

Seismic scale

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Earthquakes are measured with two kinds of **seismic scales**: scales of the *magnitude* of the energy released by the rupture, and scales of the *intensity* of the resulting ground shaking at a given location.

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Magnitude and intensity

The severity of an earthquake is described by both *magnitude* and *intensity*. These two frequently confused terms refer to different, but related, expressions. *Magnitude*, usually expressed as an Arabic numeral characterizes the size of an earthquake by measuring indirectly the energy released. By contrast, *intensity* indicates the local effects and potential for damage produced by an earthquake on the Earth's surface as it affects humans, animals, structures, and natural objects such as bodies of water. Intensities are usually expressed in Roman numerals, and represent the severity of the shaking resulting from an earthquake. Ideally, any given earthquake can be described by only one *magnitude*, but many *intensities* since the earthquake effects vary with circumstances such as distance from the epicenter and local soil conditions. In practice, the same earthquake might have magnitude estimates typically differing by few tenths of a unit, depending on which magnitude scale is used and which data are included in the analysis.

Charles Richter, the creator of the Richter magnitude scale, distinguished *intensity* and *magnitude* as follows: "I like to use the analogy with radio transmissions. It applies in seismology because seismographs, or the receivers, record the waves of elastic disturbance, or radio waves, that are radiated from the earthquake source, or the broadcasting station. Magnitude can be compared to the power output in kilowatts of a broadcasting station. Local intensity on the Mercalli scale is then comparable to the signal strength on a receiver at a given locality; in effect, the quality of the signal. Intensity, like signal strength, will generally fall off with distance from the source, although it also depends on the local conditions and the pathway from the source to the point."^[1]

Seismic intensity scales

The first simple classification of earthquake intensity was devised by Domenico Pignataro in the 1780s.

^[2] However, the first recognisable intensity scale in the modern sense of the word was drawn up by P.N.G. Egen in 1828; it was ahead of its time. The first widely adopted intensity scale, the *Rossi–Forel scale*, was introduced in the late 19th century. Since then numerous intensity scales have been developed and are used in different parts of the world.

Country/Region	Seismic intensity scale used
 China	Liedu scale (GB/T 17742-1999)
 Europe	European Macroseismic Scale (EMS-98) ^[3]
 Hong Kong	Modified Mercalli scale (MM) ^[4]
 India	Medvedev–Sponheuer–Karnik scale
 Israel	Medvedev–Sponheuer–Karnik scale (MSK-64)
 Japan	Shindo scale
 Kazakhstan	Medvedev–Sponheuer–Karnik scale (MSK-64)
 Russia	Medvedev–Sponheuer–Karnik scale (MSK-64)
 Taiwan	Shindo scale
 United States	Modified Mercalli scale (MM) ^[5]

Unlike magnitude scales, intensity scales do not have a mathematical basis; instead they are an arbitrary ranking based on observed effects. Most seismic intensity scales have twelve degrees of intensity and are roughly equivalent to one another in values but vary in the degree of sophistication employed in their formulation.

Magnitude scales

The first attempt to qualitatively define a single, absolute value to describe the size of earthquakes was the magnitude scale (the name being inspired by scales used to represent the brightness of stars).^[6]

Local magnitude scale and related scales

The *local magnitude scale* (M_L), also popularly known as the *Richter scale*, is a quantitative logarithmic scale. In the 1930s, California seismologist Charles F. Richter devised a simple numerical scale to describe the relative sizes of earthquakes in Southern California. The name "Richter scale" was coined by journalists and is not generally used by seismologists in technical literature. M_L is obtained by measuring the maximum displacement amplitude of a recording on a Wood–Anderson torsion seismometer (or one calibrated to it) at a distance of up to 600 km from the epicenter of the earthquake.

^[7] Other more recent magnitude measurements include: *body wave magnitude* (m_b), *surface wave magnitude* (M_s), and *duration magnitude* (M_D). Each of these is scaled to give values similar to those given by the local magnitude scale; but because each is based on a measurement of one aspect of the seismogram, they do not always capture the overall power of the source. Specifically, some can be

affected by *saturation* at higher magnitude values—meaning that they systematically underestimate the magnitude of larger events. This problem sets in at around magnitude 6 for local magnitude; surface-wave magnitude saturates above 8. Despite the limitations of older magnitude scales, they are still in wide use, as they can be calculated rapidly, catalogues of them dating back many years are available, they are sufficient for the vast majority of observed events, and the public is familiar with them.

Moment magnitude scale

Because of the limitations of the magnitude scales, a new, more uniformly applicable extension of them, known as *moment magnitude* (M_w) scale for representing the size of earthquakes, was introduced by Thomas C. Hanks and Hiroo Kanamori in 1977. In particular, for very large earthquakes moment magnitude gives the most reliable estimate of earthquake size. This is because seismic moment is derived from the concept of moment in physics and therefore provides clues to the physical size of an earthquake—the size of fault rupture and accompanying slip displacement—as well as the amount of energy released. So while seismic moment, too, is calculated from seismograms, it can also be obtained by working backwards from geologic estimates of the size of the fault rupture and displacement. The values of moments for observed earthquakes range over more than 15 orders of magnitude, and because they are not influenced by variables such as local circumstances, the results obtained make it easy to objectively compare the sizes of different earthquakes.

See also

- Earthquake engineering
- Seismic performance
- Spectral acceleration
- Peak ground acceleration
- Magnitude of completeness

References

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5. "The Severity of an Earthquake". U.S. Geological Survey. Retrieved 2012-01-15.
6. Hough, S.E. (2007). *Richter's scale: measure of an earthquake, measure of a man*. Princeton University Press. p. 121. ISBN 978-0-691-12807-8. Retrieved 10 December 2011.
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External links

- Earthquake Energy Calculator (<http://www.alabamaquake.com/energy.html>) with seismic energy approximated in everyday equivalent measures.

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