**Richter Magnitude Scale**

The **Richter magnitude test scale** (or more correctly **local magnitude** *M*L scale) assigns a single number to quantify the size of an earthquake. It is a base-10 logarithmic scale obtained by calculating the logarithm of the combined horizontal amplitude of the largest displacement from zero on a seismometer output. Measurements have no limits and can be either positive or negative!

**Development**

Developed in 1935 by Charles Richter in collaboration with Beno Gutenberg, both of the California Institute of Technology, the scale was originally intended to be used only in a particular study area in California, and on seismograms recorded on a particular instrument, the Wood-Anderson torsion seismometer. Richter originally reported values to the nearest quarter of a unit, but decimal numbers were used later. His motivation for creating the local magnitude scale was to separate the vastly larger number of smaller earthquakes from the few larger earthquakes observed in California at the time. His inspiration for the technique was the stellar magnitude scale used in astronomy to describe the brightness of stars and other celestial objects. Richter arbitrarily chose a magnitude 0 event to be an earthquake that would show a maximum combined horizontal displacement of 1 micrometer on a seismogram recorded using a Wood-Anderson torsion seismometer 100 km from the earthquake epicenter. This choice was intended to prevent negative magnitudes from being assigned. However, the Richter scale has no upper or lower limit, and sensitive modern seismographs now routinely record quakes with negative magnitudes.

Because of the limitations of the Wood-Anderson torsion seismometer used to develop the scale, the original *M*L cannot be calculated for events larger than about 6.8. Many investigators have proposed extensions to the local magnitude scale, the most popular being the surface wave magnitude *M*S and the body wave magnitude *m*b. These traditional magnitude scales have largely been superseded by the implementation of methods for estimating the seismic moment and its associated moment magnitude scale.

**Richter magnitudes**

Events with magnitudes of about 4.6 or greater are strong enough to be recorded by any seismographs all over the world.

The following describes the typical effects of earthquakes of various magnitudes near the epicenter. This table should be taken with extreme caution, since intensity and thus ground effects depend not only on the magnitude, but also on the distance to the epicenter, and geological conditions (certain terrains can amplify seismic signals).

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| --- | --- | --- | --- |
| **Description** | **Richter Magnitudes** | **Earthquake Effects** | **Frequency of Occurrence** |
| Micro | Less than 2.0 | Microearthquakes, not felt. | About 8,000 per day |
| Very minor | 2.0-2.9 | Generally not felt, but recorded. | About 1,000 per day |
| Minor | 3.0-3.9 | Often felt, but rarely causes damage. | 49,000 per year (est.) |
| Light | 4.0-4.9 | Noticeable shaking of indoor items, rattling noises. Significant damage unlikely. Much like a passing truck | 6,200 per year (est.) |
| Moderate | 5.0-5.9 | Can cause major damage to poorly constructed buildings over small regions. At most slight damage to well-designed buildings. | 800 per year |
| Strong | 6.0-6.9 | Can be destructive in areas up to about 100 miles across in populated areas. | 120 per year |
| Major | 7.0-7.9 | Can cause serious damage over larger areas. | 18 per year |
| Great | 8.0-8.9 | Can cause serious damage in areas several hundred miles across. | 1 per year |
| Rarely, great | 9.0 or greater | Devastating in areas several thousand miles across. | 1 per 20 years |

(*Adapted from U.S. Geological Survey documents.*)

Great earthquakes occur once a year, on average. The largest recorded earthquake was the Great Chilean Earthquake of May 22, 1960 which had a magnitude (MW) of 9.5 (Chile 1960).

The following table needs review. It currently lists the approximate energy equivalents in terms of TNT explosive force.

|  |  |  |
| --- | --- | --- |
| **Richter Approximate Magnitude** | **Approximate TNT for Seismic Energy Yield** | **Example** |
| 0.5 | 5.6 kg (12.4 lb.) | Hand grenade |
| 1.0 | 32 kg (70 lb) | Construction site blast |
| 1.5 | 178 kg (392 lb) | WWII conventional bombs |
| 2.0 | 1 metric ton | late WWII conventional bombs |
| 2.5 | 5.6 metric tons | WWII blockbuster bomb |
| 3.0 | 32 metric tons | Massive Ordnance Air Blast bomb |
| 3.5 | 178 metric tons | Chernobyl nuclear disaster, 1986 |
| 4.0 | 1 kiloton | Small atomic bomb |
| 4.5 | 5.6 kilotons | Average tornado (total energy) |
| 5.0 | 32 kiloton | Nagasaki atomic bomb |
| 5.5 | 178 kilotons | Little Skull Mtn., NV Quake, 1992 |
| 6.0 | 1 megaton | Double Spring Flat, NV Quake, 1994 |
| 6.5 | 5.6 megatons | Northridge quake, 1994 |
| 7.0 | 50 megatons | Tsar Bomba, largest thermonuclear weapon ever tested (magnitude seen on seismographs reduced because detonated 4 km in the atmosphere.) |
| 7.5 | 178 megatons | Landers, CA Quake, 1992 |
| 8.0 | 1 gigaton | San Francisco, CA Quake, 1906 |
| 8.5 | 5.6 gigatons | Anchorage, AK Quake, 1964 |
| 9.2 | 32 gigatons | 2004 Indian Ocean earthquake |
| 10.0 | 1 teraton | estimate for a 20 km rocky bolide impacting at 25 km/s |

**Problems with the Richter scale**

The major problem with Richter magnitude is that it is not easily related to physical characteristics of the earthquake source. Furthermore, there is a saturation effect near 6.3-6.5, owing to the scaling law of earthquake spectra, that causes traditional magnitude methods (such as *M*S) to yield the same magnitude estimate for events that are clearly of different size. By the beginning of the 21st century, most seismologists considered the traditional magnitude scales to be largely obsolete, being replaced by a more physically meaningful measurement called the seismic moment which is more directly relatable to the physical parameters, such as the dimension of the earthquake rupture, and the energy released from the earthquake. In 1979, seismologists Tom Hanks and Hiroo Kanamori, also of the California Institute of Technology, proposed the moment magnitude scale (*M*W), which provides a way of expressing seismic moments in a form that can be approximately related to traditional seismic magnitude measurements.