

Geology 15 Fall 2013
Lecture 13

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- Field Trip(s)
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 - Earthquake Size (Magnitude)

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Earthquake Size (Magnitude)

MAGNITUDE SCALES

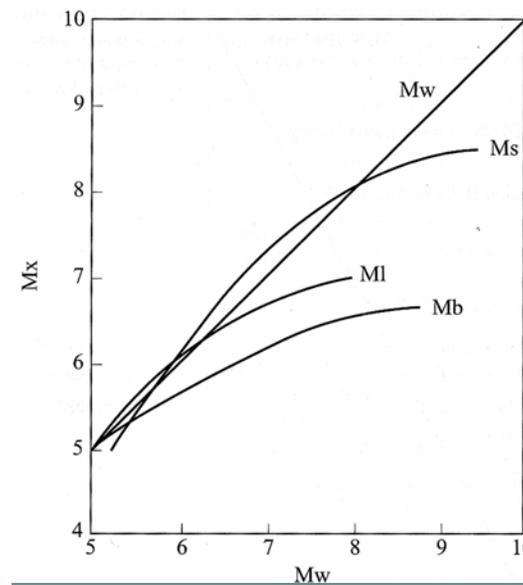
M_L = Local Magnitude scale of Richter uses any wave's amplitude with $T = .1$ to 2 seconds

M_b = body wave magnitude, $T = 1$ to 10 seconds

M_s = Surface wave magnitude, $T = 18$ to 22 seconds

M_d = duration magnitude, usually used for microearthquakes

M_w = Moment magnitude, the best estimate of true energy released where moment is $M_0 = \mu A d$

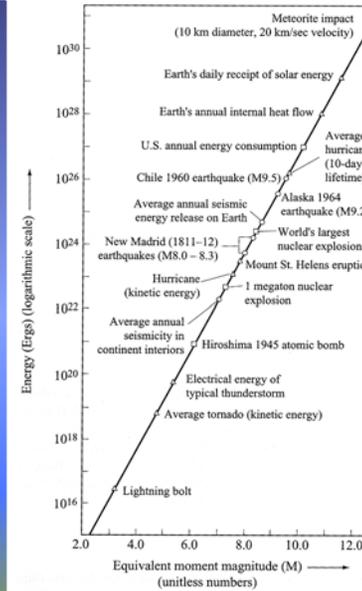


Saturation of the scales with large earthquakes is a problem except for the M_w scale

MAGNITUDE

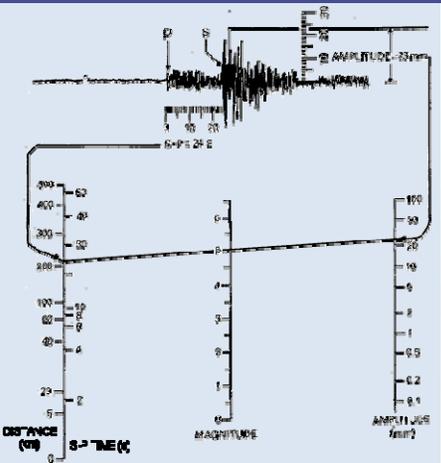
Ms vs Mw

Earthquake	area of fault rupture	duration	Ms	Mw
1906 San Francisco	5,000 square km	40 seconds	8.3	7.8
1960 Chile	100,000 square km	7 minutes	8.5	9.5
1964 Alaska	50,000 square km	5 minutes	8.4	9.2



Richter Magnitude	TNT for Seismic Energy Yield (approximate)	Example (approximate)
-1.5	6 ounces	Breaking a rock on a lab table
1.0	30 pounds	Large Blast at a Construction Site
1.5	320 pounds	Large Quarry or Mine Blast
2.0	1 ton	
2.5	4.6 tons	Small Nuclear Weapon
3.0	29 tons	
3.5	73 tons	Average Tornado (total energy)
4.0	1,000 tons	
4.5	5,100 tons	Little Skull Mtn., NV Quake, 1992
5.0	32,000 tons	
5.5	80,000 tons	Double Spring Flat, NV Quake, 1994
6.0	1 million tons	
6.5	5 million tons	Northridge, CA Quake, 1994
7.0	32 million tons	
7.5	160 million tons	Hyogo-Ken Nambu, Japan Quake, 1995; Largest Thermonuclear Weapon
8.0	1 billion tons	Landers, CA Quake, 1992
8.5	5 billion tons	San Francisco, CA Quake, 1906
9.0	32 billion tons	Anchorage, AK Quake, 1964
10.0	1 trillion tons	Chilean Quake, 1960
12.0	160 trillion tons	(San-Andreas type fault circling Earth) (Fault Earth in half through center, OR Earth's daily receipt of solar energy)

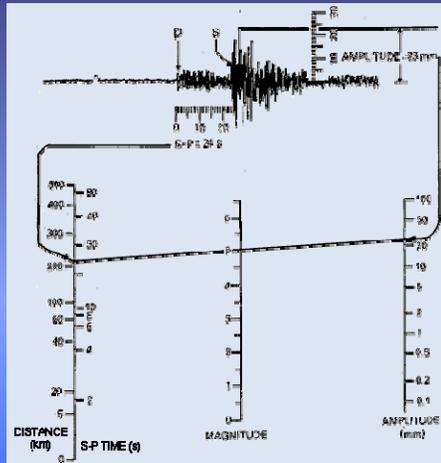
Magnitude	Number of Quakes Per Year	Description
8.5 and up	0.3	Great
8-8.4	1	
7.5-7.9	3	Major
7-7.4	15	
6.6-6.9	56	Strong (Destructive)
6-6.5	210	
5-5.9	800	Moderate (Damaging)
4-4.9	6,200	Light
3-3.9	49,000	Minor
2-2.9	350,000	Very minor
0-1.9	3,000,000	



One of **Dr. Charles F. Richter's** most valuable contributions was to recognize that the **seismic waves** radiated by all earthquakes can provide good estimates of their magnitudes.

He collected the recordings of seismic waves from a large number of earthquakes, and developed a calibrated system of measuring them for magnitude.

<http://crack.seismo.unr.edu/ftp/pub/louie/class/100/magnitude.html>

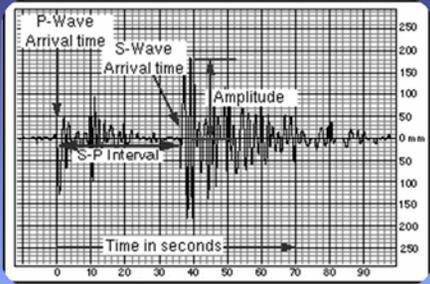


Richter showed that, the larger the intrinsic energy of the earthquake, the larger the **amplitude** of ground motion at a given distance. He calibrated his scale of magnitudes using measured maximum amplitudes of shear waves on seismometers particularly sensitive to shear waves with periods of about one second.

A **nomogram** is a 2-D graphical calculating device, designed to allow the approximate graphical calculation of a function.

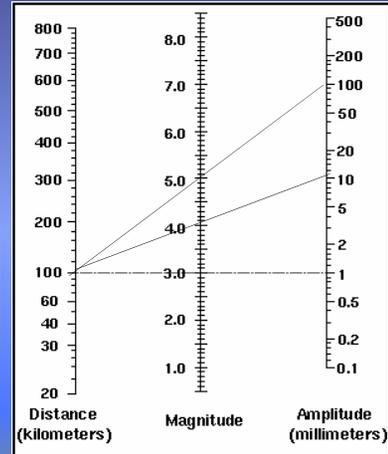
$$M_L = \log_{10}A(mm) + (\text{Distance correction factor})$$

<http://crack.seismo.unr.edu/ftp/pub/louie/class/100/magnitude.html>



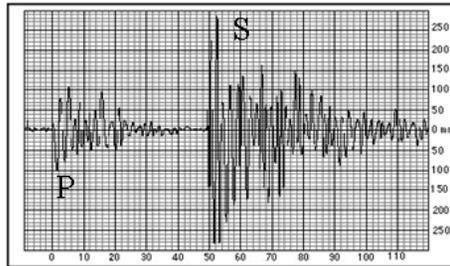
Amplitude is measured in millimeters (mm) from the center of the seismic record to the maximum on the trace.

In this case the amplitude is 180 mm



Note that an earthquake of magnitude 4 on the Richter scale at 100 km distance would have an amplitude of 10 mm, whereas one of magnitude 5 at the same 100 km distance would have an amplitude of 100 mm.

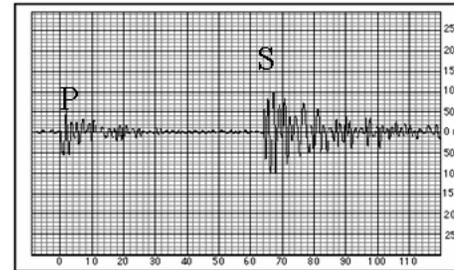
A Real Example - Loma Prieta (1989)



Eureka, CA

S - P = 49 seconds Distance = 480 km

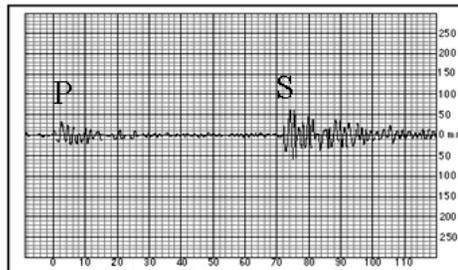
Amplitude = 280 mm



Las Vegas, NV

S - P = 64 seconds Distance = 600 km

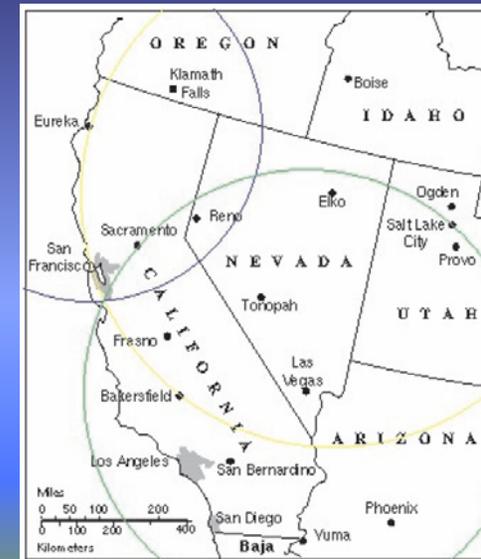
Amplitude = 100 mm

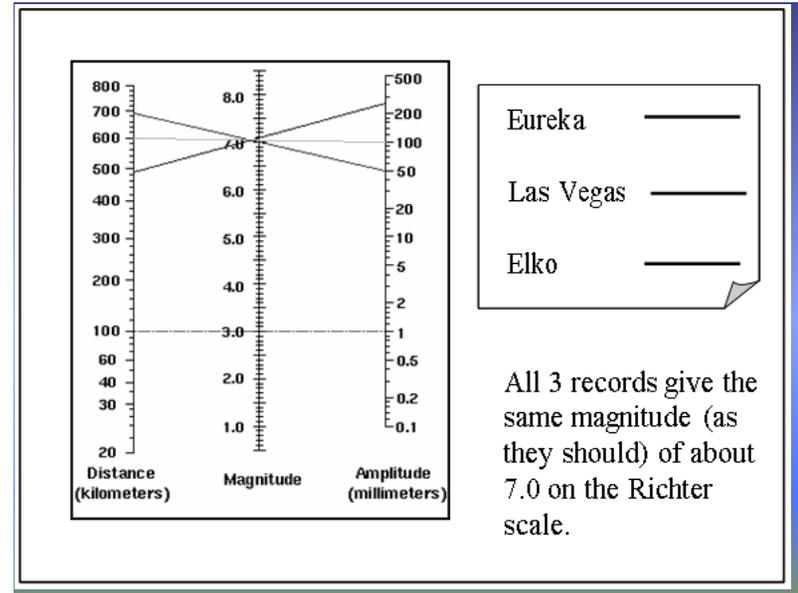
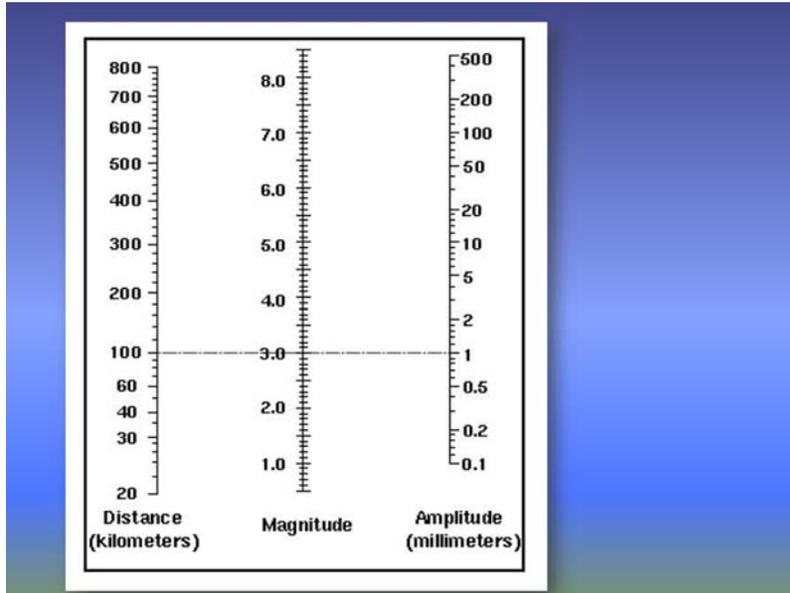


Elko, NV

S - P = 72 seconds Distance = 690 km

Amplitude = 60 mm





Estimate the max. amplitude for the S-wave (write the value below each seismogram). The distances from the stations to the epicenter are shown in the box above the nomogram.

Remember, where the three lines cross is the estimated M_s .
 Write your estimate in the space at lower right. For full credit you should be $M_s 0.2$

Distance from Epicenter	
Station A	605km
Station B	405 km
Station C	585 km

A max S-wave amplitude _____ mm

B max S-wave amplitude _____ mm

C max S-wave amplitude _____ mm

Estimated M_s _____