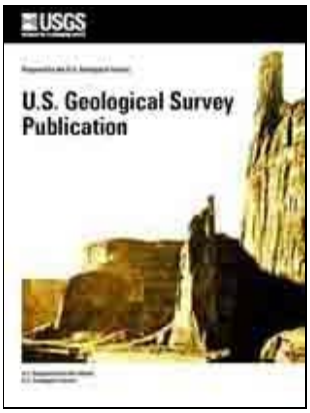

The severity of an earthquake

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The Severity of an Earthquake

The severity of an earthquake can be expressed in terms of both *intensity* and *magnitude*. However, the two terms are quite different, and they are often confused.

Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter.

Magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments which have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value.

Earthquakes are the result of forces deep within the Earth's interior that continuously affect the surface of the Earth. The energy from these forces is stored in a variety of ways within the rocks. When this energy is released suddenly, for example by shearing movements along faults in the crust of the Earth, an earthquake results. The area of the fault where the sudden rupture takes place is called the *focus* or *hypocenter* of the earthquake. The point on the Earth's surface directly above the focus is called the *epicenter* of the earthquake.

San Fernando, California, 1971. Highway interchange heavily damaged by the magnitude 6.5 earthquake
[Click on image for a larger view]

The Richter Magnitude Scale

Seismic waves are the vibrations from earthquakes that travel through the Earth; they are recorded on instruments called seismographs. Seismographs record a zig-zag trace that shows the varying amplitude of ground oscillations beneath the instrument. Sensitive seismographs, which greatly magnify these ground motions, can detect strong earthquakes from sources anywhere in the world. The time, location, and magnitude of an earthquake can be determined from the data recorded by seismograph stations.

The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included in the magnitude formula to compensate for the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude of 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Van Norman Dam, San Fernando, California, 1971. Earthquake-induced liquefaction of the earth-filled dam resulted in a landslide that caused partial collapse
[Click on image for a larger view]

At first, the Richter Scale could be applied only to the records from instruments of identical manufacture. Now, instruments are carefully calibrated with respect to each other. Thus, magnitude can be computed from the record of any calibrated seismograph.

Earthquakes with magnitude of about 2.0 or less are usually called microearthquakes; they are not commonly felt by people and are generally recorded only on local seismographs. Events with magnitudes of about 4.5 or greater--there are several thousand such shocks annually--are strong enough to be recorded by sensitive seismographs all over the world. Great earthquakes, such as the 1964 Good Friday earthquake in Alaska, have magnitudes of 8.0 or higher. On the average, one earthquake of such size occurs somewhere in the world each year. Although the Richter Scale has no upper limit, the largest known shocks have had magnitudes in the 8.8 to 8.9 range. Recently, another scale called the moment magnitude scale has been devised for more precise study of great earthquakes.

The Richter Scale is not used to express damage. An earthquake in a densely populated area which results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that does nothing more than frighten the wildlife. Large-magnitude earthquakes that occur beneath the oceans may not even be felt by humans.

(Top) San Francisco, California, 1906. Collapse of City Hall after the 8.3 magnitude earthquake. Most of the property destruction was caused by the fire that raged after the earthquake.

(Bottom) Anchorage, Alaska, 1964. Much of the damage after this magnitude 8.6 earthquake was due to huge landslides, such as this one under Government Hill elementary School.

[Click on image for a larger view]

The Modified Mercalli Intensity Scale

The effect of an earthquake on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally--total destruction. Although numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli (MM) Intensity Scale. It was developed in 1931 by the American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects.

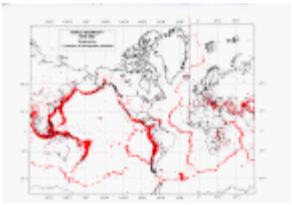
The Modified Mercalli Intensity value assigned to a specific site after an earthquake has a more meaningful measure of severity to the nonscientist than the magnitude because intensity refers to the effects actually experienced at that place. After the occurrence of widely-felt earthquakes, the Geological Survey mails questionnaires to postmasters in the disturbed area requesting the information so that intensity values can be assigned. The results of this postal canvass and information furnished by other sources are used to assign an intensity value, and to compile isoseismal maps that show the extent of various levels of intensity within the felt area. The maximum observed intensity generally occurs near the epicenter.

(Top) Mindanao, Phillippines, 1976. Apartment building destroyed by a magnitude 7.9 earthquake.

(Bottom) Long Beach, California, 1933. Exterior walls collapsed onto parked cars after this magnitude 6.3 earthquake (photo by Southern California Earthquake Pictures).

[Click on image for a larger view]

The lower numbers of the intensity scale generally deal with the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage. Structural engineers usually contribute information for assigning intensity values of VIII or above.



Ninety percent of the world's earthquakes occur in specific areas that are the boundaries of the Earth's major crustal plates. Shown on the map are the epicenter locations of earthquakes of magnitude 4.5 or greater that occurred from 1978 through 1987. [Click on image for a larger view]

The following is an abbreviated description of the 12 levels of Modified Mercalli intensity.

I. Not felt except by a very few under especially favorable conditions.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.

IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V. Felt by nearly everyone; many awakened. some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.

VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.

VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chmineys, factory stacks, columns, monuments, walls. Heavy furniture overturned.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rail bent.

XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.

XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Another measure of the relative strength of an earthquake is the size of the area over which the shaking is noticed. This measure has been particularly useful in estimating the relative severity of historic shocks that were not recorded by seismographs or did not occur in populated areas. The extent of the associated felt areas indicates that some comparatively large earthquakes have occurred in the past in places not considered by the general public to be regions of major earthquake activity. For example, the three shocks in 1811 and 1812 near New Madrid, Mo., were each felt over the entire eastern United States. Because there were so few people in the area west of New Madrid, it is not known how far it was felt in that direction. The 1886 Charleston, S.C., earthquake was also felt over a region of about 2 million square miles, which includes most of the eastern United States.

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