

# Kelly Kiloton Index of Earthquake Moment Magnitudes

The Richter Earthquake Magnitude Scale, which was perfected by Charles Richter of Cal Tech in 1935, has always been misleading for people who are not used to thinking logarithmically. In this case, it's log-10: every whole position is 10 times greater than the one before. Therefore, if 4.0 is taken to be the equivalent of 10 units, 5.0 is 100.

But according to a new way of measuring earthquakes, based on the seismic "moment of force," translated to the equivalent energy released by an explosion of TNT, the Richter Scale is converted from a log-10 to a 2/3 log-10 scale. In this scale, every positional increase, e.g. Richter 4.0 to 5.0, goes up by a factor of 31.62, which we can round to 32. Thus, R 2.0 corresponds to the detonation of 1 ton of TNT, R 3.0 = 32t, R 4.0 = 1000t, R 5.0 = 32,000t, 6.0 = 1,000,000t, 7.0 = 32,000,000t, and so on. This "Moment Magnitude" is represented by  $M_w$ . The "w", introduced by Hiroo Kanamori in 1977, presumably stands for "work"; it refers to "elastic strain energy." The formula used here is:  $\text{Tonnage} = 10^{(1.5R-3)}$ .

The Kelly Kiloton Index (KKI), formulated in 2006 by H. A. Kelly of UCLA, in consultation with Geoffrey Mess of the UCLA Math Department, aims at giving a "realistic" picture of earthquake energy. It uses the kiloton (= 1000 metric tons = 2,200,000 lbs) as the basic unit. Here is the KKI range for Richter 6.0 to 6.9 and for 7.0 to 7.9:

Richter	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9
KKI	1000	1400	2000	2800	4000	5600	8000	11,000	16,000	22,000

Richter	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9
KKI	32,000	45,000	63,000	90,000	125,000	180,000	250,000	355,000	500,000	710,000

The increase for every 2 positions, say, from R 6.0 to R 8.0, is not x 100, as it would be on a log-10 scale, but x 1000. So, since 6.0 is 1000, 8.0 is KKI 1000 x 1000 = 1,000,000. Similarly, 8.1 is KKI 1400 x 1000 = 1,400,000, and so on. See below for a complete table.

Here is how some past earthquakes register on the Richter Scale and the Kelly Kiloton Index:

Assisi 1997	Richter 5.6	KKI 250
Northridge (LA) aftershock 1994	Richter 5.9	KKI 710
Sylmar (LA) 1971	Richter 6.6	KKI 8000
Northridge (LA) 1994	Richter 6.7	KKI 11,000
Loma Prieta Peak (SF) 1989	Richter 7.1	KKI 45,000
Pakistan 2005	Richter 7.6	KKI 250,000
San Francisco 1906	Richter 8.3	KKI 2,800,000

Sumatra 2004	Richter 9.2	KKI 63,000,000
Chile 1960	Richter 9.5	KKI 180,000,000

So, the Loma Prieta Earthquake (from San Francisco to Santa Cruz) of 1989 was more than 5 times bigger than the Sylmar quake of 1971, and 4 times bigger than the Northridge quake of 1994. But the San Francisco quake of 1906, just over one position larger on the Richter scale, was 62 times bigger than Loma Prieta, and the recent Sumatra quake of 2004, just two Richter positions higher, had 1400 times the energy. It should be clear that small quakes do not do much in the way of defusing or diffusing the pent-up energy that the big ones have in store for us.

### Complete Conversion Table

Richter Scale	Kelly Kiloton Index	
2.0	.001 (1 ton)	
2.5	.0056 (5.6 tons)	
3.0	.032 (32 tons)	
3.5	.180 (180 tons)	
4.0	1 (1000 tons)	
4.1	1.4	
4.2	2	
4.3	2.8	
4.4	4	
4.5	5.6	
4.6	8	
4.7	11	
4.8	16	
4.9	22	
5.0	32	
5.1	45	
5.2	63	
5.3	90	
5.4	125	
5.5	180	
5.6	250	
5.7	355	Assisi 1997
5.8	500	
5.9	710	
		Northridge (LA) Aftershock 1994
6.0	10001400	
6.1	2000	
6.2	2800	
6.3	4000	
6.4	5600	
6.5	8000	
6.6	11,000	Sylmar (LA) 1971
6.7	16,000	Northridge (LA) 1994
6.8	22,000	
6.9		

7.0	32,000	
7.17.2	45,00063,000	Loma Prieta (SF) 1989
7.3	90,000	
7.4	125,000180,000	
7.5	250,000	
7.6	355,000	
7.7	500,000	Pakistan 2005
7.8	710,000	
7.9		
8.0	1,000,000	
8.18.2	1,400,0002,000,000	
8.3	2,800,000	San Francisco 1906
8.4	4,000,000	
8.5	5,600,000	
8.6	8,000,000	
8.7	11,000,000	
8.8	16,000,000	
8.9	22,000,000	
9.0	32,000,000	
9.1	45,000,000	
9.29.3	63,000,000	Sumatra 2004
9.4	90,000,000	
9.5	125,000,000	
9.6	180,000,000	Chile 1960
9.7	250,000,000	
9.8	355,000,000	
9.9	500,000,000	
	710,000,000	
10.0	1,000,000,000	