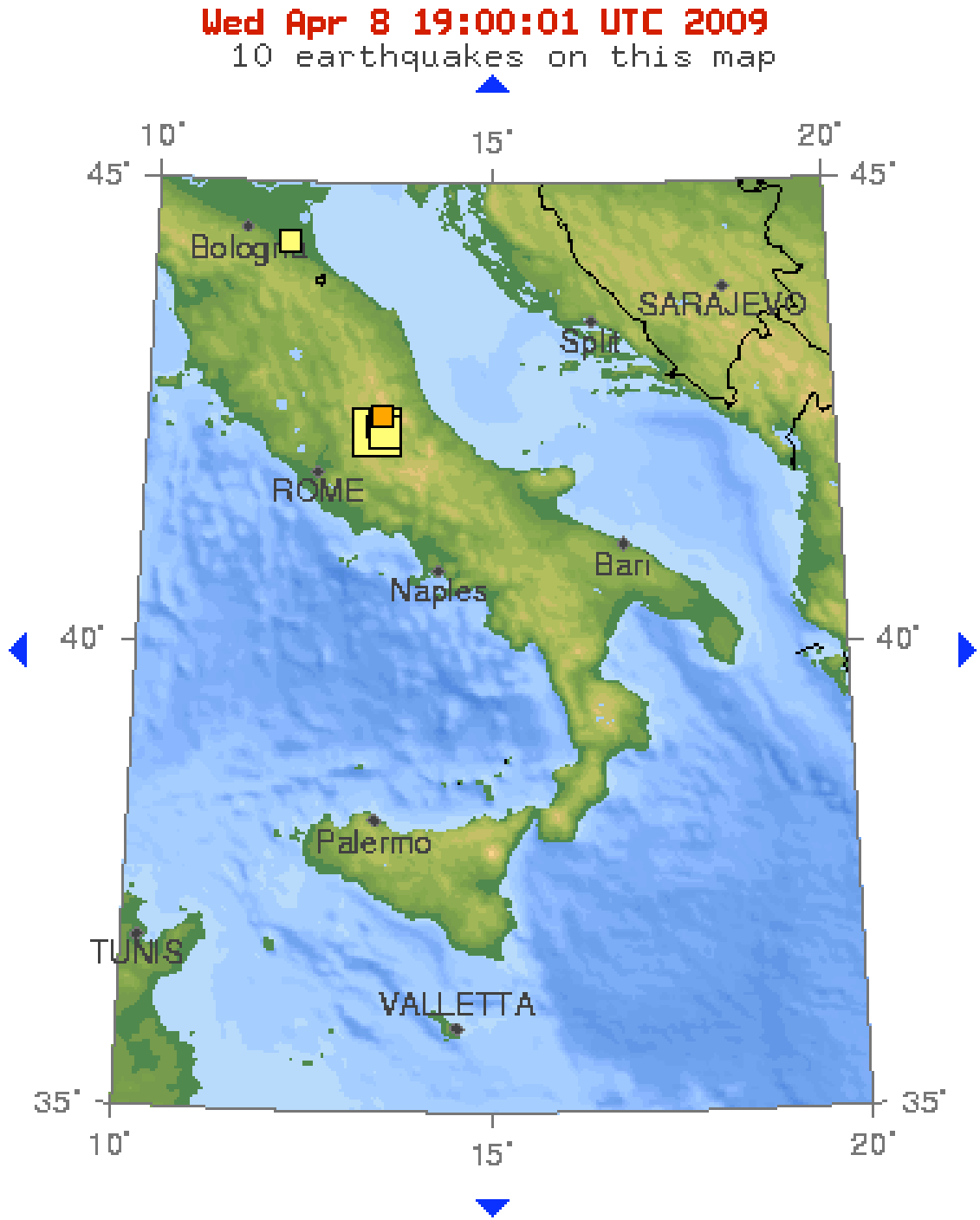
Magnitude 6.3 - Central Italy

> at least 227 killed

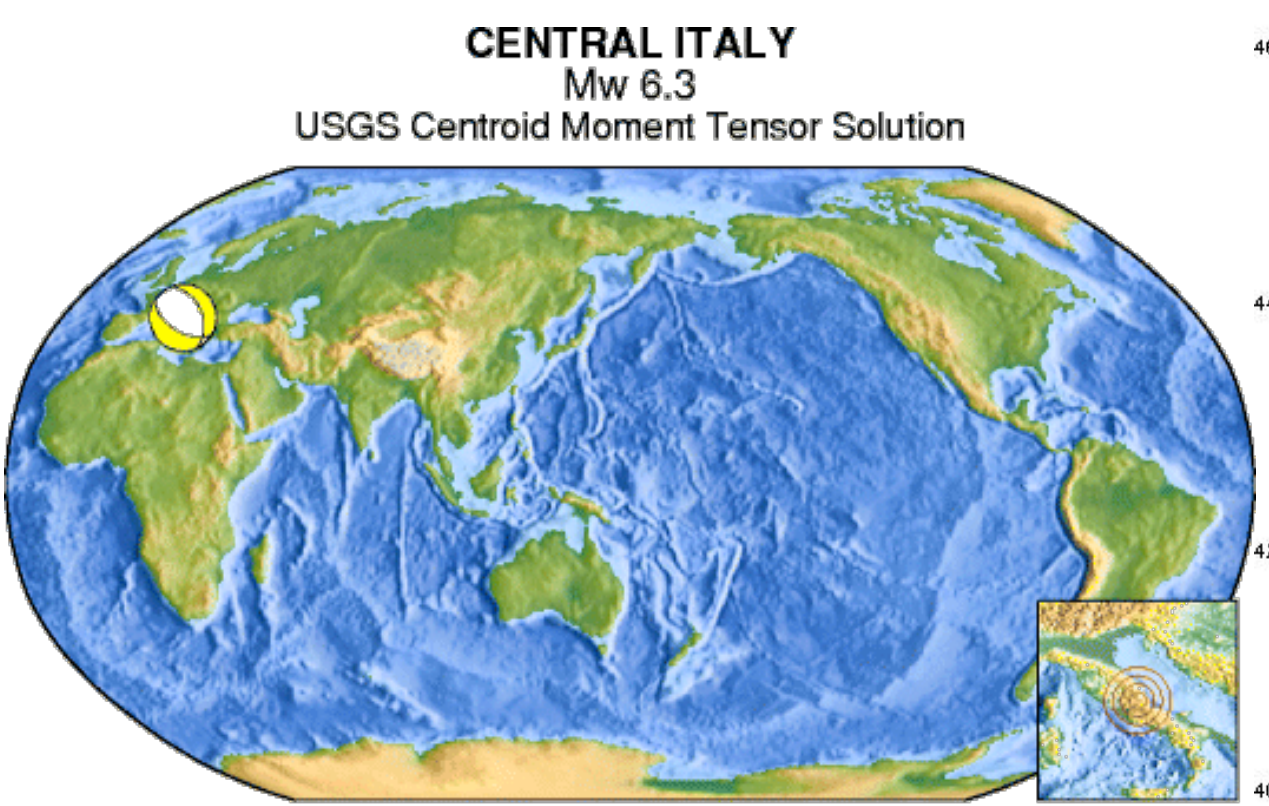
> 1000 injured, 10000 bldgs destroyed or damaged

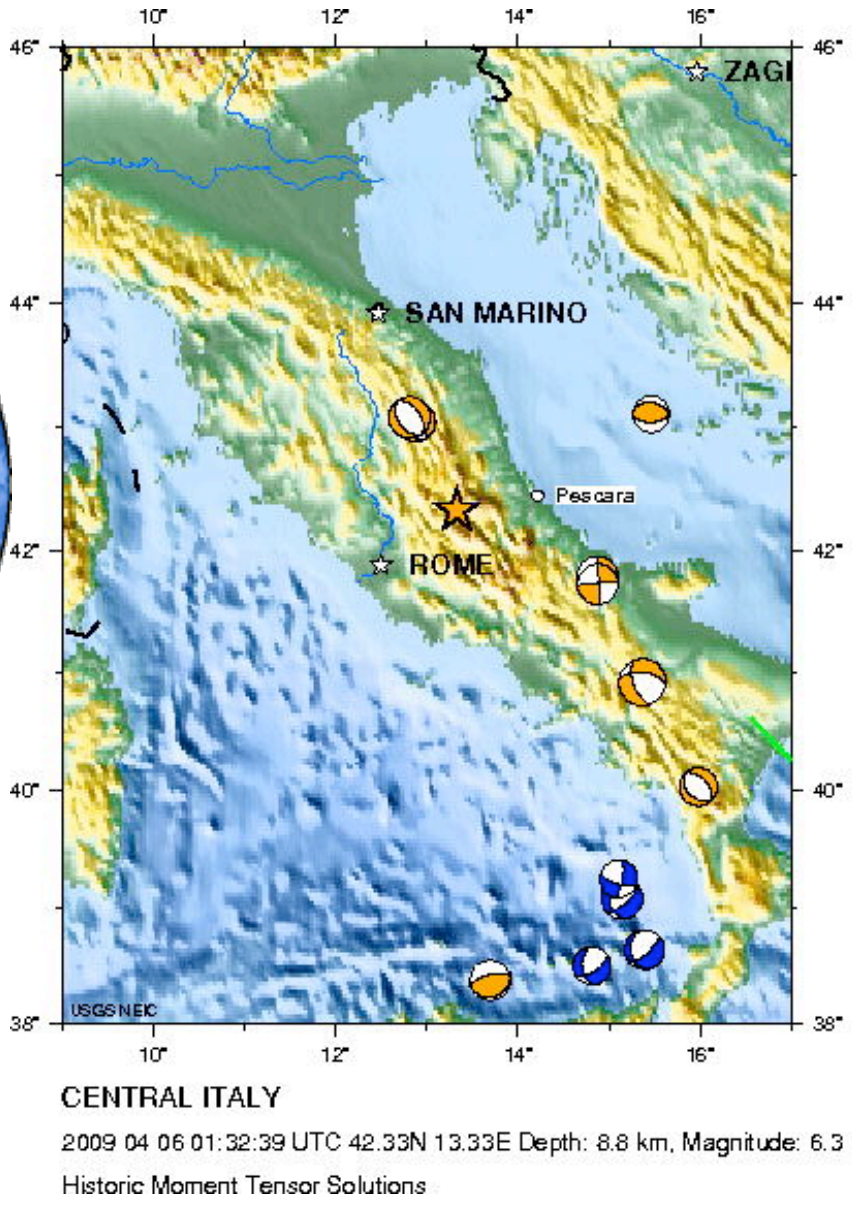
> occurred in central Appenines, a mountain range formed as a large accretionary wedge

> Mediterranean highly complex due to interactions of numerous microplates



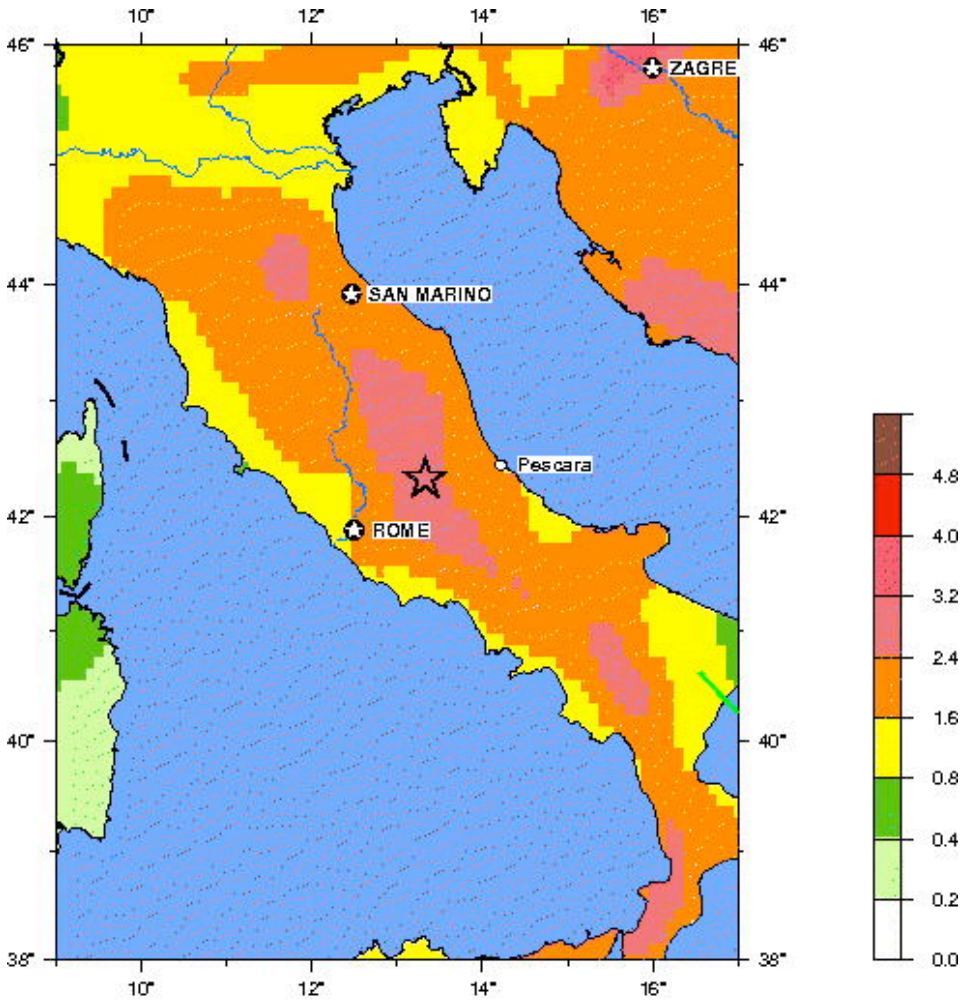
FOCAL MECHANISM AND HISTORIC SEISMICITY





> What kind of fault did it occur on?

EQ HAZARD MAP

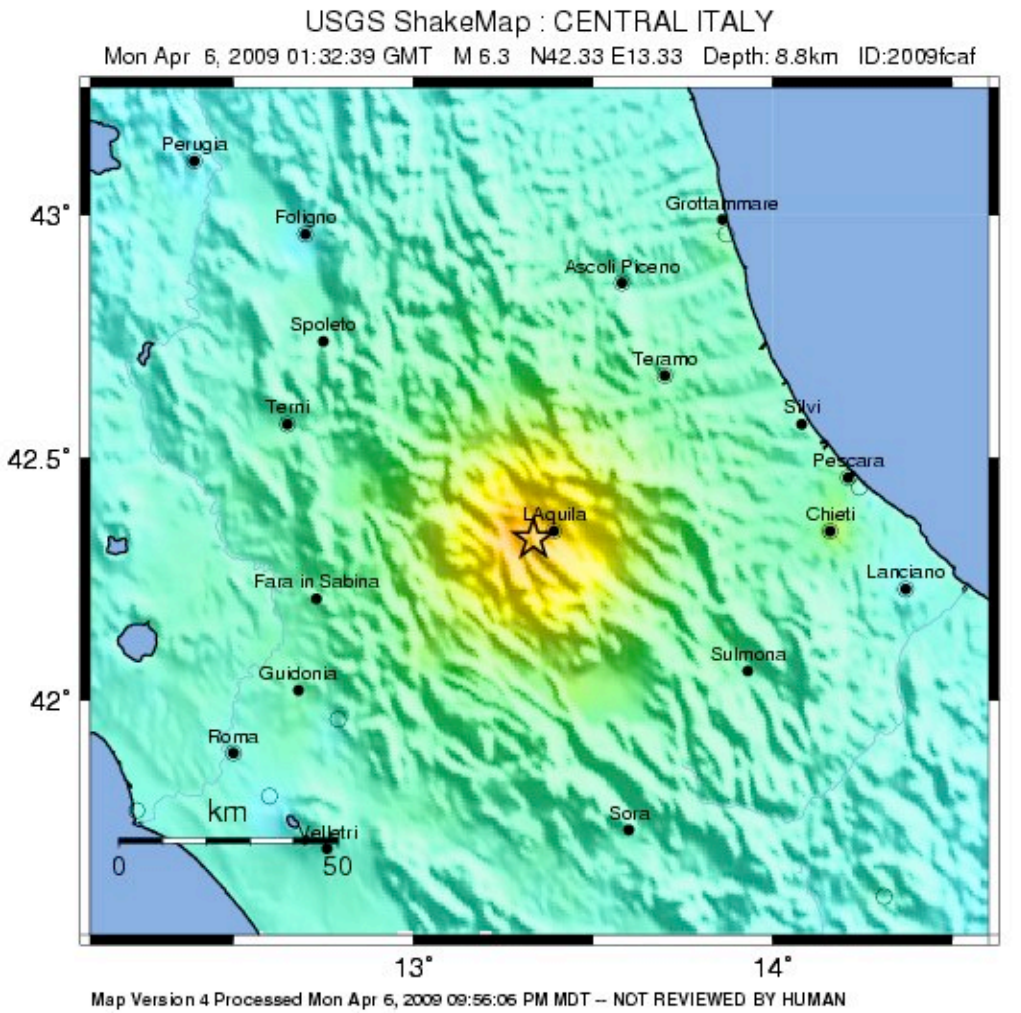


CENTRAL ITALY

2009 04 06 01:32:39 UTC 42.33N 13.33E Depth: 8.8 km, Magnitude: 6.3

Peak Ground Acceleration (m/s^2) with 10% Probability of Exceedance in 50 Years

SHAKE MAP (PGA)



Map Version 4 Processed Mon Apr 6, 2009 09:56:06 PM MDT -- NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Earthquake Hazards Program

Magnitude 6.3 - CENTRAL ITALY

2009 April 06 01:32:39 UTC

Versión en Español

Details | Summary | Maps | Scientific & Technical | Additional Info | Where can I find...?

Earthquake Details

Magnitude	**6.3**
Date-Time	**Monday, April 06, 2009 at 01:32:39 UTC** Monday, April 06, 2009 at 03:32:39 AM at epicenter Time of Earthquake in other Time Zones
Location	42.334°N, 13.334°E
Depth	8.8 km (5.5 miles) set by location program
Region	CENTRAL ITALY
Distances	75 km (45 miles) W of **Pescara, Italy** 85 km (55 miles) NE of **ROME, Italy** 115 km (75 miles) SE of **Perugia, Italy** 145 km (90 miles) S of **Ancona, Italy**
Location Uncertainty	Error estimate not available
Parameters	NST=321, Nph=321, Dmin=6 km, Rmss=0 sec, Gp= 14°, M-type=teleseismic moment magnitude (Mw), Version=A
Source	Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy
Event ID	us2009fcaf

This event has been reviewed by a seismologist.

Did you feel it? Report shaking and damage at your location. You can also view a map displaying accumulated data from your report and others.

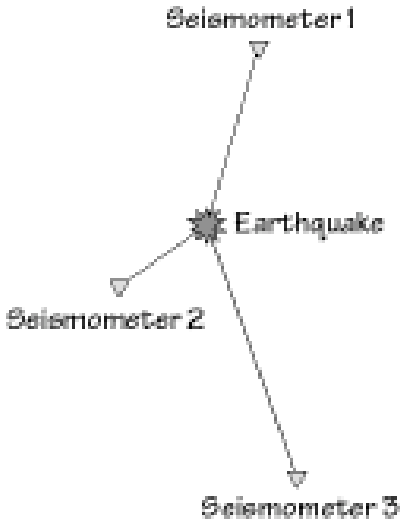
EARTHQUAKE SIZE

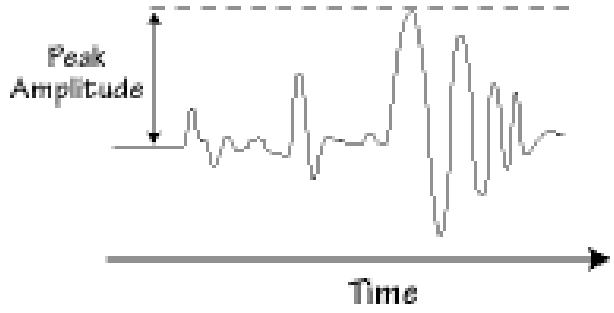
How do we measure the size of an earthquake?

What other factors influence amplitude of signals on seismograms?

DEVELOPMENT OF MAGNITUDE SCALE

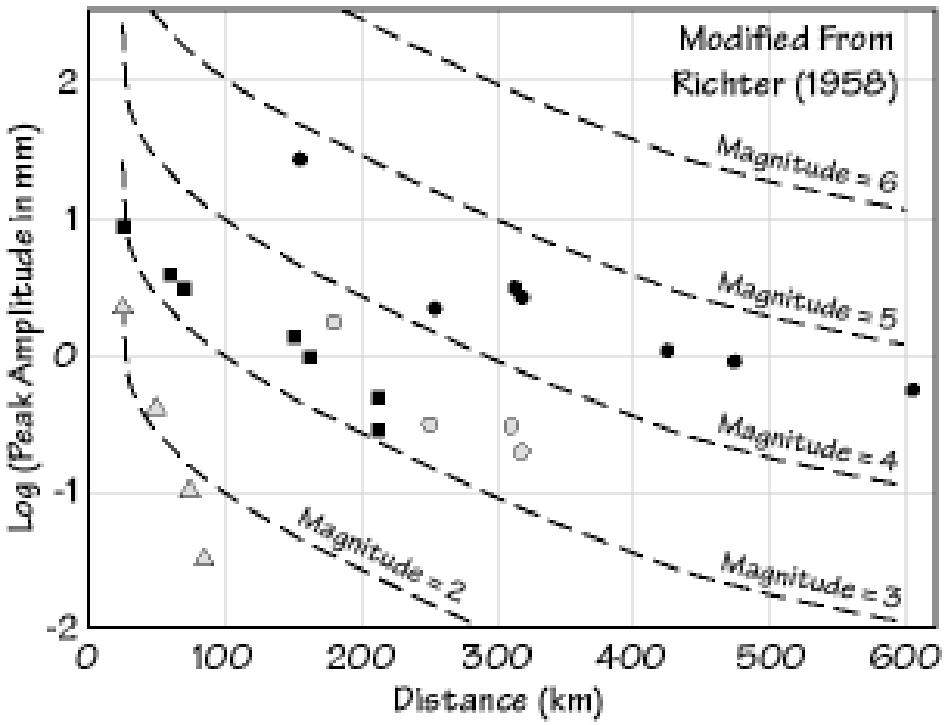
> expect signal amplitude to vary with distance to epicenter





> seismologists K Wadati and C Richter both noticed that peak ground motion of quakes varied with distance

> proposed magnitude scale through analogy with stellar brightness scale (similar to pH scale)



CONCEPT OF MAGNITUDE

> first measure of size was termed "magnitude"

> magnitude scales have form:

$$M = \log(A/T) + F(h, \Delta) + C$$

A : signal amplitude

T : dominant period

$F(h, \Delta)$: correction for quake depth & distance

C : regional scale factor

> logarithmic: unit increase equivalent to 10-fold increase in signal amplitude; necessary since earth motions span a range of 10^{10}

HISTORY OF MAGNITUDES

> first devised by Charles Richter in 1935 for S California: ``Richter Scale" or ``local" magnitude

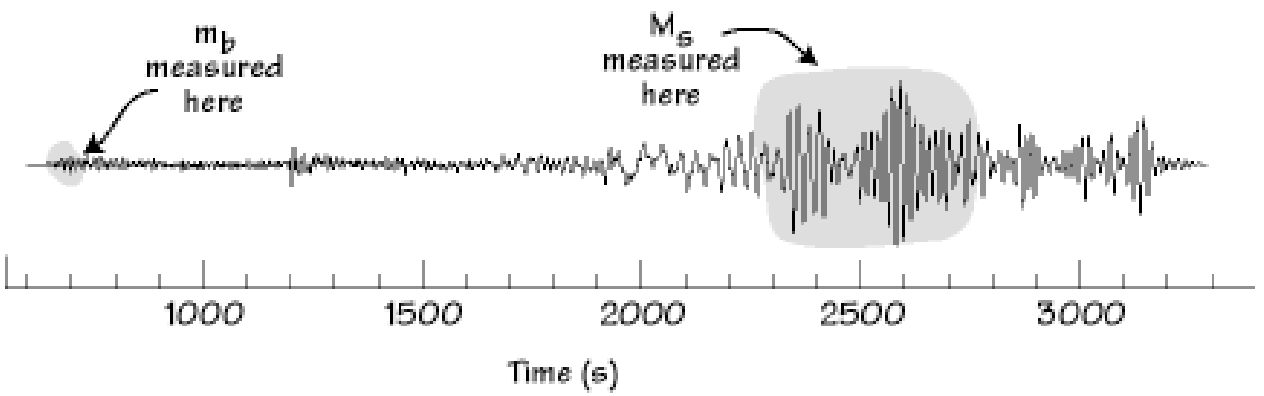
$$M_L = \log A + 2.76 \log \Delta - 2.48$$

> valid for Wood-Anderson seismograph (resonant frequency = 0.8 Hz) and uses S-wave amplitude

> sometimes still reported since good indicator of structural damage

> later modifications include global body wave and surface wave scales:

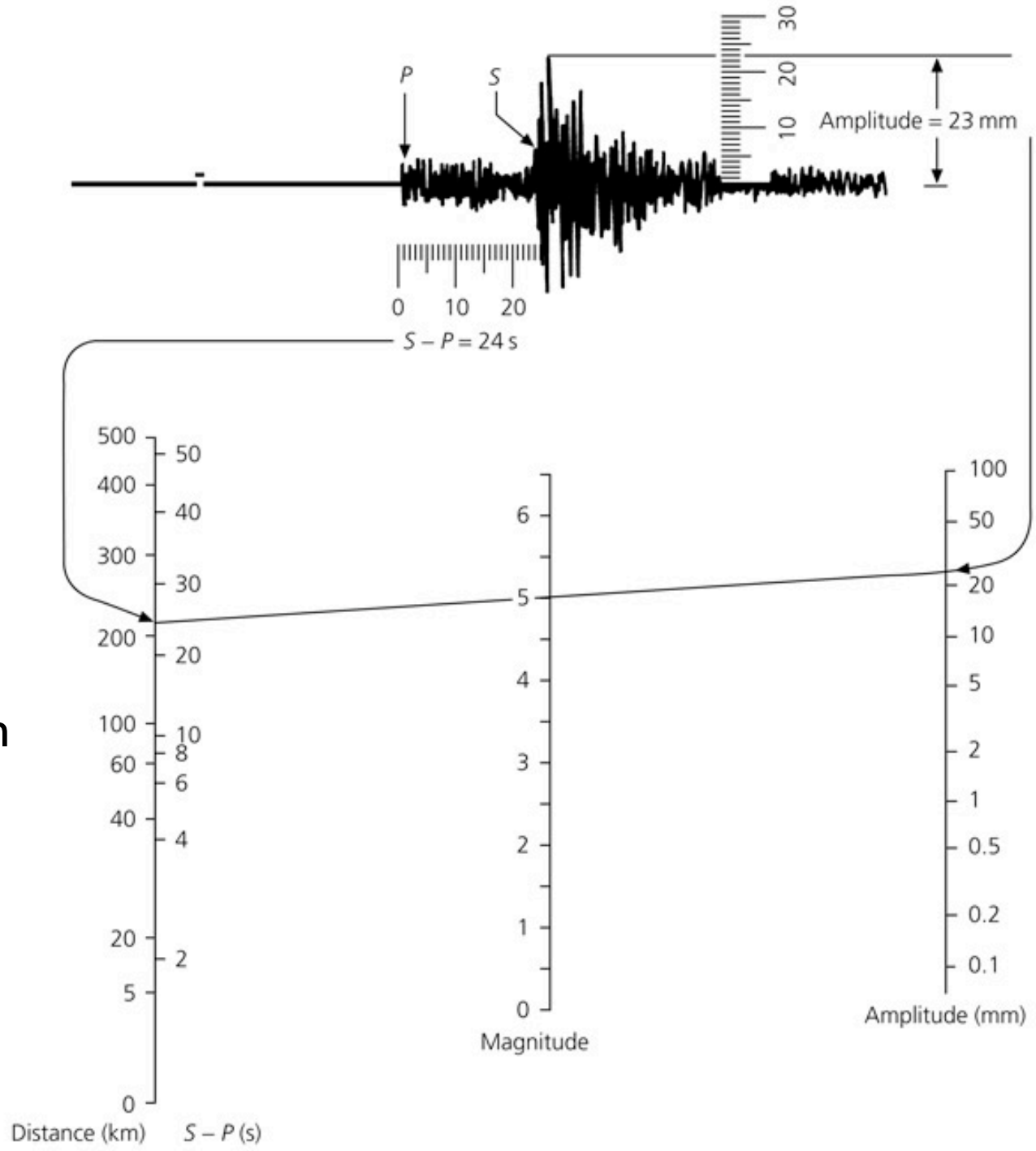
$$m_b = \log(A/T) + Q(h, \Delta) \qquad M_s = \log(A/T) + 1.6 \log \Delta + 3.3$$



RICHTER SCALE FOR LOCAL MAGNITUDE

> magnitude found from amplitude of largest arrival and the S-P travel time difference

> in example, maximum amplitude is 23mm and S-P time is 24 s, yielding an ML of 5.0



MAGNITUDES AS MEASURES OF EARTHQUAKE SIZE

ADVANTAGES:

1. directly measured from seismograms; no sophisticated signal processing required

2. yield units of order 1, providing intuitively attractive scale: M=5, moderate; M=6, strong, M=7, major, M=8, great etc.

LIMITATIONS:

1. entirely empirical, not physically based (dimensions don't match)

2. magnitudes often discrepant between scales

3. magnitude scales saturate

MAGNITUDE DISCREPANCIES

Earthquake	Body wave magnitude m_b	Surface wave magnitude M_s	Fault area (km^2) length × width	Average dislocation (m)	Moment (dyn-cm) M_0	Moment magnitude M_w
Truckee, 1966	5.4	5.9	10×10	0.3	8.3×10^{24}	5.8
San Fernando, 1971	6.2	6.6	20×14	1.4	1.2×10^{26}	6.7
Loma Prieta, 1989	6.2	7.1	40×15	1.7	3.0×10^{26}	6.9
San Francisco, 1906		8.2	320×15	4	6.0×10^{27}	7.8
Alaska, 1964	6.2	8.4	500×300	7	5.2×10^{29}	9.1
Chile, 1960		8.3	800×200	21	2.4×10^{30}	9.5

> note discrepant body-wave and surface wave magnitudes (due to empirical nature, no account for radiation pattern, fault dimensions and locations can vary along fault etc).

> body-wave magnitudes saturate at ~6.2, surface wave magnitudes at ~8.4

THE SEISMIC MOMENT

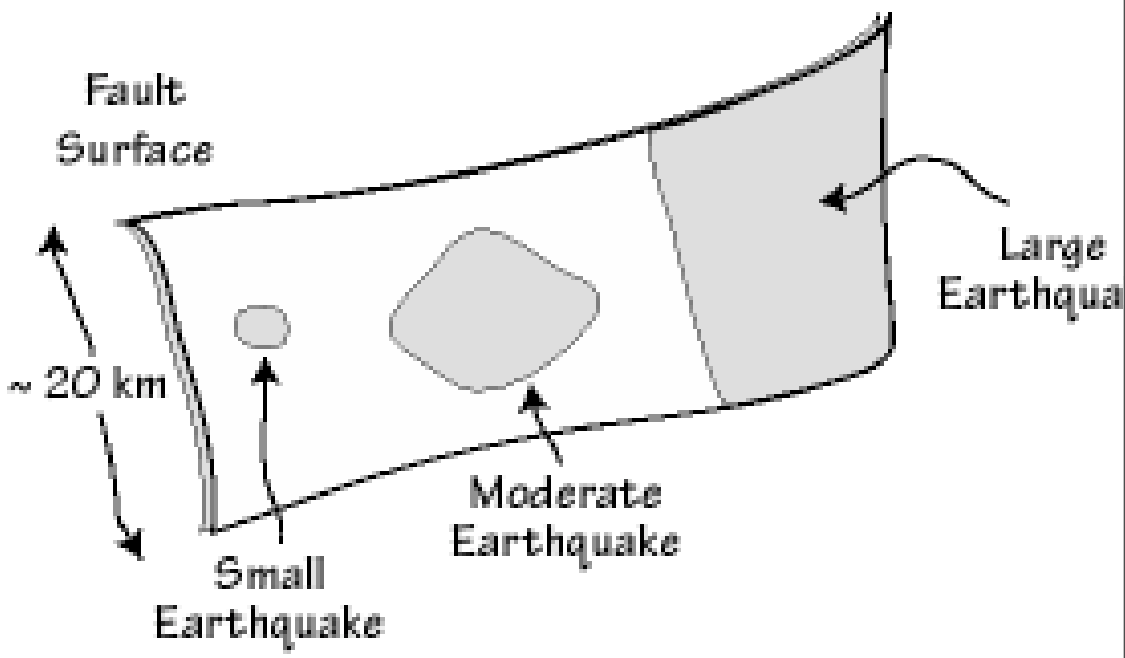
> a physically based measure of earthquake size/energy (units?)

$$M_0 = \mu D S$$

μ : rigidity (shear modulus) of fault materials

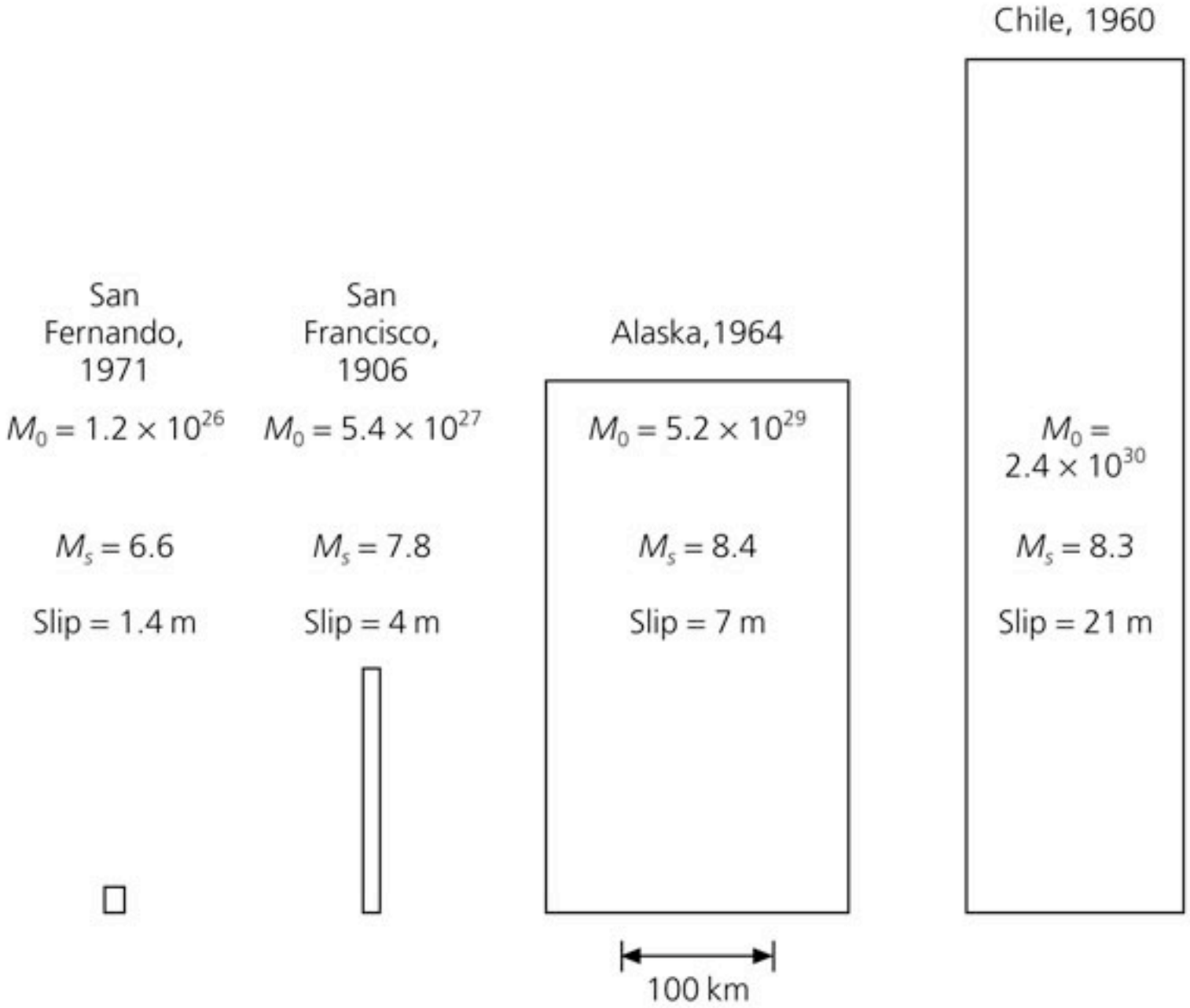
D : slip as function of time

S : fault area



> latter terms are time-dependent since they can vary during an earthquake but we approximate as constant

RELATIVE AREAS, SLIP MOMENTS OF SOME EARTHQUAKES



THE MOMENT MAGNITUDE

> moment estimated through sophisticated modelling of seismograms to estimate D, S

> define moment magnitude as:

$$M_w = \frac{\log M_0}{1.5} - 10.73$$

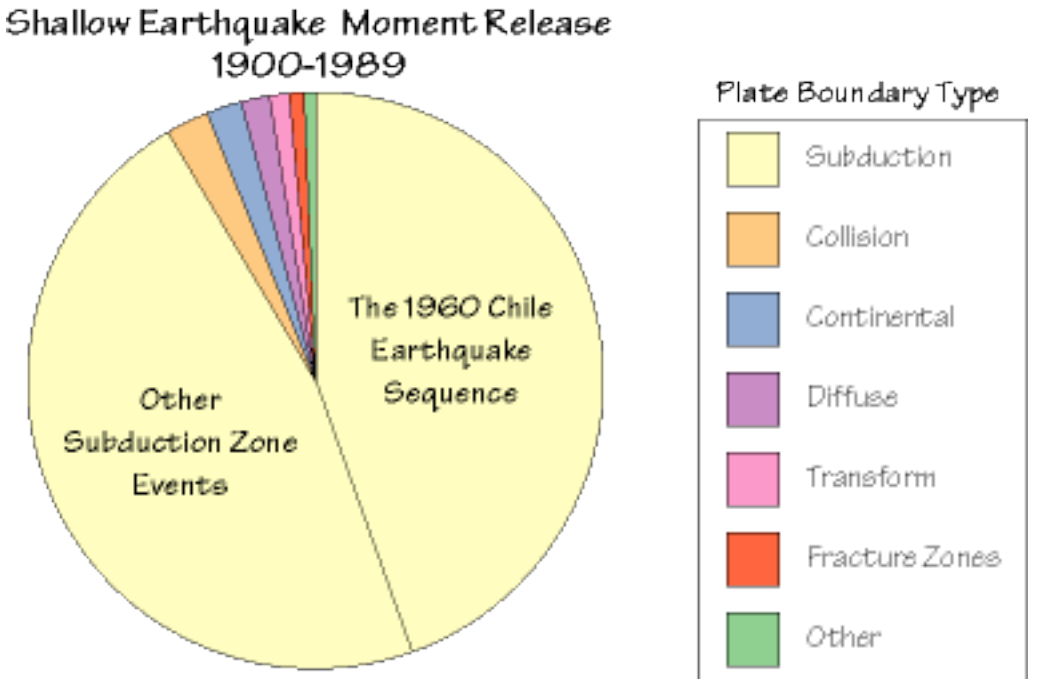
> physically based with terms 1.5, 10.73 chosen to achieve good agreement with m_b, M_s

> doesn't saturate

> largest earthquakes bounded to $M_w < 10$

ENERGY RELEASE

> seismic moment and moment magnitude allow us to compare size of largest earthquakes



> find that energy release for earthquakes of last century is dominated by a few large subduction earthquakes