

# Earthquake Glossary

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## Reference Glossary

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A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

### A

#### Acceleration

The change from one speed, or velocity, to another is called acceleration. During an earthquake when the ground is shaking, it also experiences acceleration. The peak acceleration is the largest acceleration recorded by a particular station during an earthquake.

#### Accelerogram

The recording of the acceleration of the ground during an earthquake.

#### Accretionary Wedge

Sediments, the top layer of material on a tectonic plate, that accumulate and deform where oceanic and continental plates collide. These sediments are scraped off the top of the downgoing oceanic crustal plate and are appended to the edge of the continental plate.

#### Active fault

A fault that is likely to have another earthquake sometime in the future. Faults are commonly considered to be active if they have moved one or more times in the last 10,000 years.

#### Aftershocks

Earthquakes that follow the largest shock of an earthquake sequence. They are smaller than the

mainshock and within 1-2 fault lengths distance from the mainshock fault. Aftershocks can continue over a period of weeks, months, or years. In general, the larger the mainshock, the larger and more numerous the aftershocks, and the longer they will continue.

#### Alluvium

Loose gravel, sand, silt, or clay deposited by streams.

#### Amplification

Most earthquakes are relatively small, in fact, so small that no one feels them. In order for seismologists to see the recording of the movement of the ground from the smaller earthquakes, the recording has to be made larger. It's like looking at the recording through a magnifying glass, and the amount that it is magnified is the amplification. Shaking levels at a site may also be increased by focusing of seismic energy caused by the geometry of the sediment velocity structure, such as basin subsurface topography, or by surface topography.

#### Amplitude

The size of the wiggles on an earthquake recording.

#### Arc

A chain of volcanoes (volcanic arc) that sometimes forms on the land when an oceanic plate collides with a continental plate and then slides down underneath it (subduction).

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## **Aseismic**

This term describes a fault on which no earthquakes have been observed.

## **Asperity**

An area on a fault that is stuck.

## **Asthenosphere**

The ductile part of the earth just below the lithosphere, including the lower mantle. The asthenosphere is about 180 km thick.

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## **B**

## **Backarc**

The region landward of the chain of volcanoes (volcanic arc), in a subduction system.

## **Basement**

Harder and usually older igneous and metamorphic rocks that underlie the main sedimentary rock sequences (softer and usually younger) of a region and extend downward to the base of the crust.

## **Bedrock**

Relatively hard, solid rock that commonly underlies softer rock, sediment, or soil; a subset of the

basement.

### **Benioff Zone**

A dipping planar (flat) zone of earthquakes that is produced by the interaction of a downgoing oceanic crustal plate with a continental plate. These earthquakes can be produced by slip along the subduction thrust fault or by slip on faults within the downgoing plate as a result of bending and extension as the plate is pulled into the mantle. Also known as the Wadati-Benioff zone.

### **Blind Thrust Fault**

A thrust fault that does not rupture all the way up to the surface so there is no evidence of it on the ground. It is "buried" under the uppermost layers of rock in the crust.

### **Body Wave**

A seismic wave that moves through the interior of the earth, as opposed to surface waves that travel near the earth's surface. P and S waves are examples. Each type of wave shakes the ground in different ways.

### **Brittle-Ductile Boundary**

The depth in the crust where the crust changes from being brittle (tending to break) above, to being ductile (tending to bend) below. Most earthquakes occur in the brittle portion of the crust above the brittle-ductile boundary.

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## **C**

### **<sup>14</sup>C Age Date**

An absolute age obtained for geologic materials containing bits or pieces of carbon using measurements of the proportion of radioactive carbon (<sup>14</sup>C) to daughter carbon (<sup>12</sup>C). These dates are independently calibrated with calendar dates. This is used to determine when past earthquakes occurred on a fault.

### **Compressional Stress**

The stress that squeezes something. It is the stress component perpendicular to a given surface, such as a fault plane, that results from forces applied perpendicular to the surface or from remote forces transmitted through the surrounding rock.

### **Compressional Wave**

See P wave.

### **Core**

The innermost part of the earth. The outer core extends from 2500 to 3500 miles below the earth's surface and is liquid metal. The inner core is the central 500 miles and is solid metal.

### **Creep**

Slow, more or less continuous movement occurring on faults due to ongoing tectonic deformation. Faults that are creeping do not tend to have large earthquakes.



## **F**

### **Fault**

A fracture along which the blocks of crust on either side have moved relative to one another parallel to the fracture. Strike-slip faults are vertical (or nearly vertical) fractures where the blocks have mostly moved horizontally. If the block opposite an observer looking across the fault moves to the right, the slip style is termed right lateral; if the block moves to the left, the motion is termed left lateral. Dip-slip faults are inclined fractures where the blocks have mostly shifted vertically. If the rock mass above an inclined fault moves down, the fault is termed normal, whereas if the rock above the fault moves up, the fault is termed reverse (or thrust). Oblique-slip faults have significant components of both slip styles.

### **Fault Creep**

See creep.

### **Fault Gouge**

Crushed and ground-up rock produced by friction between the two sides when a fault moves.

### **Fault Plane**

The planar (flat) surface along which there is slip during an earthquake.

### **Fault Plane Solution**

A fault plane solution is a way of showing the fault and the direction of slip on it from an earthquake, using circles with two intersecting curves that look like beach balls.

### **Fault Scarp**

A feature on the surface of the earth that looks like a step caused by slip on the fault.

### **Fault Trace**

Intersection of a fault with the ground surface; also, the line commonly plotted on geologic maps to represent a fault.

### **First Motion**

On a seismogram, the direction of ground motion as the P wave arrives at the seismometer. Upward ground motion indicates an expansion in the source region; downward motion indicates a contraction.

### **Focal Depth**

A term that refers to the depth of an earthquake hypocenter.

### **Focal-Mechanism Solution**

See fault-plane solution.

## Focus

See hypocenter.

## Forearc

The region between the subduction zone and the volcanic chain (volcanic arc).

## Foreshocks

Foreshocks are relatively smaller earthquakes that precede the largest earthquake in a series, which is termed the mainshock. Not all mainshocks have foreshocks.

## Frequency

The number of times something happens in a certain period of time, such as the ground shaking up and down or back and forth during an earthquake.

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## G

### G or g

G or g is the force of gravity (an acceleration of 9.78 meters/second<sup>2</sup>). When there is an earthquake, the forces caused by the shaking can be measured as a percentage of the force of gravity, or percent g.

## Geology

The study of the planet earth — the materials it is made of, the processes that act on those materials, the products formed, and the history of the planet and its life forms since its origin.

## Gravity

The attraction between two masses, such as the earth and an object on its surface. Commonly referred to as the acceleration of gravity. Changes in the gravity field can be used to infer information about the structure of the earth's lithosphere and upper mantle.

## Graben

a down-dropped block of the earth's crust resulting from extension, or pulling, of the crust. See also horst.

## Ground Failure

A general reference to landslides, liquefaction, lateral spreads, and any other consequence of shaking that affects the stability of the ground.

## Ground Motion (Shaking)

The movement of the earth's surface from earthquakes or explosions. Ground motion is produced by waves that are generated by sudden slip on a fault or sudden pressure at the explosive source and travel through the earth and along its surface.

## H

### Harmonic Tremor

Continuous rhythmic earthquakes that can be detected by seismographs. Harmonic tremors often precede or accompany volcanic eruptions.

### Hertz (Hz)

A unit of frequency. Expressed in cycles per second.

### Holocene

Refers to a period of time between the present and 10,000 years before present. Applied to rocks or faults, this term indicates the period of rock formation or the time of most recent fault slip. Faults of this age are commonly considered active.

### Horst

An upthrown block lying between two steep-angled fault blocks. See also graben.

### Hypocenter

The point within the earth where an earthquake rupture starts. Also commonly termed the focus

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## I

### Intensity

A number (written as a Roman numeral) describing the severity of an earthquake in terms of its effects on the earth's surface and on humans and their structures. Several scales exist, but the ones most commonly used in the United States are the Modified Mercalli scale and the Rossi-Forel scale. There are many intensities for an earthquake, depending on where you are, unlike the magnitude, which is one number for each earthquake.

### Intraplate And Interplate

Intraplate pertains to processes within the earth's crustal plates.  
Interplate pertains to processes between the plates.

### Interplate Coupling

The ability of a fault between two plates to lock and accumulate stress. Strong interplate coupling means that the fault is locked and capable of accumulating stress, whereas weak coupling means that the fault is unlocked or only capable of accumulating low stress.

### Isoseismal

A contour or line on a map bounding points of equal intensity for a particular earthquake.

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## J



## K

### Kinematic

Referring to the general movement patterns and directions of the earth's rocks that produce rock deformation.

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## L

### Landslide

The downslope movement of soil and/or rock.

### Late Quaternary

The age between the present and 500,000 years before the present. Faults of this age are sometimes considered active based on the observation of historical activity on faults of this age in some locales.

### Lateral Spread And Flow

Terms referring to landslides that commonly form on gentle slopes and that have rapid fluid-like flow movement, like water.

### Left-Lateral

If you were to stand on the fault and look along its length, this is a type of strike-slip fault where the left block moves toward you and the right block moves away. (See also right-lateral.)

### Lifelines

Structures that are important or critical for a community to function, such as roadways, pipelines, powerlines, sewers, communications, and port facilities.

### Liquefaction

A process by which water-saturated sediment temporarily loses strength and acts as a fluid, like when you wiggle your toes in the wet sand near the water at the beach. This effect can be caused by earthquake shaking.

### Lithology

The description of rock composition (what it's made of) and texture.

### Lithosphere

The outer solid part of the earth, including the crust and uppermost mantle. The lithosphere is about 100 km thick, although its thickness is age dependant (older lithosphere is thicker).The lithosphere below the crust is brittle enough at some locations to produce earthquakes by faulting, such as within a subducted oceanic plate.

### Locked Fault

A fault that is not slipping because frictional resistance on the fault is greater than the shear stress across

the fault (it is stuck). Such faults may store strain for extended periods that is eventually released in an earthquake when frictional resistance is overcome.

## Love wave

A type of seismic surface wave having a horizontal motion that is transverse (or perpendicular) to the direction the wave is traveling.

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## M

### Ma

An abbreviation for one million years ago (Megannum).

### Mainshock

The mainshock is the largest earthquake in a sequence, sometimes preceded by one or more foreshocks, and almost always followed by many aftershocks.

### Magnetic Polarity Reversal

A change of the earth's magnetic field to the opposite polarity that has occurred at irregular intervals during geologic time. Polarity reversals can be preserved in sequences of magnetized rocks and compared with standard polarity-change time scales to estimate geologic ages of the rocks. Rocks created along the oceanic spreading ridges commonly preserve this pattern of polarity reversals as they cool, and this pattern can be used to determine the rate of ocean ridge spreading. The reversal patterns recorded in the rocks are termed sea-floor magnetic lineaments.

## Magnitude

A number that characterizes the relative size of an earthquake. Magnitude is based on measurement of the maximum motion recorded by a seismograph. Several scales have been defined, but the most commonly used are (1) local magnitude (ML), commonly referred to as "Richter magnitude," (2) surface-wave magnitude (Ms), (3) body-wave magnitude (Mb), and (4) moment magnitude (Mw). Scales 1-3 have limited range and applicability and do not satisfactorily measure the size of the largest earthquakes. The moment magnitude (Mw) scale, based on the concept of seismic moment, is uniformly applicable to all sizes of earthquakes but is more difficult to compute than the other types. All magnitude scales should yield approximately the same value for any given earthquake, mainshock. The largest earthquake in a sequence, sometimes preceded by one or more foreshocks, and almost always followed by many aftershocks.

## Mantle

The part of the earth's interior between the metallic outer core and the crust.

### Microzonation

The identification of separate individual areas having different potentials for hazardous earthquake effects.

## Moho

The boundary between the crust and the mantle in the earth. This is a depth where seismic waves change



velocity and there is also a change in chemical composition. Also termed the Mohorovicic' discontinuity after the Croatian seismologist Andrija Mohorovicic' (1857-1936) who discovered it. The boundary is between 25 and 60 km deep beneath the continents and between 5 and 8 km deep beneath the ocean floor.

## **Moment Magnitude**

See magnitude.

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## **N**

### **Natural Frequency**

The frequency at which a particular object or system vibrates when pushed by a single force or impulse, and not influenced by other external forces or by damping. If you hold a slinky by one end and let it hang down and then give it one push up from the bottom, the rate of up-and-down motion is its natural frequency.

### **Normal Stress**

That stress component perpendicular to a given plane. If you lean against a door after you close it, you are applying normal stress to the door. ( See also shear stress.)

### **Normal Fault**

(See fault.)

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## **O**

## **P**

### **P Wave**

A seismic body wave that shakes the ground back and forth in the same direction and the opposite direction as the direction the wave is moving.

### **Paleoseismic**

Referring to the history of seismic events that is determined by looking at the layers of rock beneath the surface and how they have been shifted by earthquakes in the past.

### **Peak Acceleration**

See acceleration

### **Pedogenic**

Pertaining to processes that add, transfer, transform, or remove soil constituents.

### **Period**

The time interval required for one full cycle of a wave.

## Plate Tectonics

A theory supported by a wide range of evidence that considers the earth's crust and upper mantle to be composed of several large, thin, relatively rigid plates that move relative to one another. Slip on faults that define the plate boundaries commonly results in earthquakes. Several styles of faults bound the plates, including thrust faults along which plate material is subducted or consumed in the mantle, oceanic spreading ridges along which new crustal material is produced, and transform faults that accommodate horizontal slip (strike slip) between adjoining plates.

## Pleistocene

The time period between about 10,000 years before present and about 1,650,000 years before present. As a descriptive term applied to rocks or faults, it marks the period of rock formation or the time of most recent fault slip, respectively. Faults of Pleistocene age may be considered active though their activity rates are commonly lower than younger faults.

## Poisson Distribution

A probability distribution that characterizes discrete events occurring independently of one another in time.

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## Q

## Q

See attenuation.

## Quaternary

The geologic time period comprising about the last 1.65 million years.

## R

## Radiometric

Pertaining to the measurement of geologic time by the analysis of certain radioisotopes in rocks and their known rates of decay.

## Rayleigh Wave

A seismic surface wave causing the ground to shake in an elliptical motion, with no transverse, or perpendicular, motion.

## Recurrence Interval

The average time span between large earthquakes at a particular site. Also termed "return period".

## Reflection

The energy or wave from an earthquake that has been returned (reflected) from a boundary between two different materials within the earth, just as a mirror reflects light.

## Refraction

(1) The deflection, or bending, of the ray path of a seismic wave caused by its passage from one material to another having different elastic properties. (2) Bending of a tsunami wave front owing to variations in the water depth along a coastline.

## Return Period

See recurrence interval.

## Right-Lateral

If you were to stand on the fault and look along its length, this is a type of strike-slip fault where the right block moves toward you and the left block moves away. (See also left-lateral.)

## Ring of Fire

The zone of earthquakes surrounding the Pacific Ocean which is called the Circum-Pacific belt—about 90% of the world's earthquakes occur there. The next most seismic region (5-6% of earthquakes) is the Alpine belt (extends from Mediterranean region, eastward through Turkey, Iran, and northern India.

## Rupture Front

The instantaneous boundary between the slipping and locked parts of a fault during an earthquake. Rupture in one direction on the fault is referred to as unilateral. Rupture may radiate outward in a circular manner or it may radiate toward the two ends of the fault from an interior point, behavior referred to as bilateral.

## Rupture Velocity

The speed at which a rupture front moves across the surface of the fault during an earthquake.

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## S

### S wave

A seismic body wave that shakes the ground back and forth perpendicular to the direction the wave is moving, also called a shear wave.

## Sand Boil

Sand and water that come out onto the ground surface during an earthquake as a result of liquefaction at shallow depth.

## Sea-Floor Spreading

See magnetic polarity reversals.

## Secular

Referring to long-term changes that take place slowly and imperceptibly. Commonly used to describe changes in elevation, tilt, and stress or strain rates that are related to long-term tectonic deformation. For example, a mountain that is growing is getting taller so slowly that we cannot see it happen, but if we



were to measure the elevation one year and then the next, we could see that it has grown taller.

## **Segmentation**

The breaking up of a fault along its length into several smaller faults. This can happen as a result of other faults crossing it, topography changes, or bends in the strike of the faults. Segmentation can limit the length of faulting in a single earthquake to some fraction of the total fault length, thus also limiting the size of the earthquake.

## **Seiche**

The sloshing of a closed body of water from earthquake shaking. Swimming pools often have seiches during earthquakes.

## **Seismic Gap**

A section of a fault that has produced earthquakes in the past but is now quiet. For some seismic gaps, no earthquakes have been observed historically, but it is believed that the fault segment is capable of producing earthquakes on some other basis, such as plate-motion information or strain measurements.

## **Seismic Hazard**

See earthquake hazard.

## **Seismicity**

The geographic and historical distribution of earthquakes.

## **Seismic Moment**

A measure of the size of an earthquake based on the area of fault rupture, the average amount of slip, and the force that was required to overcome the friction sticking the rocks together that were offset by faulting. Seismic moment can also be calculated from the amplitude spectra of seismic waves.

## **Seismic Reflection or Refraction Line**

A set of seismographs usually lined up along the earth's surface to record seismic waves generated by an explosion for the purpose of recording reflections and refractions of these waves from velocity discontinuities within the earth. The data collected can be used to infer the internal structure of the earth.

## **Seismic Wave**

An elastic wave generated by an impulse such as an earthquake or an explosion. Seismic waves may travel either along or near the earth's surface (Rayleigh and Love waves) or through the earth's interior (P and S waves).

## **Seismic Zone**

An area of seismicity probably sharing a common cause. Example: "The New Madrid Seismic Zone."

## **Seismogenic**

Capable of generating earthquakes.

## **Seismogram**

A record written by a seismograph in response to ground motions produced by an earthquake, explosion, or other ground-motion sources.

## Seismology

The study of earthquakes and the structure of the earth, by both naturally and artificially generated seismic waves.

## Seismometer Or Seismograph

A seismometer is an instrument used to detect and record earthquakes. Generally, it consists of a mass attached to a fixed base. During an earthquake, the base moves and the mass doesn't. The motion of the base with respect to the mass is commonly transformed into an electrical voltage. The electrical voltage is recorded on paper, magnetic tape, or another recording medium. This record is proportional to the motion of the seismometer mass relative to the earth, but it can be mathematically converted to a record of the absolute motion of the ground. Seismograph is a term that refers to the seismometer and its recording device as a single unit.

## Shear Stress

The stress component parallel to a given surface, such as a fault plane, that results from forces applied parallel to the surface or from remote forces transmitted through the surrounding rock. If you lean against the edge of the door where the latch is, you are applying shear stress to the door.

## Shear Wave

See S wave.

## Slab

The oceanic crustal plate that underthrusts the continental plate in a subduction zone and is consumed by the earth's mantle.

## Slickensides

Polished striated rock surfaces caused by one rock mass moving across another on a fault.

## Slip

The relative displacement of formerly adjacent points on opposite sides of a fault, measured on the fault surface.

## Slip Model

A kinematic model that describes the amount, distribution, and timing of slip associated with an earthquake.

## Slip Rate

How fast the two sides of a fault are slipping relative to one another, as determined from geodetic measurements, from offset man-made structures, or from offset geologic features whose age can be estimated. It is measured parallel to the predominant slip direction or estimated from the vertical or horizontal offset of geologic markers.

## Soil



(1) In engineering, all unconsolidated material above bedrock. (2) In soil science, naturally occurring layers of mineral and (or) organic constituents that differ from the underlying parent material in their physical, chemical, mineralogical, and morphological character because of pedogenic processes (3) In other words, dirt.

## **Soil Profile**

The vertical arrangement of layers of soil down to the bedrock.

## **Source**

The released forces that generate acoustic or seismic waves, also called the earthquake source.

## **Spectral Acceleration or SA**

PGA (peak acceleration) is what is experienced by a particle on the ground. SA is approximately what is experienced by a building, as modeled by a particle on a massless vertical rod having the same natural period of vibration as the building.

## **Spectrum**

A curve showing amplitude and phase as a function of frequency or period, or how much of each type of shaking there is from an earthquake.

## **Station**

Refers to the place where a geophysical instrument is located.

## **Stick-Slip**

The fast movement that occurs between two sides of a fault when the two sides of the fault become unstuck. Stick-slip displacement on a fault radiates energy in the form of seismic waves, creating an earthquake.

## **Stochastic**

Applied to processes that have random characteristics.

## **Strain**

Small changes in length and volume associated with deformation of the earth by tectonic stresses or by the passage of seismic waves.

## **Strain Rate**

How fast the lithosphere is being deformed from plate tectonic movement.

## **Stress**

Force per unit area acting on a plane within a body. Six values are required to characterize completely the stress at a point: three normal components and three shear components.

## **Stress Drop**

The difference between the stress across a fault before and after an earthquake

The difference between the stress across a fault before and after an earthquake.



## Strike

Trend or bearing, relative to north, of the line defined by the intersection of a planar geologic surface (for example, a fault or a bed) and a horizontal surface such as the ground.

## Strike-Slip

See fault.

## Strong Motion

Ground motion of sufficient amplitude and duration to be potentially damaging to a building or other structure.

## Subduction

The process of the oceanic lithosphere colliding with and descending beneath the continental lithosphere.

## Subduction Zone

The place where two lithosphere plates come together, one riding over the other. Most volcanoes on land occur parallel to and inland from the boundary between the two plates.

## Surface Faulting

Displacement that reaches the earth's surface during slip along a fault. Commonly occurs with shallow earthquakes, those with an epicenter less than 20 km. Surface faulting also may accompany aseismic creep or natural or man-induced subsidence.

## Surface Wave

Seismic wave that travels along the earth's surface. Love and Rayleigh waves are the most common.

## Surface-Wave Magnitude

See magnitude.

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## T

### Tectonic

Refers to rock-deforming processes and resulting structures that occur over large sections of the lithosphere.

### Tectonic Plates

The large, thin, relatively rigid plates that move relative to one another on the outer surface of the Earth.

### Telesismic

Pertaining to earthquakes at distances greater than 1,000 km from the measurement site.

### Tensional Stress

The stress that tends to pull something apart. It is the stress component perpendicular to a given surface, such as a fault plane, that results from forces applied perpendicular to the surface or from remote forces transmitted through the surrounding rock.

### Thrust Fault

See fault.

### Time History

The sequence of values of any time-varying quantity (such as a ground motion measurement) measured at a set of fixed times. Also termed time series.

### Transform Fault

A special variety of strike-slip fault that accommodates relative horizontal slip between other tectonic elements, such as oceanic crustal plates. Often extend from oceanic ridges.

### Travelttime Curve

A graph of arrival times, commonly P or S waves, recorded at different points as a function of distance from the seismic source. Seismic velocities within the earth can be computed from the slopes of the resulting curves.

### Tsunami

A sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major submarine slides, or exploding volcanic islands.

### Tsunamigenic

Referring to those earthquakes, commonly along major subduction-zone plate boundaries such as those bordering the Pacific Ocean, that can generate tsunamis.

### Tsunami Magnitude (Mt)

A number used to compare sizes of tsunamis generated by different earthquakes and calculated from the logarithm of the maximum amplitude of the tsunami wave measured by a tide gauge distant from the tsunami source.

### Turbidites

Sea-bottom deposits formed by massive slope failures where rivers have deposited large deltas. These slopes fail in response to earthquake shaking or excessive sedimentation load. The temporal correlation of turbidite occurrence for some deltas of the Pacific Northwest suggests that these deposits have been formed by earthquakes.

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### U

### V

### Velocity

How fast a point on the ground is shaking as a result of an earthquake.

## Velocity Structure

A generalized regional model of the earth's crust that represents crustal structure using layers having different assumed seismic velocities.

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## W

### Wave Front

See rupture front.

### Wavelength

The distance between successive points of equal amplitude and phase on a wave (for example, crest to crest or trough to trough).

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## X

## Y

### YBP

An abbreviation for Years Before Present.

## Z