Hot Science Cool Talks

UT Environmental Science Institute

6

When the Earth Quakes

Dr. Randall Marrett

August 25, 2000

QUAKE

Serving the San Fernando and Neighboring Valleys

Daily News SPECIAL

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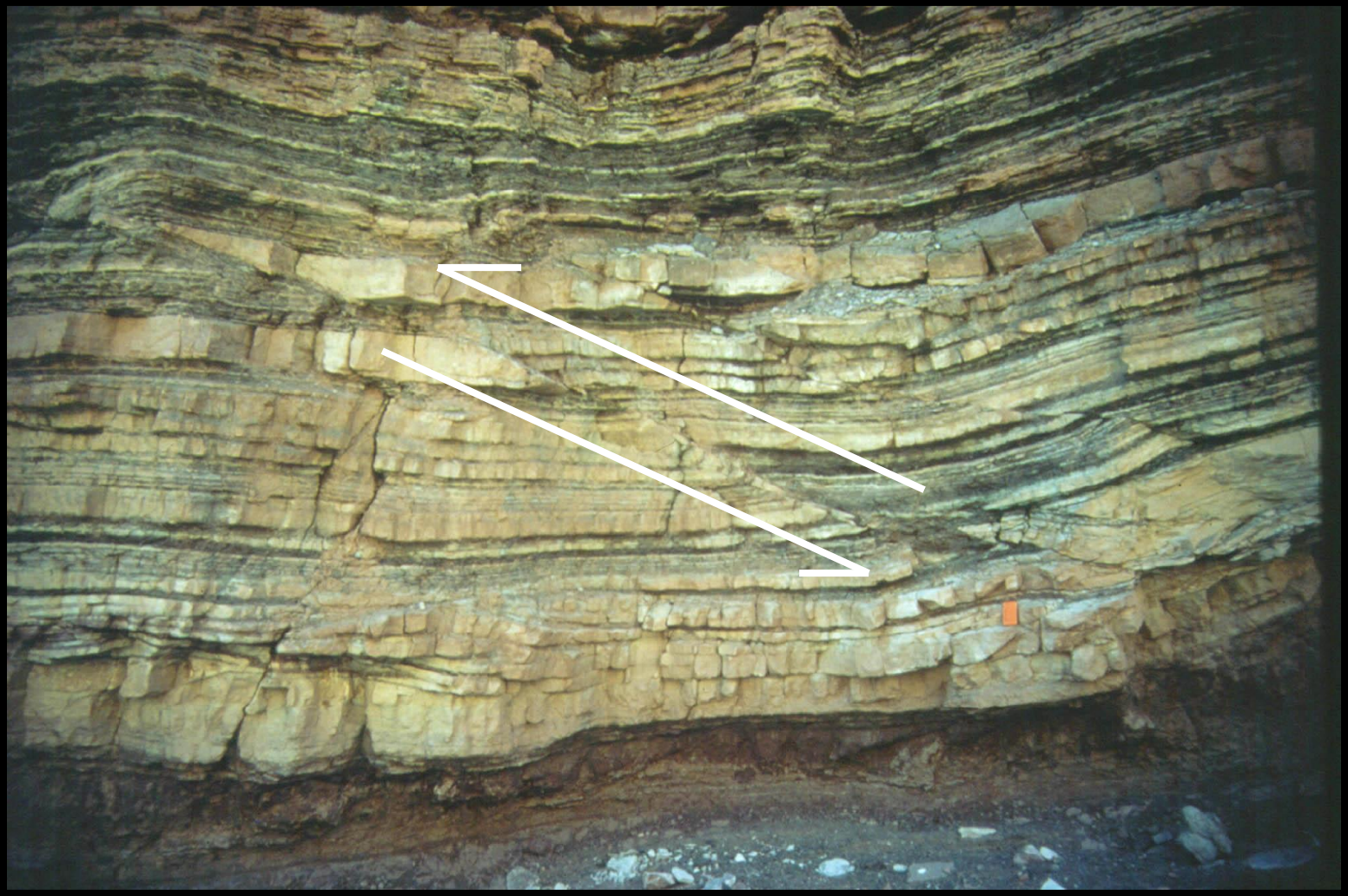
TUESDAY, JANUARY 18, 1994

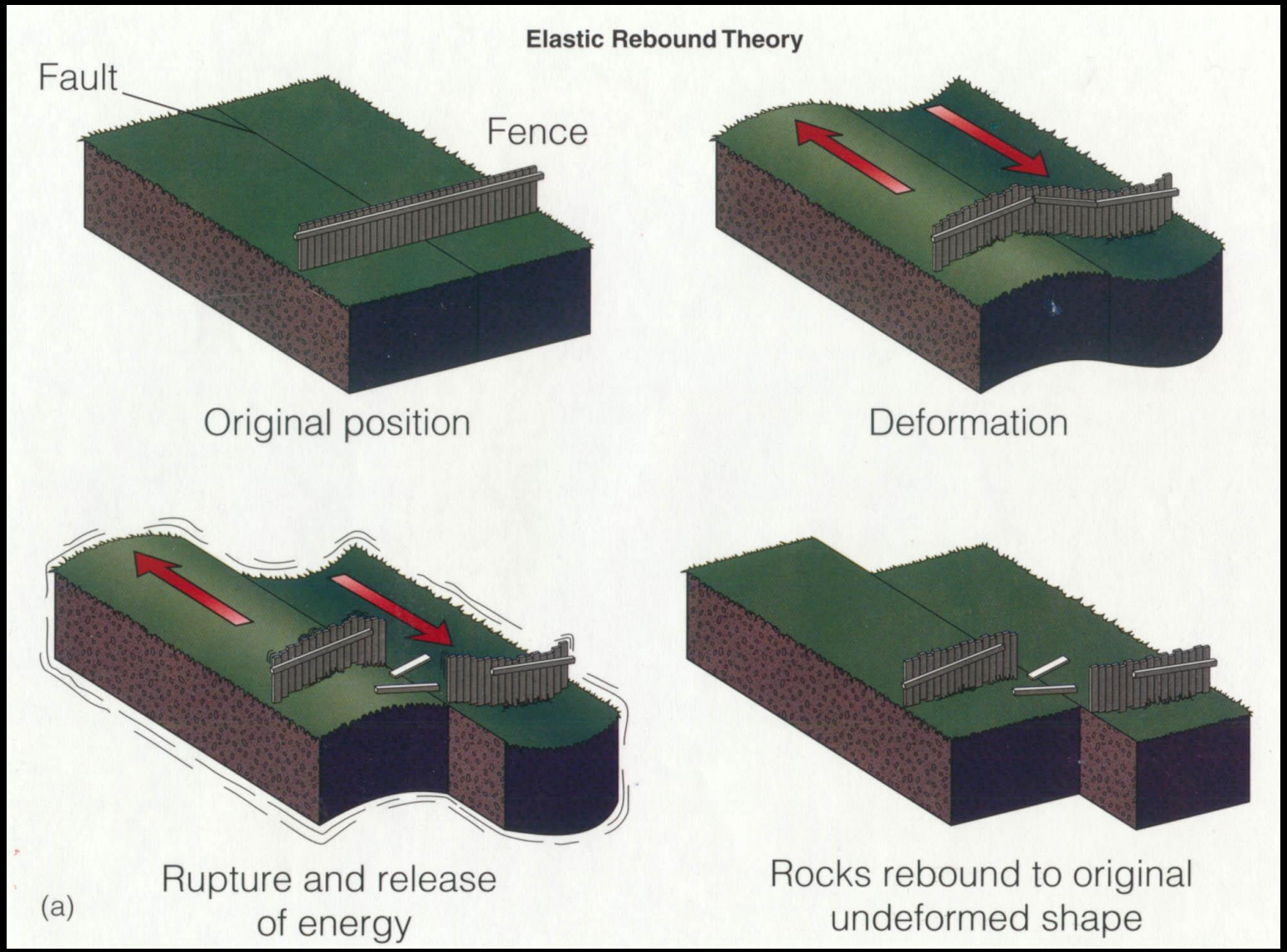
25 CENTS
DESIGNATED AREAS HIGHER

6.6 temblor cripples Southland; 24 killed

Earthquakes and Faults

- An ***earthquake*** is vibration of the Earth due to a sudden release of natural energy, usually as a result of slip along a fault.
- A ***fault*** is a surface within the Earth along which rocks on opposite sides have slid.
- A ***fault scarp*** is a step in the Earth's surface due to being displaced by fault movement.




Elastic Rebound Theory
Fault
Fence
Original position
Deformation
Rupture and release of energy
Rocks rebound to original undeformed shape
(a)

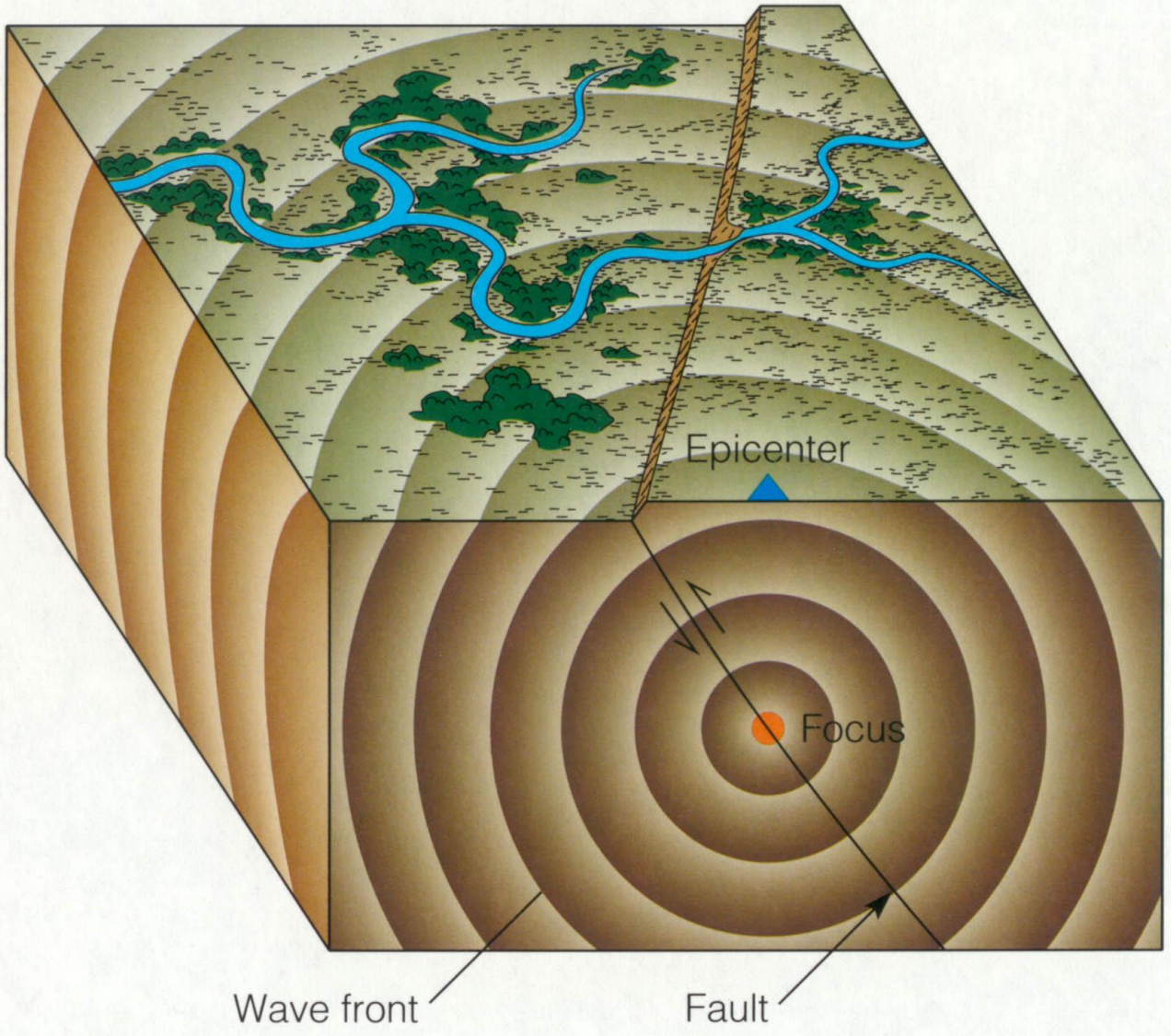
Movie for Mac
Click once, with cursor on image,
to activate movie.

Movie for PC
Double click here

A warning comes up about viruses
Just click OK.

The movie called: 2cycles_snap.mov, does not play in Adobe Acrobat.
2cycles_snap.mov can be found in the images directory.

Focus and Epicenter of an Earthquake



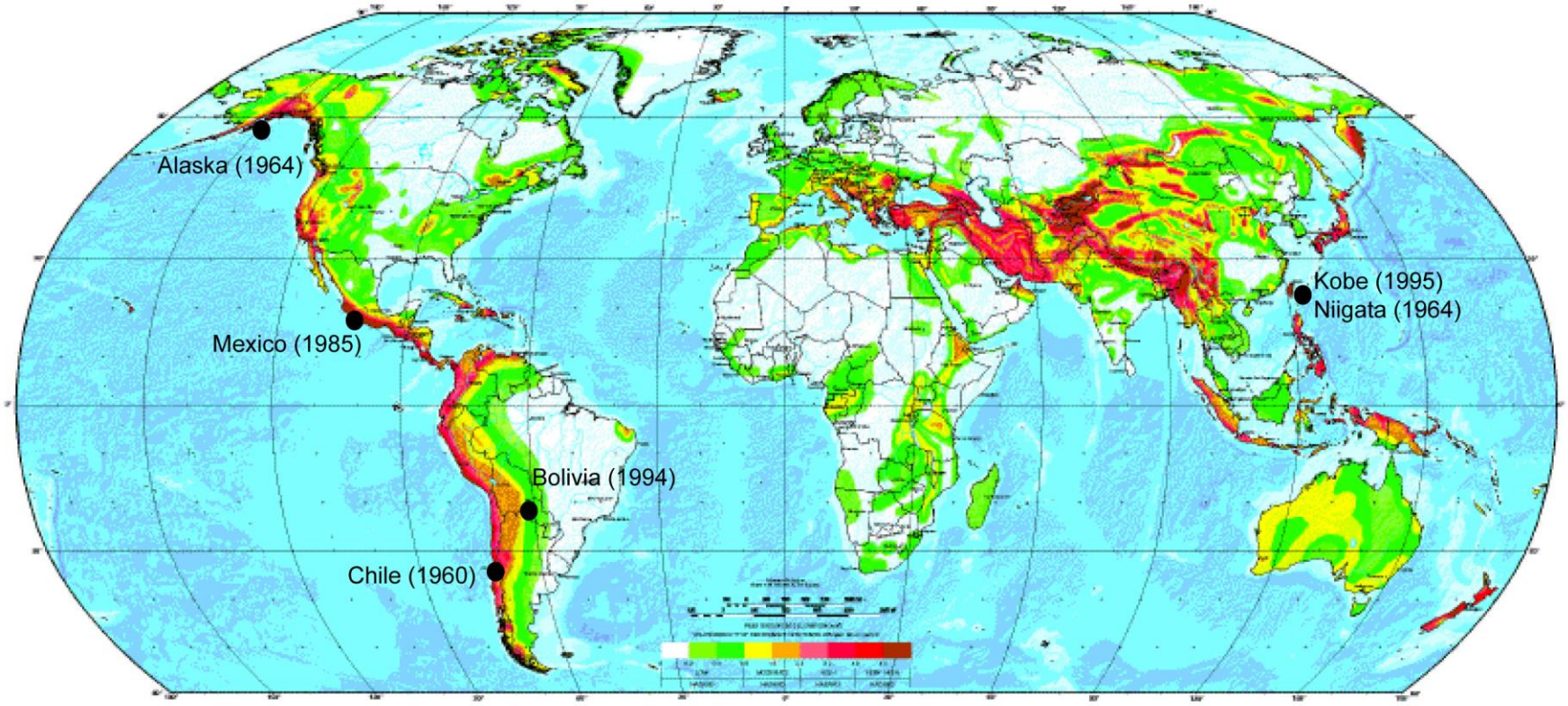
Logarithmic Magnitude Scale

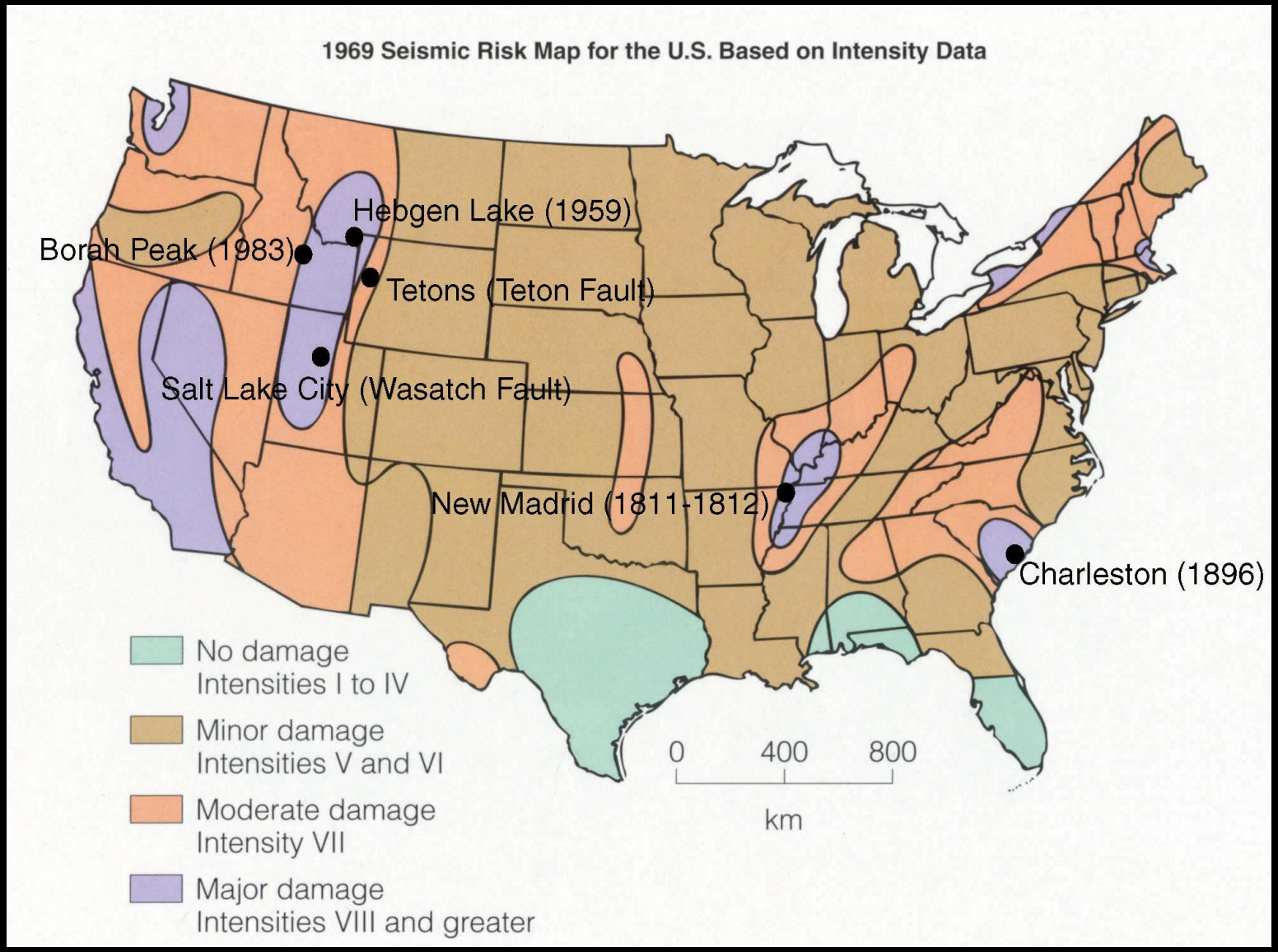
Magnitude	Shaking Amplitude	Energy Release
8	10,000x	300,000 kilotons TNT (600,000,000,000 pounds)
7	1,000x	10,000 kilotons TNT (largest nuclear test done)
6	100x	300 kilotons TNT
5	10x	10 kilotons TNT (Hiroshima nuclear bomb)
4	reference	0.3 kilotons TNT

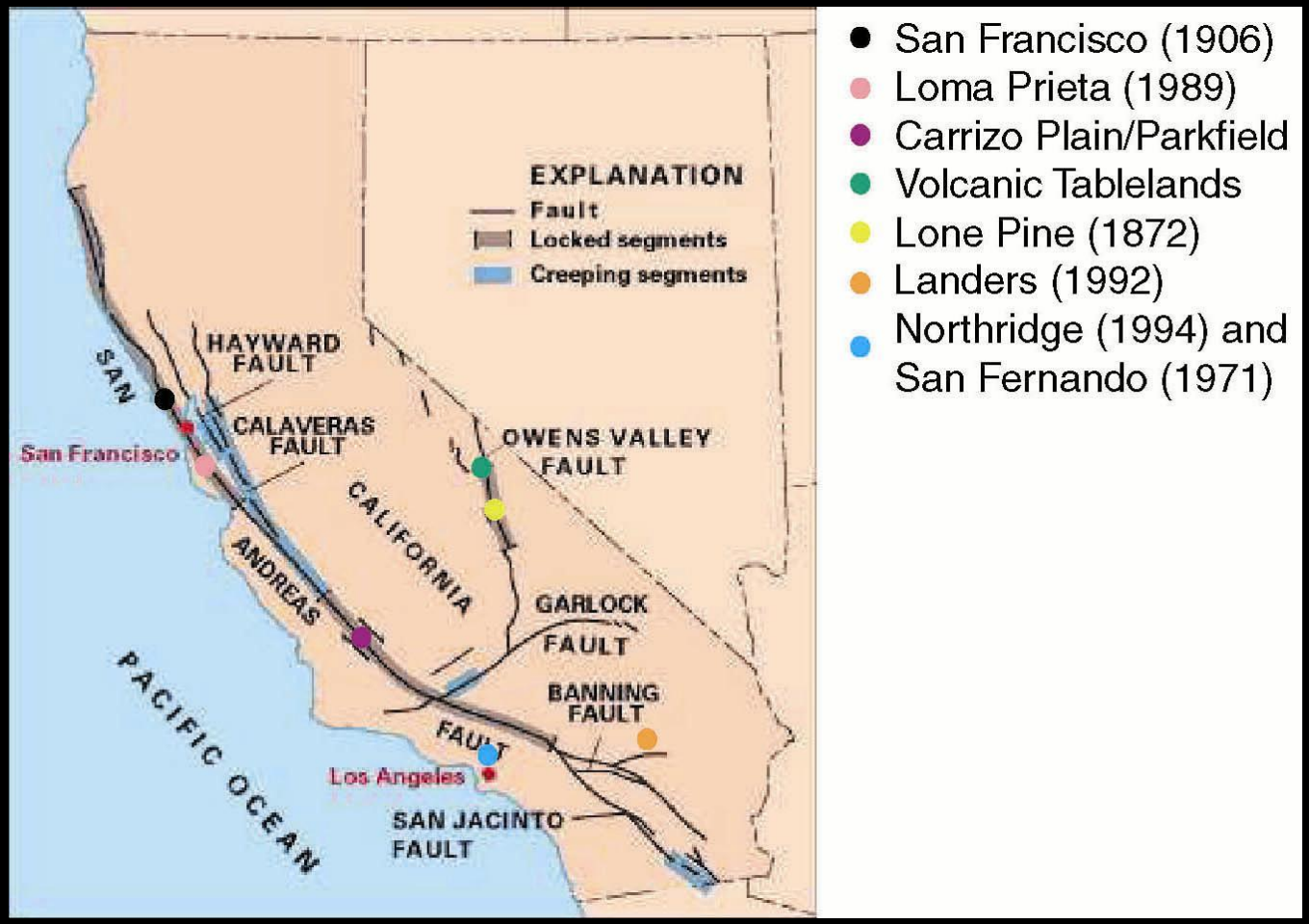
Recurrence Intervals of Earthquakes in California

Magnitude	Recurrence Interval	Earthquakes per Century
8	100 years	1
7	10 years	10
6	1 year	100
5	1 month	1,000
4	4 days	10,000

GLOBAL SEISMIC HAZARD MAP

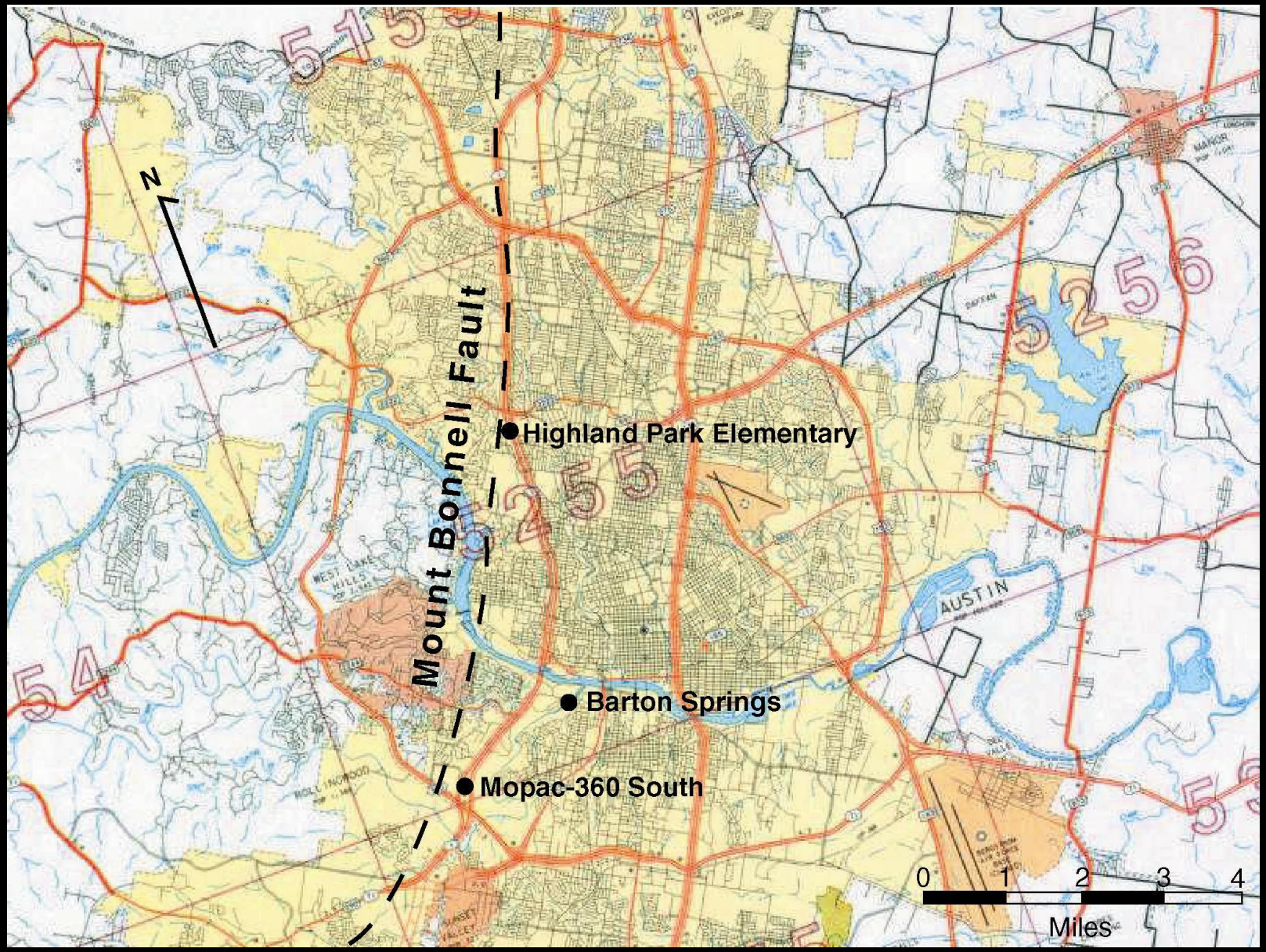



1969 Seismic Risk Map for the U.S. Based on Intensity Data
Hebgen Lake (1959)
Borah Peak (1983)
Tetons (Teton Fault)
Salt Lake City (Wasatch Fault)
New Madrid (1811-1812)
Charleston (1896)
No damage
Intensities I to IV
Minor damage
Intensities V and VI
Moderate damage
Intensity VII
Major damage
Intensities VIII and greater
0
400
800
km


EXPLANATION
Fault
Locked segments
Creeping segments
HAYWARD FAULT
SAN
CALAVERAS FAULT
San Francisco
OWENS VALLEY FAULT
CALIFORNIA
ANDREAS
GARLOCK FAULT
BANNING FAULT
FAULT
PACIFIC OCEAN
Los Angeles
SAN JACINTO FAULT
San Francisco (1906)
Loma Prieta (1989)
Carrizo Plain/Parkfield
Volcanic Tablelands
Lone Pine (1872)
Landers (1992)
Northridge (1994) and San Fernando (1971)


15 CM


moraine
moraine


N
Mount Bonnell Fault
Highland Park Elementary
Barton Springs
Mopac-360 South
AUSTIN
0
1
2
3
4
Miles


CAUTION
THE POOL BOTTOM IS A NATURAL SURFACE AND MAY BE SLIPPERY

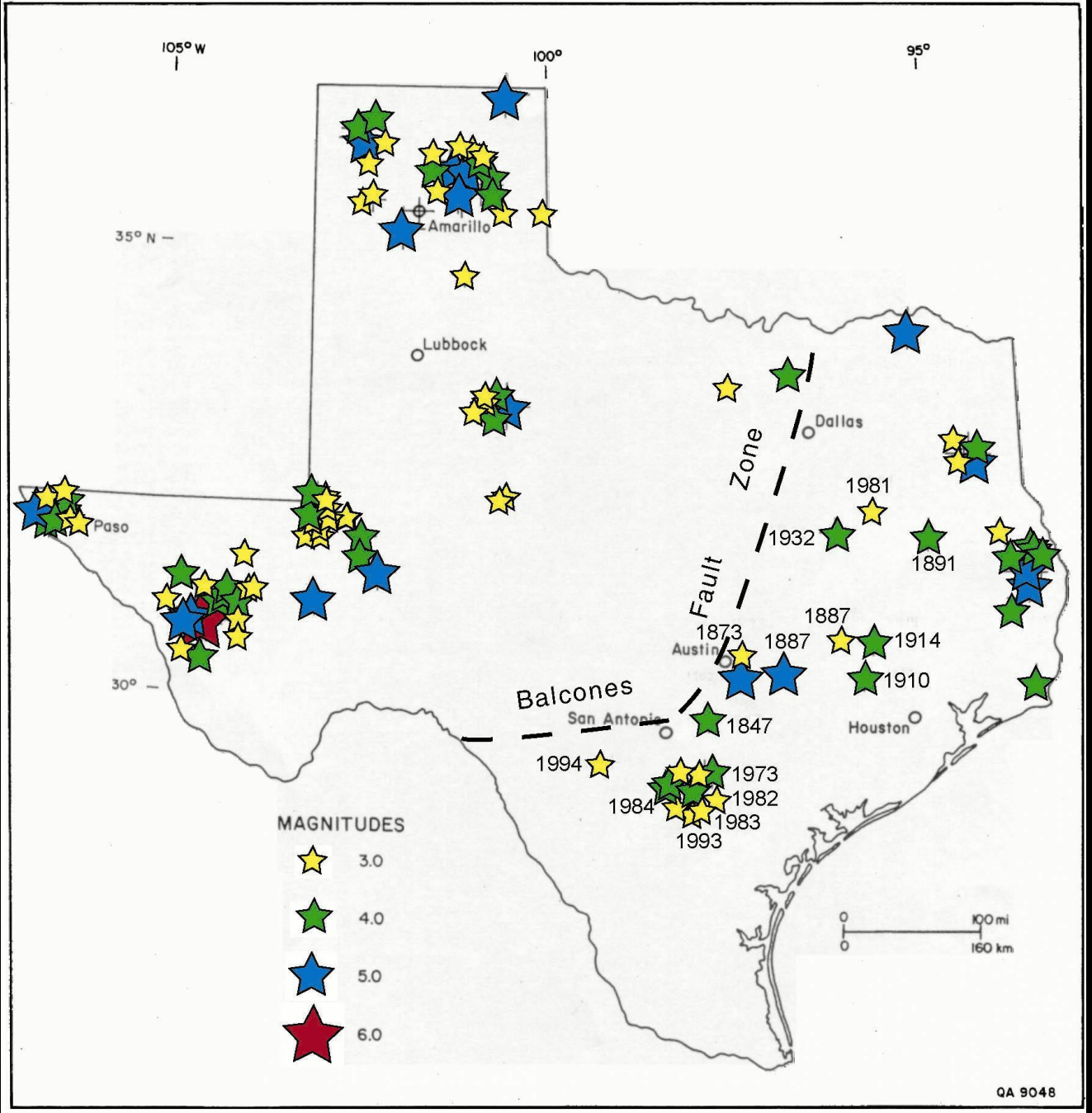


FIGURE 1. Earthquake epicenters and magnitudes in Texas, 1847 to 1986. Data are from table 1. Relative locations within large clusters of events should not be considered significant. Magnitudes shown are Richter-scale values.

Historic Earthquakes in Central Texas

Date	Magnitude	Nearby Town	Remarks
1847 Feb. 14	3.6	Seguin	Cracked timber in houses
1873 May 1	3.0	Manor	
1887 Jan. 5	4.1	Paige	
1887 Jan. 31	3.3	Wellborn	
1891 Jan. 8	4.0	Rusk	Chimneys thrown to ground
1902 Oct. 9	3.9	Creedmoor	
1910 May 8	3.8	Hempstead	
1914 Dec. 30	3.3	Anderson	
1932 April 9	4.0	Wortham-Mexia	Chimney bricks shaken loose
1973 Dec. 25	3.2	Fashing	Several aftershocks in 1974
1981 Nov. 6	3.2	Jacksonville	Minor damage
1982 Mar. 28	3.0	South Texas	
1983 July 23	3.4	Fashing	Gasoline plant shut down
1984 Mar. 3	3.9	Pleasanton	Slight damage, aftershocks
1993 April 9	4.3	Fashing	Slight damage, aftershocks
1994 Sept. 27	2.5	SW of San Antonio	Not felt?

Earthquake Magnitude and Damage

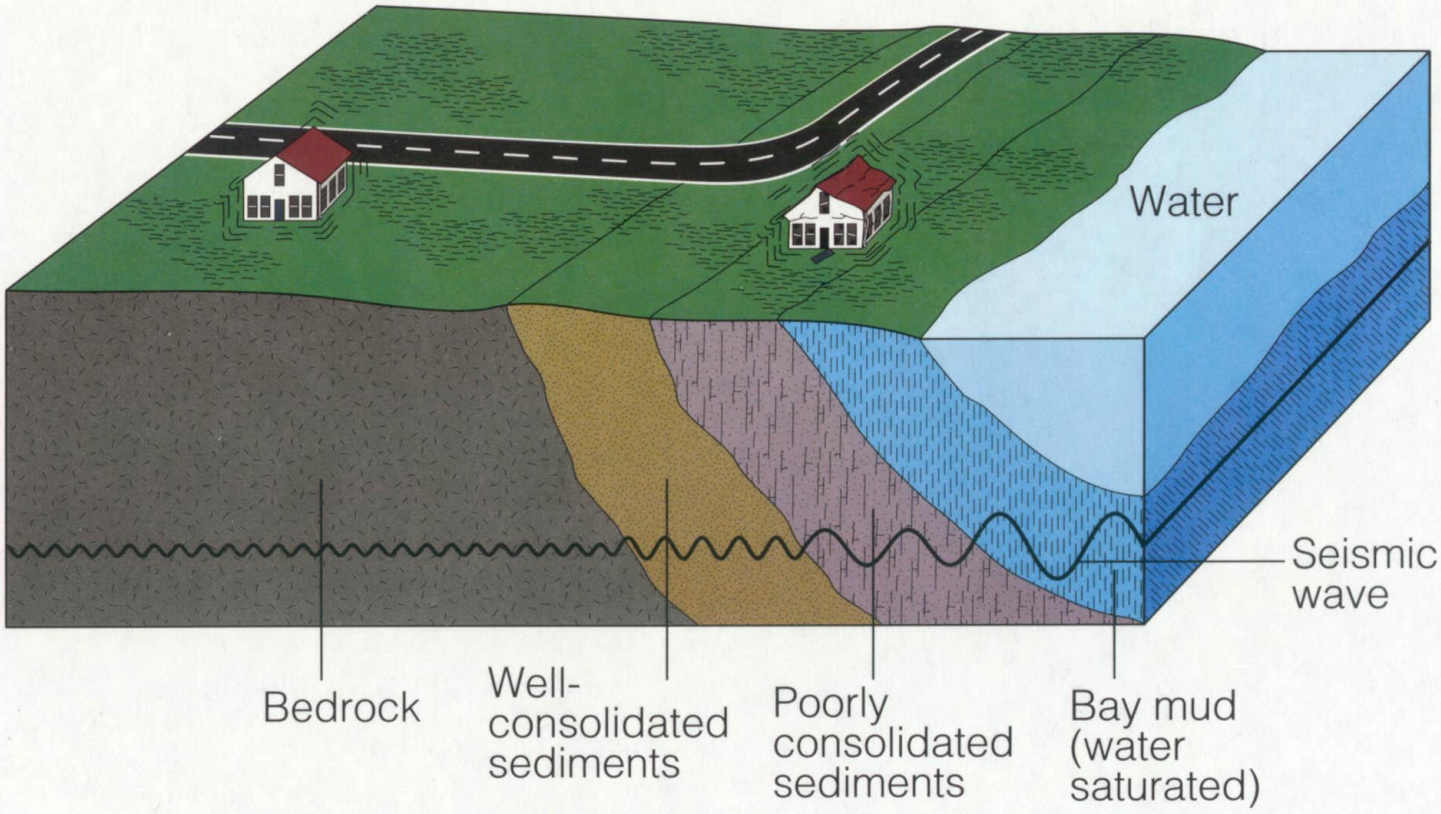
Magnitude	Earthquake	Losses	Comments
8.2	1994 Bolivia	Minimal	Felt in Toronto !
7.5	1992 Landers	$0.1 billion	Largest CA quake in 40 yrs
7.1	1989 Loma Prieta	$6 billion	During World Series
6.6	1994 Northridge	$30 billion	Where I grew up

Destructive Effects of Earthquakes

It’s often said that earthquakes don’t kill people, our buildings do !

- Shaking
- Ground failure (landslides, liquefaction)
- Fire
- Tsunami (seismic sea waves)

Variation in Amplitude, Duration, and Period of Seismic Waves in Various Types of Material



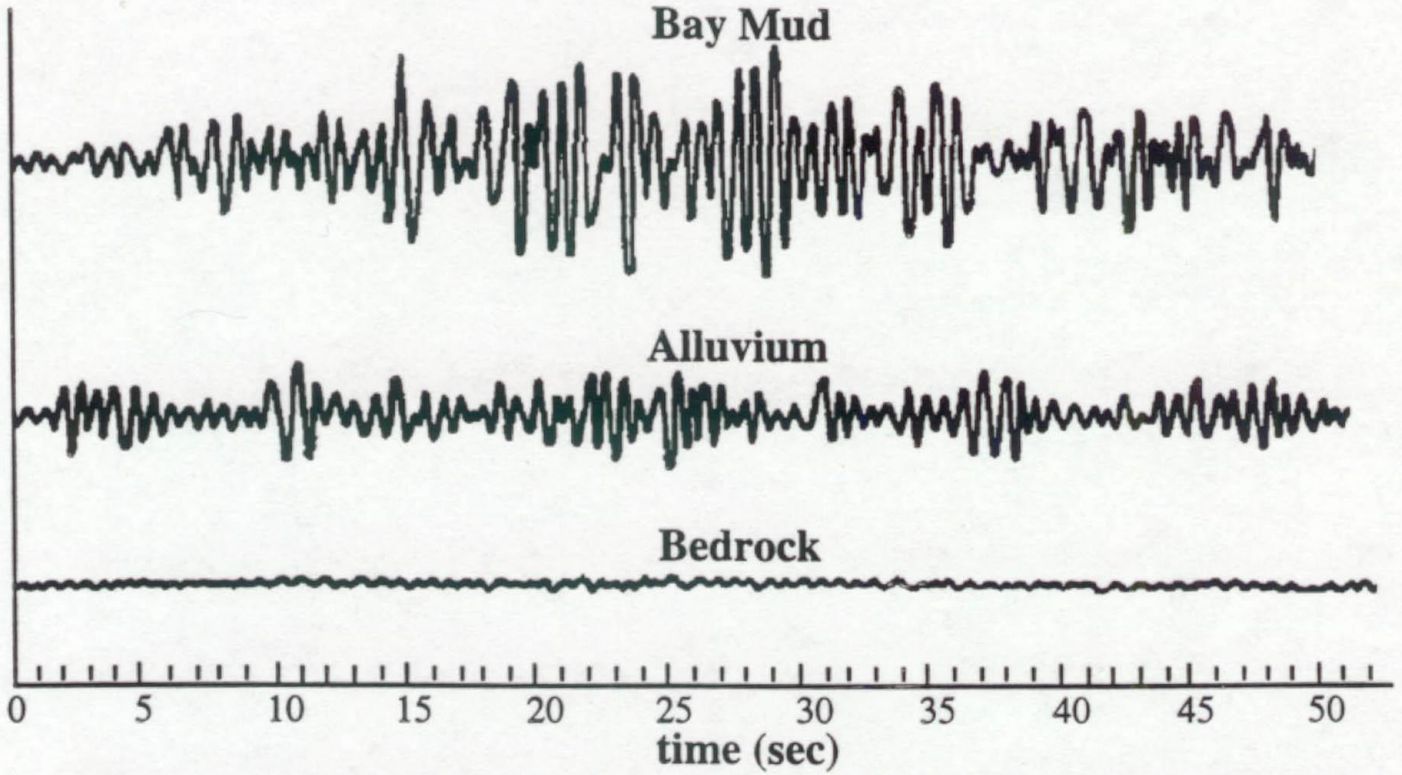


Figure 11.2. Horizontal ground motions of an underground nuclear explosion were recorded by accelographs in San Francisco. All materials were subjected to the same seismic waves. (After Borcherdt, 1975)


For
RENT!
$10 A month


2DBK243
KENNEDY


STOP

THE CITY IN FLAMES

Photograph 50-11

A remarkable panorama of San Francisco in flames taken from Mason Street 11:30 A. M., April 18th, 1906. 8 hours after the earthquake. No one looking at this picture would for a moment consider he was viewing a city destroyed by earthquake. It requires very careful examination to locate the few evidences of earthquake damage. Even a very few thousand chimneys can be found. Only a few parapet walls have been thrown down. The elaborate ornamentations of Grace Church and Temple Emanu-el appear unharmed. It will be remembered that with the exception of a limited number of the taller buildings all of the masonry structures were carried on brick bearing walls. Note the many buildings such as the old St. Mary's Cathedral, Grace Church, Mills Building, Crocker Building, Palace Hotel, Mutual Bank, California Building, etc., which are entirely intact and apparently little burned yet in the direct path of the flames which later partially destroyed them.

Birdseye View of the Ruins of San Francisco.

Supplement to the San Francisco Examiner, May 13, 1906.

Earthquake Prediction

Must specify where, when, how big, what Probability

Predictions (short-term) vs forecasts (long-term)

Instrumental record is 35-100 years long, but "seismic cycle" is 100s to 10,000s of years long

Predicting earthquakes is like trying to predict the climate based on observing the weather for a few minutes

Catch-22

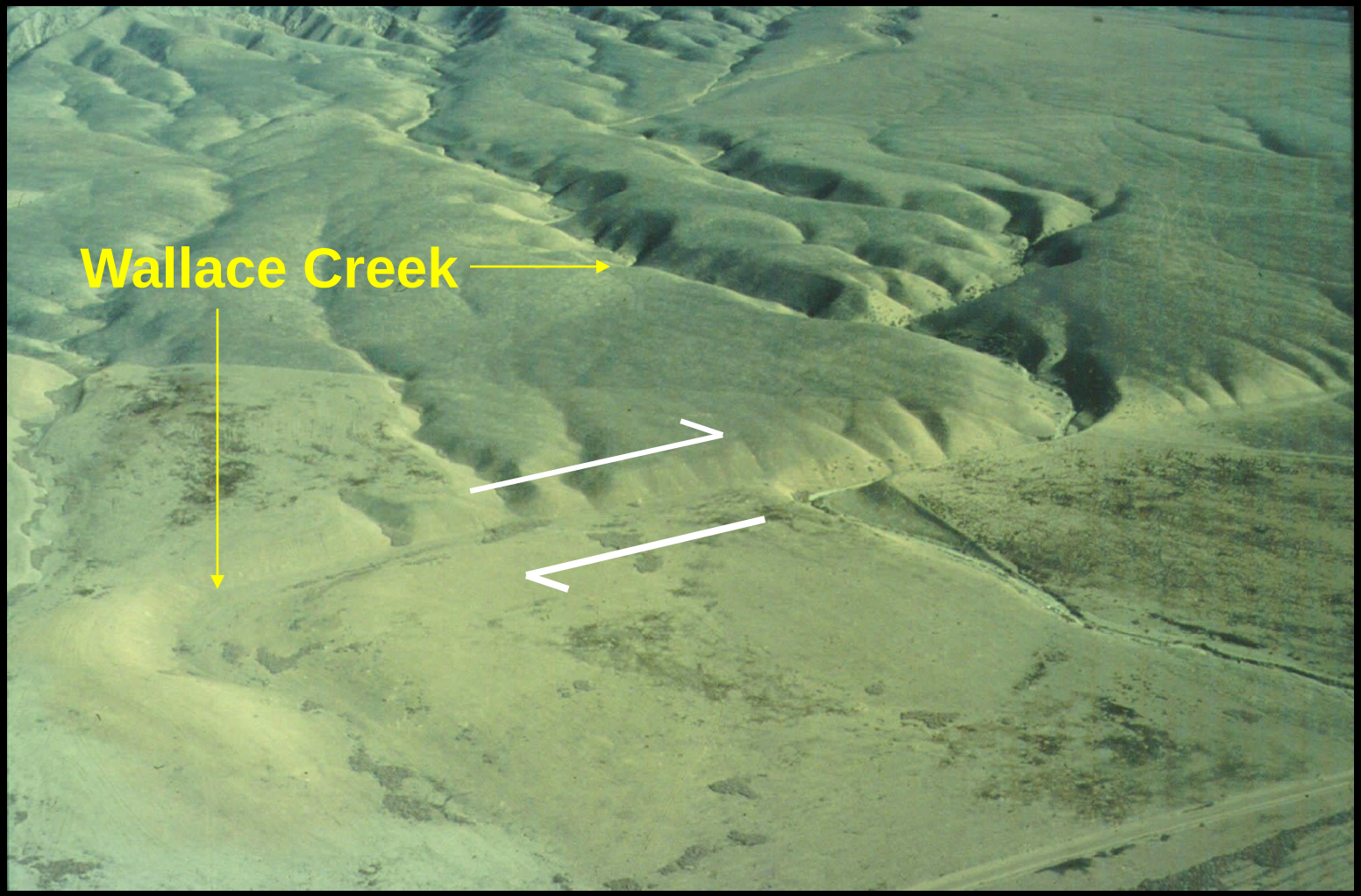
- Earthquakes are not periodic, so short-term prediction must use precursory effects
- To learn what precursory phenomena are, we must study what happens on a fault BEFORE an earthquake occurs
- So to learn how to predict earthquakes, we have to start by predicting an earthquake !
- Enter Parkfield, CA: magnitude 6 earthquakes in 1857, 1881, 1901, 1922, 1934, 1966

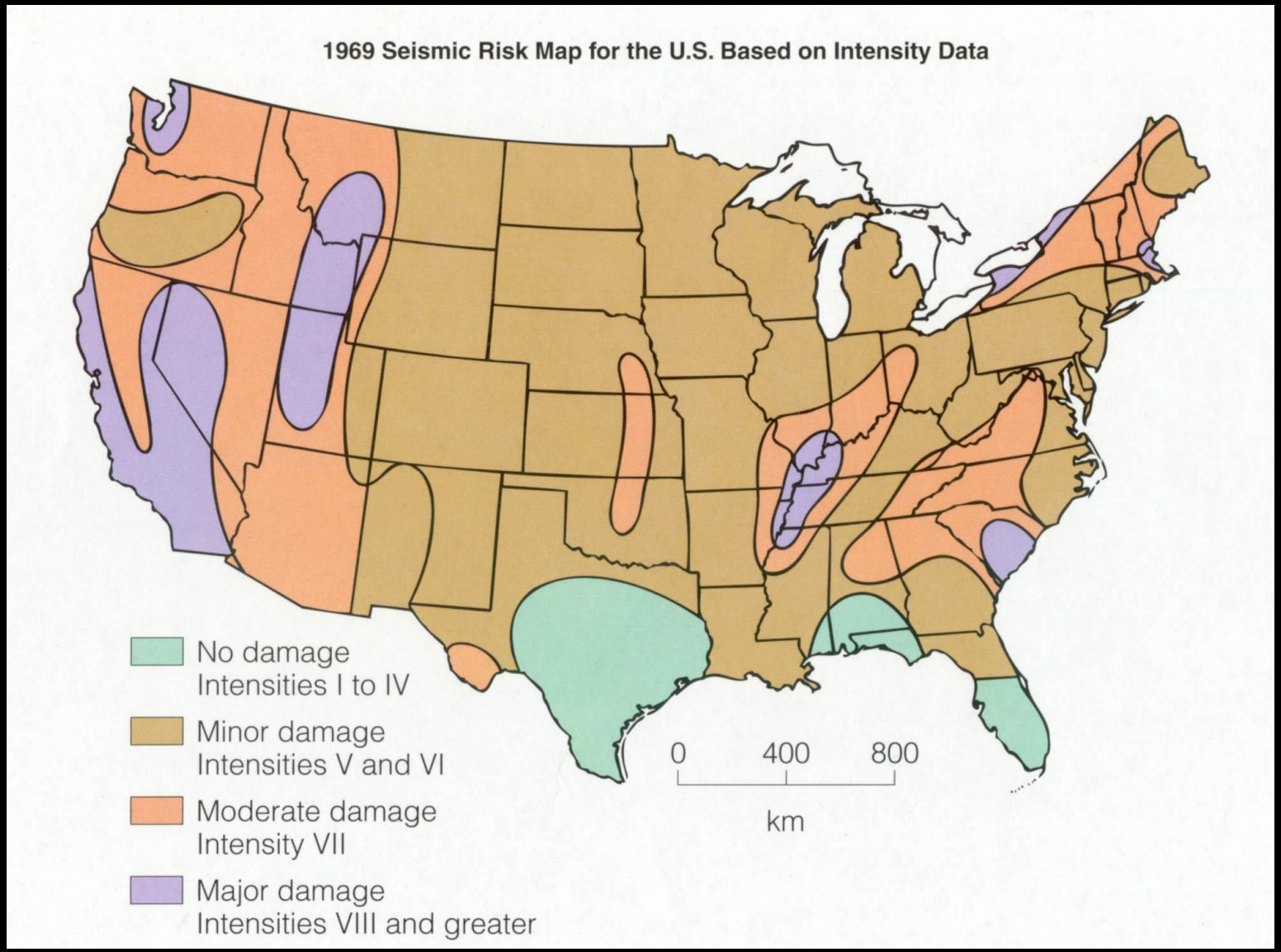

PARKFIELD CAFE
EARTHQUAKE CAPITOL of THE WORLD
PARKFIELD, CALIFORNIA
BE HERE WHEN IT HAPPENS

Long-Term Forecasts

- Instrumental record - seismographs (100 years)
- Historical records - written documents (1000’s of years)
- Paleoseismology - prehistoric earthquakes from geological evidence (100,000’s of years)

  - Trenches dug across faults
  - Deposits from catastrophic events
  - Isotopic dating to determine age


Wallace Creek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No damage
Intensities I to IV
Minor damage
Intensities V and VI
Moderate damage
Intensity VII
Major damage
Intensities VIII and greater
0
400
800
km

Educational Resources

Southern California Earthquake Center
- http://www.scec.org/outreach/index.html

US Geological Survey Seismolinks
- http://www-socal.wr.usgs.gov/seismolinks.html

National Earthquake Information Center
- http://quake.wr.usgs.gov/

UT Institute for Geophysics
- http://www.ig.utexas.edu/

Dr. Randall Marrett

Randy Marrett has degrees in Geology from the University of California at Santa Cruz (B.S.) and Cornell University (Ph.D.). He joined the faculty at UT in 1994after working for several years in industry, and teaches a variety of classes in Structural Geology, Field Geology and Physical Geology. In 1999 he received the Knebel Distinguished Teaching Award and in 1998 he was awarded a Big XII Faculty Fellowship for research. He has published numerous scientific articles and won a variety of research grants. His research on active deformation and mountain building is largely based on field work in the Andes of Argentina and Chile, the Sierra Madre of Mexico, and the Rocky Mountains of the U.S. and Canada.