAMSTEC: Japan Agency for Marine-Earth Science and Technology
AIST: National Institute of Advanced Industrial Science and Technology
NICT: National Institute of Information and Communications Technology
NRIFD: National Research Institute of Fire and Disaster

The "Policy Committee" implements the planning of basic policy concerning the promotion of earthquake research. It also coordinates budgets and other administrative work and deals with matters such as evaluation-based publications.

The "Earthquake Research Committee" holds regular meetings on a monthly basis and classifies and analyzes research and observation results, as well as study outcomes. It does this in order to evaluate seismic activity in a comprehensive manner and to publish evaluation results. In addition, ad hoc meetings are held in response to damaging earthquakes or marked seismic activity. The meeting seeks to assess the current activity and the probability of aftershocks.

The Headquarters for Earthquake Research Promotion formulated its new policy, which was titled: "New Promotion of Earthquake Research - Comprehensive Basic Policies for the Promotion of Seismic Research through the Observation, Measurement, and Survey -." This policy is a guideline of earthquake research for the next 10 years, and was released in 2009 (revised in September 2012).

Supporting Section Part 2

Applying the Outcome of Investigative Earthquake Research for Disaster Prevention

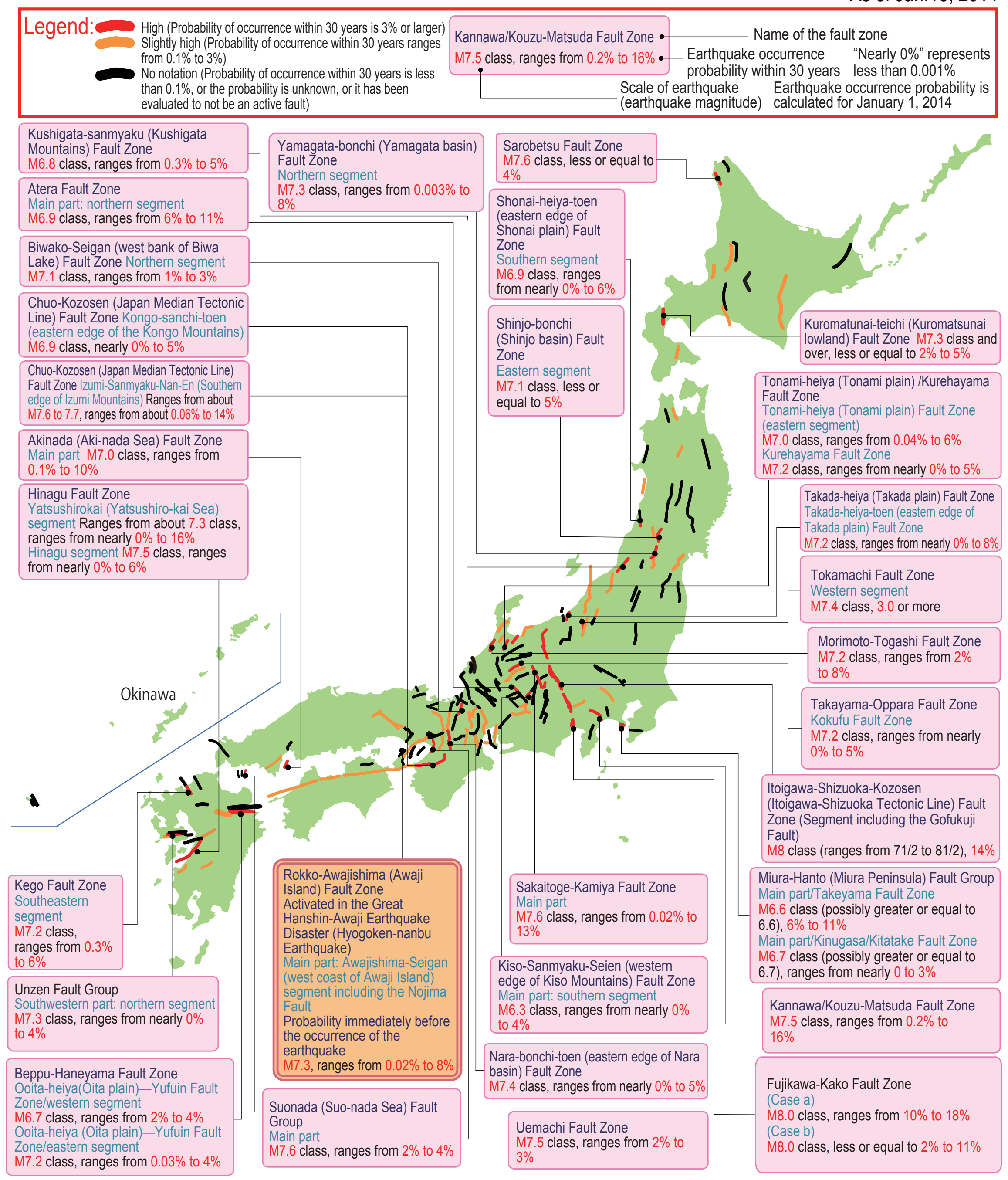
Ⅰ. Long-term Evaluation

The Headquarters for Earthquake Research Promotion is evaluating earthquakes along the main active faults of Japan, as well as and subduction zone earthquakes. It is doing this to estimate the magnitudes of possible earthquakes and the probabilities of them occurring in given periods. The Headquarters refers to this practice as "long-term evaluation."

In long-term evaluation, you can see the "places" where large-scale earthquakes might occur, as well as their their specific "scale (earthquake magnitude)" and "probability" of occurrence.

■ The results of long-term evaluation along the main active fault zones

As of Jan.15, 2014



"Occurrence probability" of earthquake

Earthquakes are generated by dislocation on a fault. It is thought that individual faults have their own individual recurrence intervals. If the recurrence interval and the time of the previous earthquake are known, the time of the next earthquake can be estimated to a certain extent. However, since the actual recurrence interval can vary and is sometimes uncertain, the time of the next earthquake is expressed as a probability.

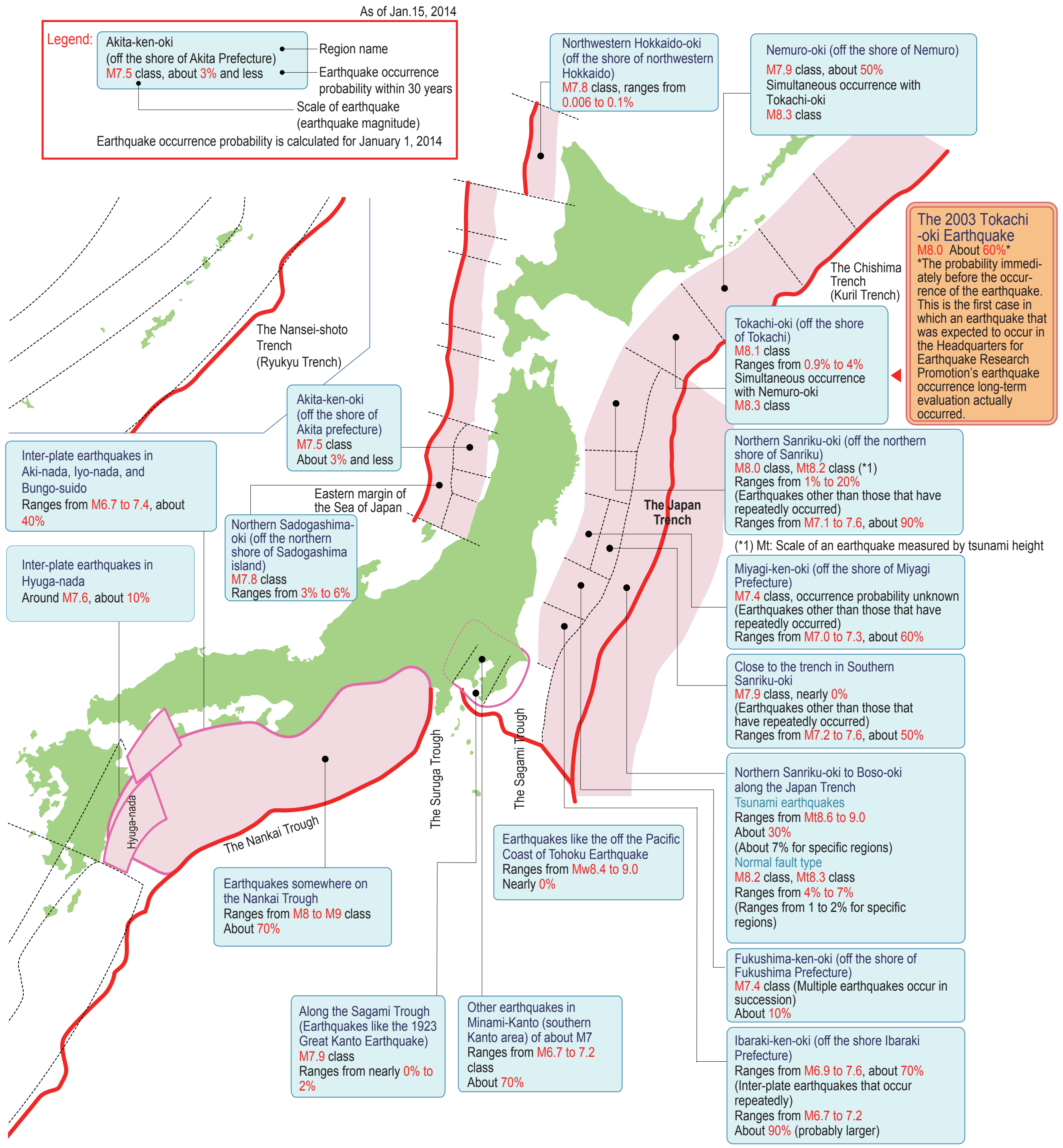
The probability of earthquake occurrence and the probability of other accidents or disastrous events

The probability of earthquake occurrence given in the figure is usually only a few percent. This might seem small, but this value does not mean that we are free from earthquakes and are safe.

For example, the probability of getting killed in a traffic accident within 30 years is approximately 0.2%*1. If you compare this value with that of an earthquake, you can see that the probability of earthquake occurrence is not so small. Furthermore, an earthquake can, even if the occurrence probability is low, inflict enormous damages once it occurs. It is important to consider its possible extent of damages when accepting this probability.

＊1 Calculated based on the statistics from the White Paper published by the Fire and Disaster Management Agency, using a specific assumption.

Results of long-term evaluations of Subduction zone earthquakes



II. Seismic Hazard Maps

The Headquarters for Earthquake Research Promotion made the "National Seismic Hazard Maps for Japan" public in 2005. Since then it has been publishing seismic hazard maps that reflect the latest information.

There are two types of seismic hazard maps, which have different perspectives. The first of these is the "Probabilistic Seismic Hazard Maps," which shows the probability of strong shakes occurring at given areas over designated periods. The second is the "Seismic Hazard Maps for Specified Seismic Source Faults," which shows specified faults and how strongly certain areas near the faults can shake if an earthquake were to occur at those faults. Seismic hazard maps are prepared based on long-term evaluations. These are predictions of earthquake magnitudes and the probability of earthquake occurrence in a given period. They target earthquakes that occur at main active faults, as well as subduction-zone earthquakes. Seismic hazard maps are also based on seismic ground motion prediction methods, which specify earthquake source faults.

Since these two maps have different perspectives, you must properly choose which should be used depending on your purpose or interest in preparing for future earthquakes.

Basic use of seismic hazard maps

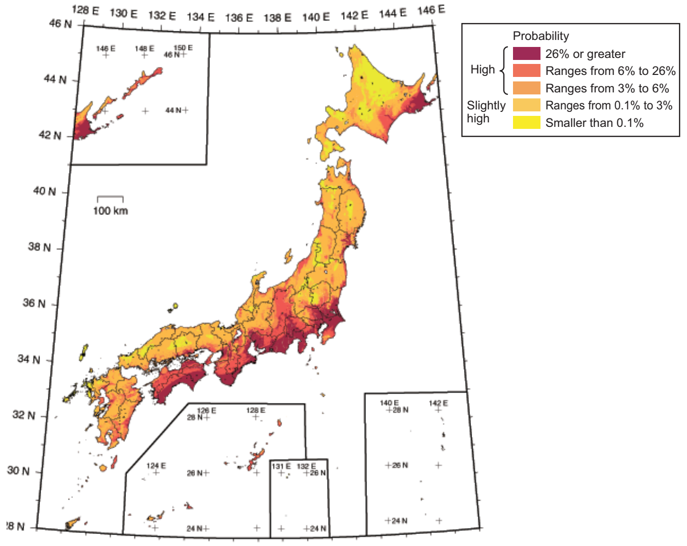
○ Probabilistic Seismic Hazard Maps

With this map you can find out how high and how regionally different the probability of strong shaking occurrences are over a certain period. You can also consider all the possible earthquakes that will influence a particular area of interest.

○ Seismic Hazard Maps for Specified Seismic Source Faults

With this map you can see how severe the ground motion would be in particular areas around a particular seismic source fault if an earthquake occurred.

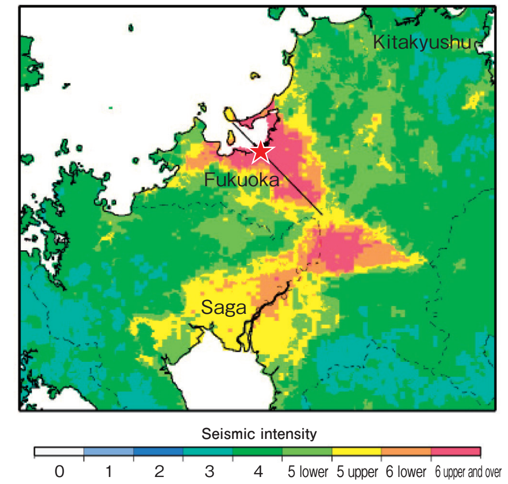
■ A diagram showing the probability distribution of a shaking with intensity 6 or greater hitting within 30 years (Base date: Jan.1, 2013)



Revisions for the seismic hazard map are currently being undertaken. Please keep in mind that the seismic hazard map in this material, including the above diagram, is in the process of revision.

■ Evaluation of a strong ground motion, assuming that an earthquake occurs along an active fault

Evaluation of a strong ground motion, assuming that the earthquake occurs along the Kego Fault Zone (south-eastern segment) (made public in April 2008)



Utilization of the "Seismic Hazard Map"

The "Probabilistic Seismic Hazard Map" and "Seismic Hazard Maps for Specified Seismic Source Faults" are prepared by the Earthquake Research Committee. They are not only used to raise awareness about seismic disaster prevention; they also fulfil the following roles:

Earthquake-related survey and observation

Basic materials for selecting areas to be highlighted for earthquake-related survey and observation.

Regional inhabitants

Raising of awareness of the local residents concerning earthquake disaster prevention.

Earthquake disaster prevention measures

Basic materials for drawing up land utilization plans, seismic designs for facilities or structures. Basic materials for the planning of regional disaster prevention schemes.

Risk evaluation

Basic materials for risk evaluation, such as locating important facilities, deciding new business locations, or evaluating of insurance rates.

Probabilistic Seismic Hazard Maps

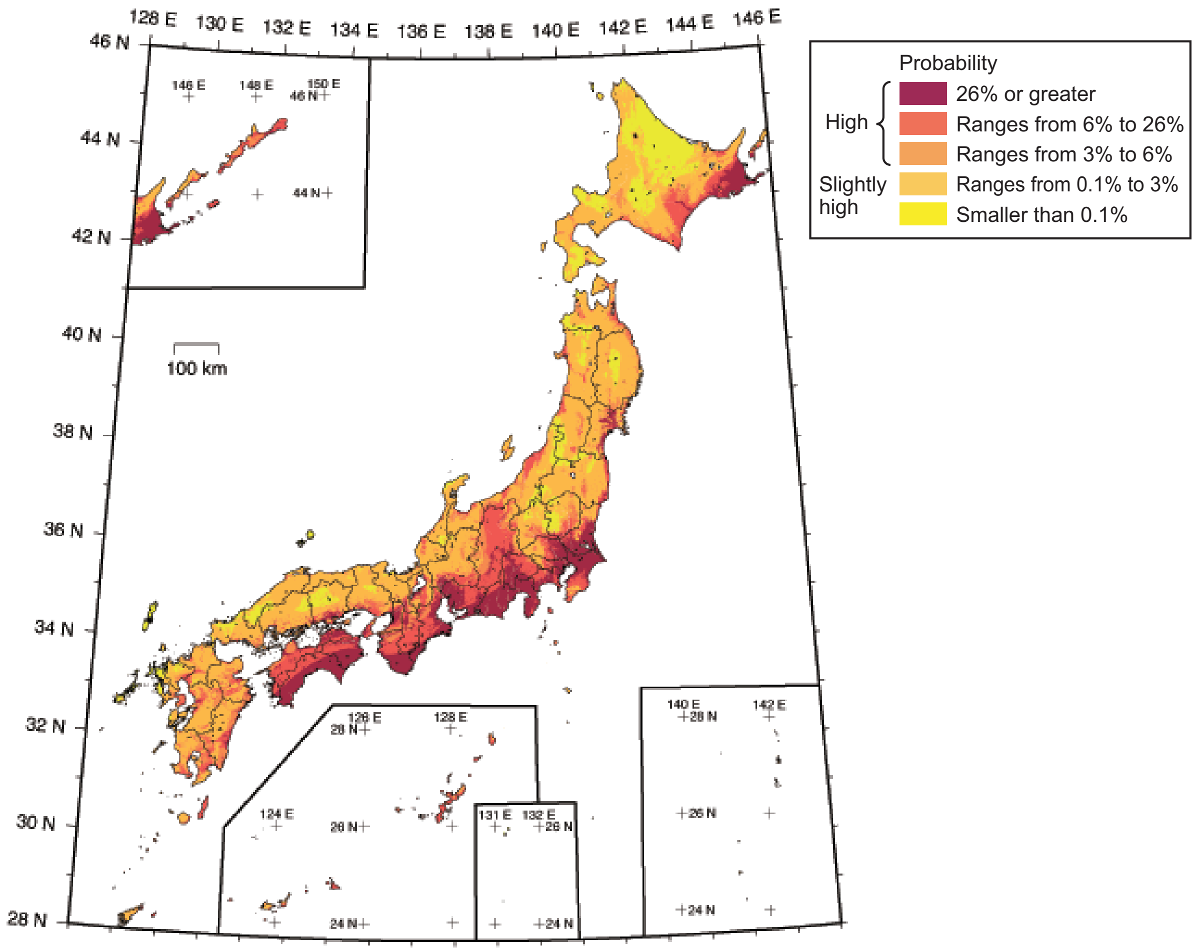
The Probabilistic Seismic Hazard Maps indicate the "possibilities of strong shaking within a certain period at every location on the map."

In preparing this map, all earthquakes that might influence a particular area have been considered. The considered earthquakes in these maps consist of not only earthquakes that have already been through long-term evaluation, but also earthquakes that are difficult to find source faults for before they occur. This includes earthquakes that occur in an area where no active fault has yet been found.

For the probabilistic seismic hazard maps, three quantities are used. These are the "time span," "intensity of shakes," and "probability." To present the maps, a convention was adopted so that two of the quantities were fixed to show the distribution of the remaining quantity. For example, below is a distribution map of "probability," that is shown with the "time period" and "intensity of ground motion" fixed. Reports on the Probabilistic Seismic Hazard Map are publicly available on the Headquarters for Earthquake Research Promotion's website.

Seismic hazard maps can also be seen on the website of the National Research Institute for Earth Science and Disaster Prevention (NIED), "Japan Seismic Hazard Information Station (J-SHIS)." You can zoom-in on the map, find out "the probability of ground motion equal to or larger than seismic intensities of 6 lower, occurring within 30 years from the present," or the "ground susceptibility to shaking." You can also check the main active faults or the hypocentral regions of subduction zone earthquakes. Seismic hazard maps are revised every year.

■ Probabilistic Seismic Hazard Maps
A distribution map with of the probability of ground motions equal to or larger than seismic intensity of 6 lower, occurring within 30 years into the future (Base date: January 1, 2013)



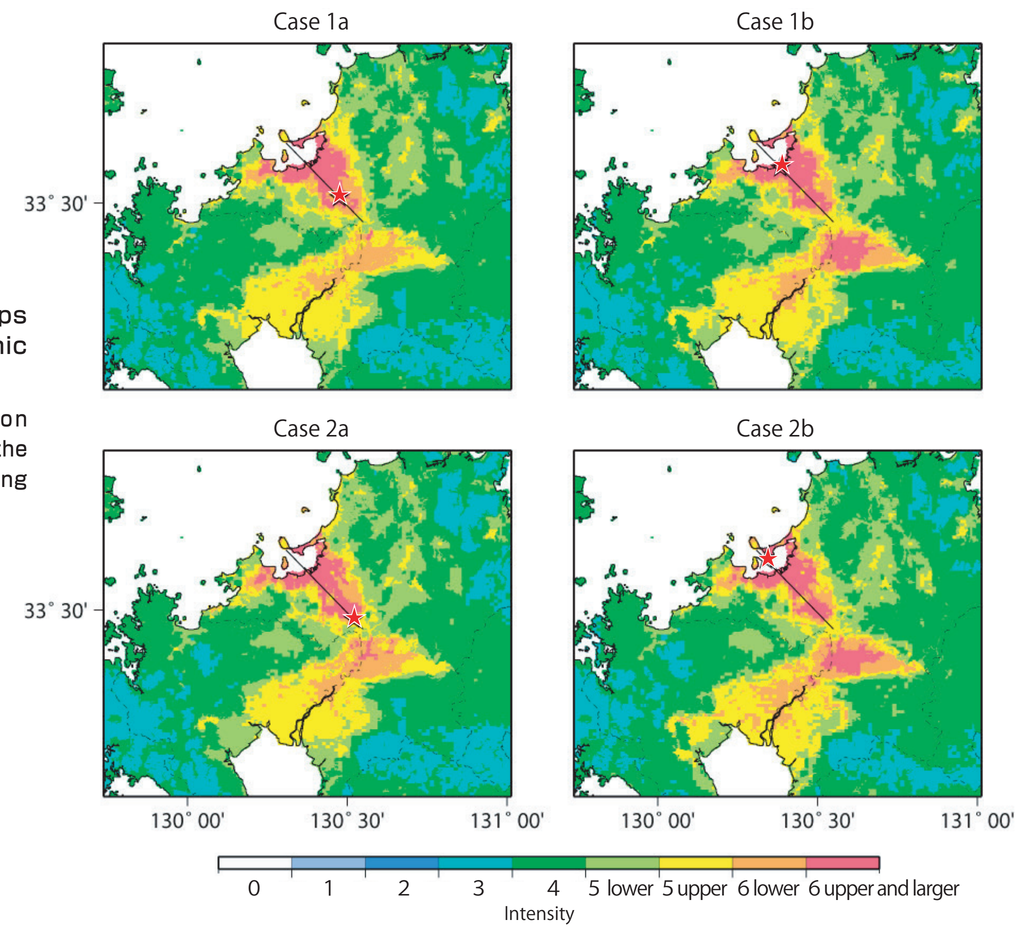
Revisions for the seismic hazard map are currently being undertaken. Please keep in mind that the seismic hazard map in this material, including the above diagram, is in the process of revision.

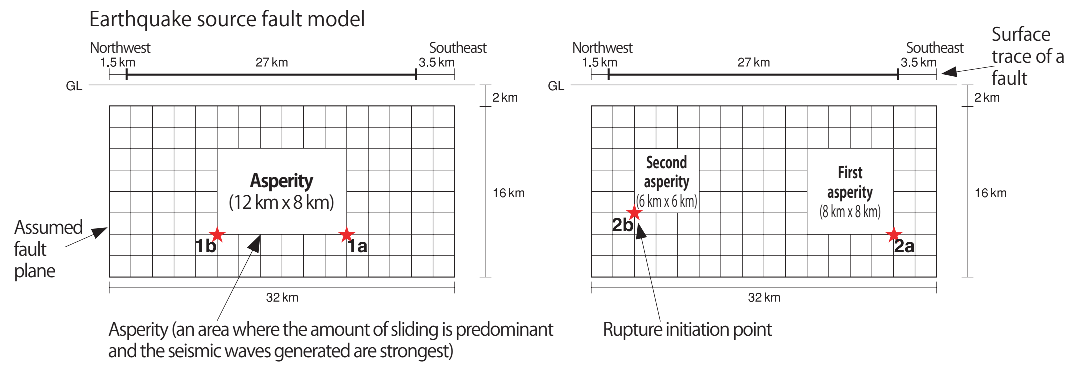
Seismic Hazard Maps for Specified Seismic Source Faults

The Seismic Hazard Maps for Specified Seismic Source Faults focuses on specific earthquake source faults. They show the shaking intensity of the areas around the faults when the earthquakes occur. For example, they are useful for checking how strong the shaking will be if an earthquake occur at a fault near you. These kinds of maps have been provided and widely utilized for estimating damages and drawing up national or regional disaster mitigation plans. To ensure that any user can obtain the same predicted results, the Earthquake Research Committee has been working toward standardization of the strong ground motion prediction method and has formulated the "Recipe for Predicting Strong Ground Motion for Specified Seismic Source Faults". At the same time, the committee has been conducting estimations of how strong shaking would be and has been making a series of seismic hazard maps publics for specified seismic source faults. For the evaluation, the committee has been selecting earthquakes that may have large impacts on their surrounding areas, out of those that may occur at active faults or subduction-zones. Seismic hazard maps for specified seismic source faults are openly available on the Headquarters for Earthquake Research Promotion's website.

■ Seismic Hazard Maps for Specified Seismic Source Faults

Strong ground motion evaluation, assuming the earthquake occurs along the Kego Fault Zone (southeastern segment)





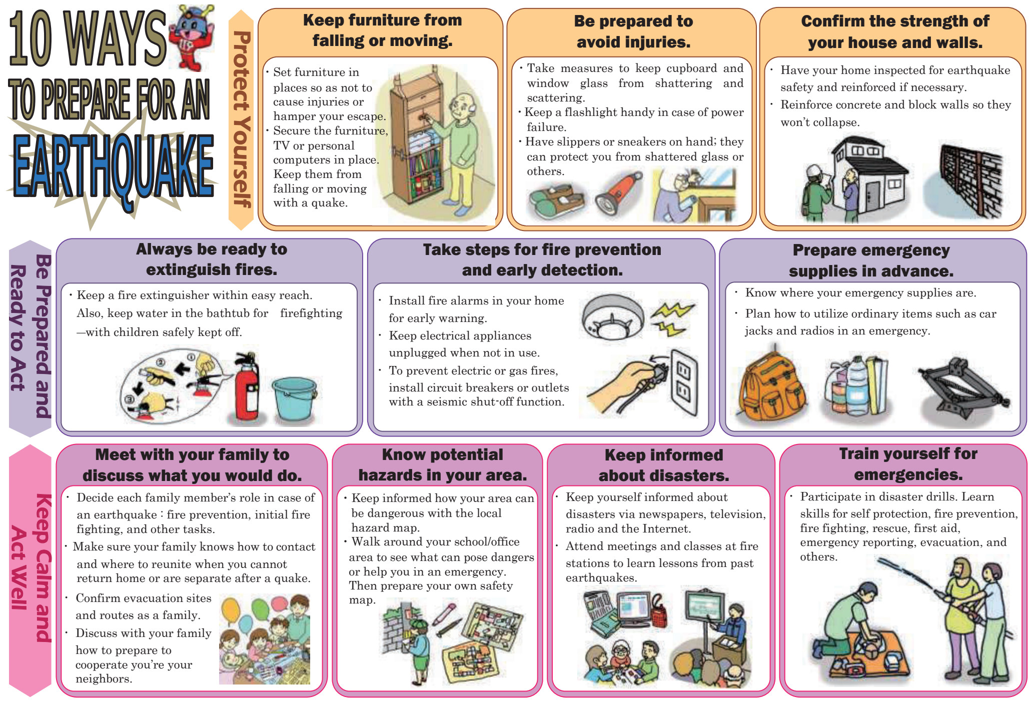
Two cases having one asperity (Case 1a and Case 1b) and two cases having two different-sized asperities (Case 2a and Case 2b) have been assumed. The rupture initiation point was the lowest point of either the northwestern end or the southeastern end.
(1a, 1b, 2a, and 2b are the rupture initiation points. They are also the case names.)

Supplementary Material Section

Measures you can take to stay safe from earthquakes

Ⅰ. Before an earthquake occurs:

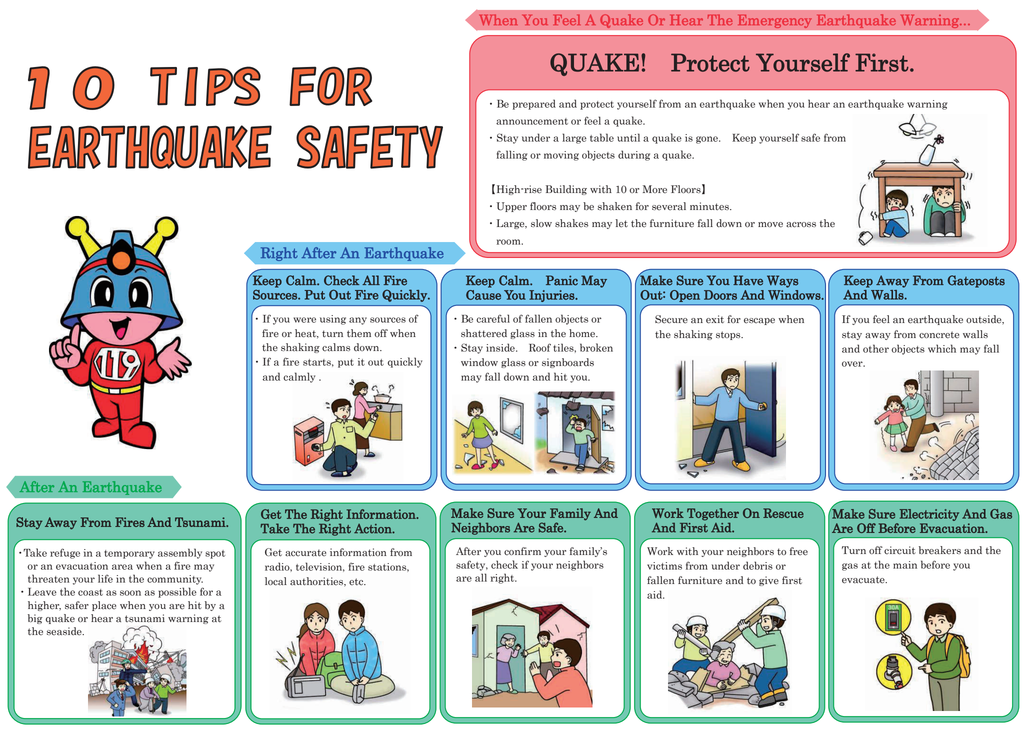
Earthquakes can hit suddenly. It is important to always be as prepared as you possibly can.



(Provided by the Tokyo Fire Department)

Ⅱ. If an earthquake occurs:

In order to stay safe from earthquakes, it is important to know and think about what to do in advance. If there is ever a tsunami threat, evacuate at once. When doing so, keep the preparations shown on the following page in mind.



(Provided by the Tokyo Fire Department)

The Earthquake and Disaster-Reduction Research Division, Research and Development Bureau, Ministry of Education, Culture, Sports, Science and Technology

(Secretariat Division of the Headquarters for Earthquake Research Promotion)

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headquarters for earthquake　検索

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