



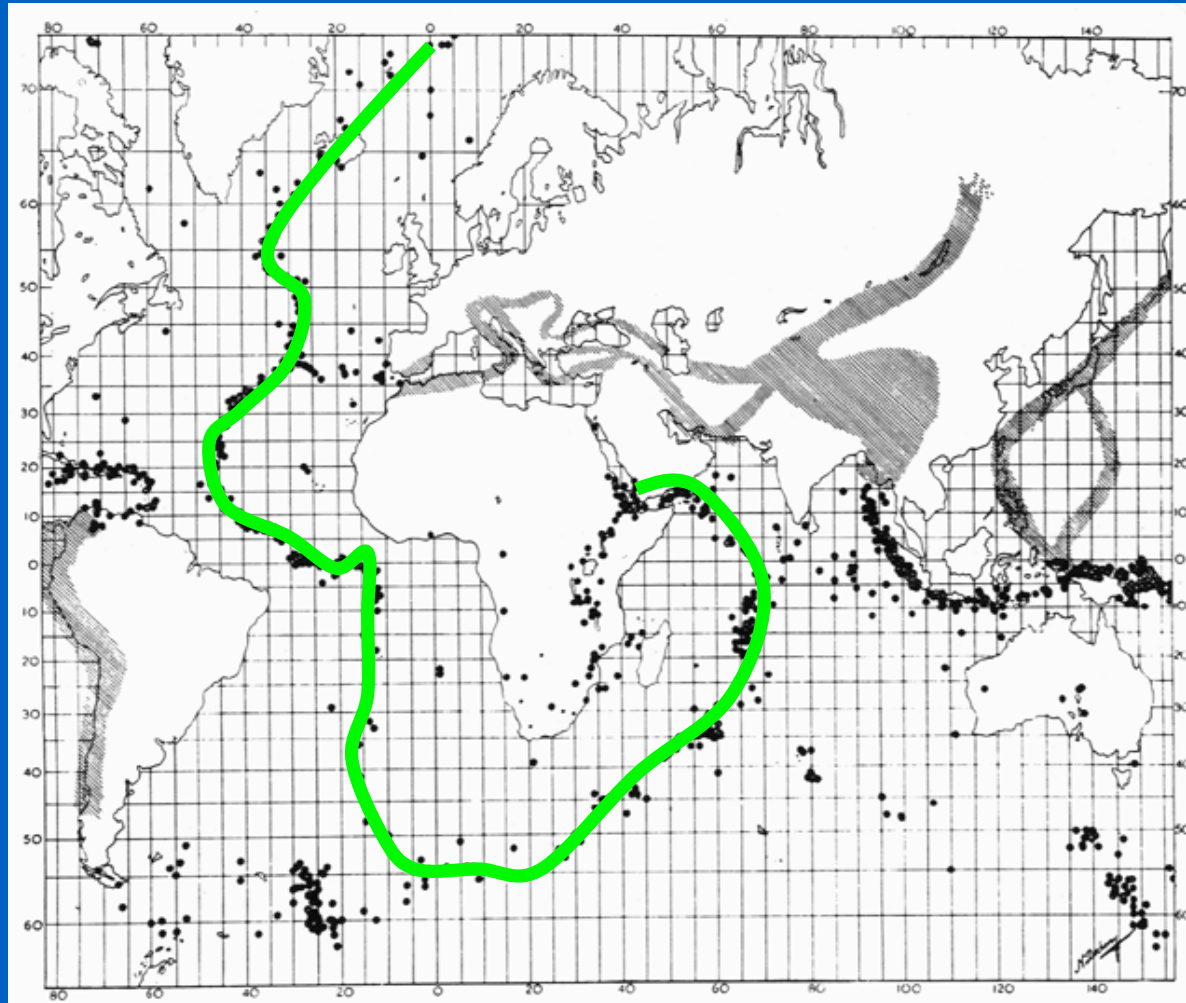
**USGS Earthquake Hazards Program**

# **Earthquakes 101 (EQ101)**

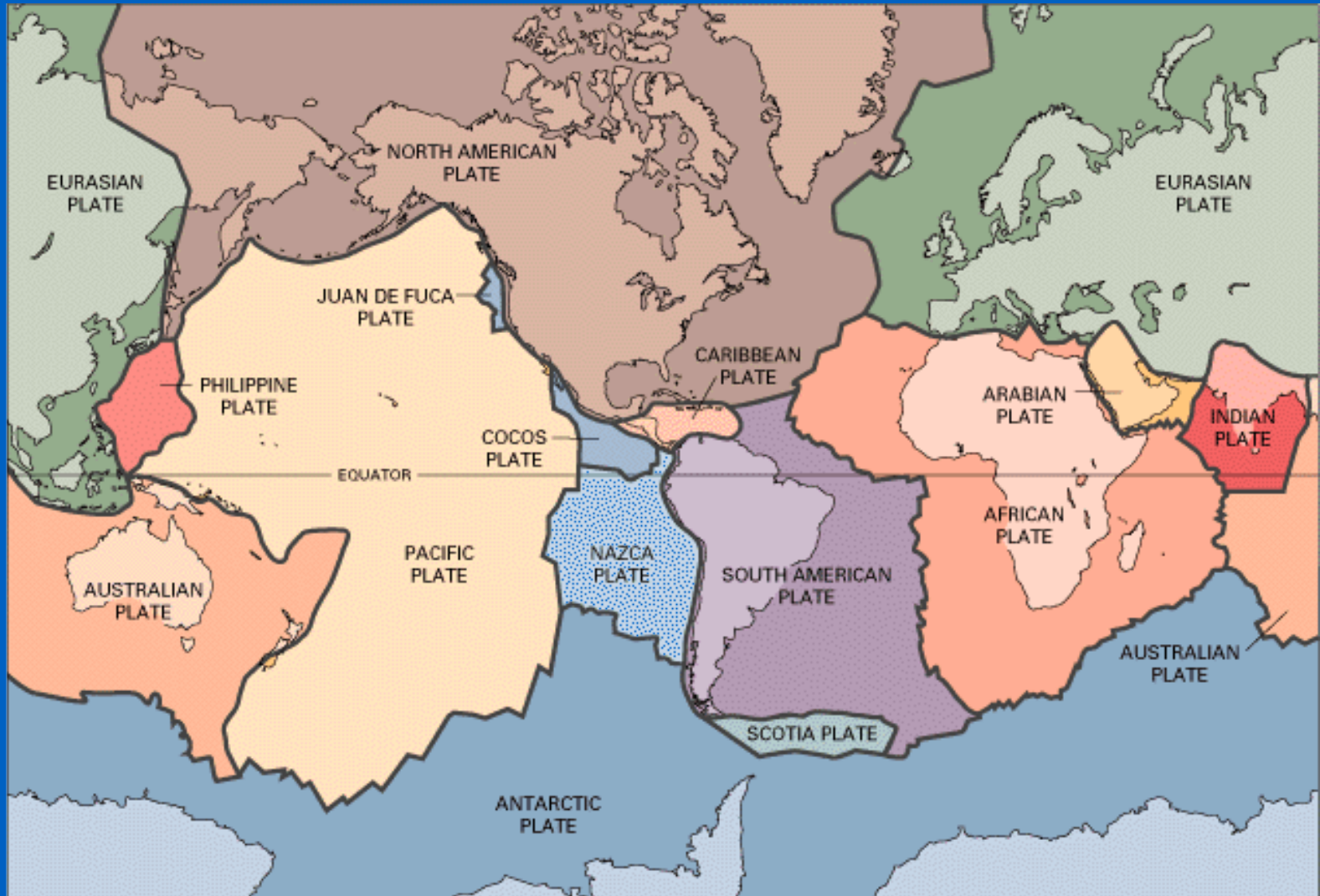
**Lisa Wald**  
**USGS Pasadena**

U.S. Department of the Interior  
U.S. Geological Survey

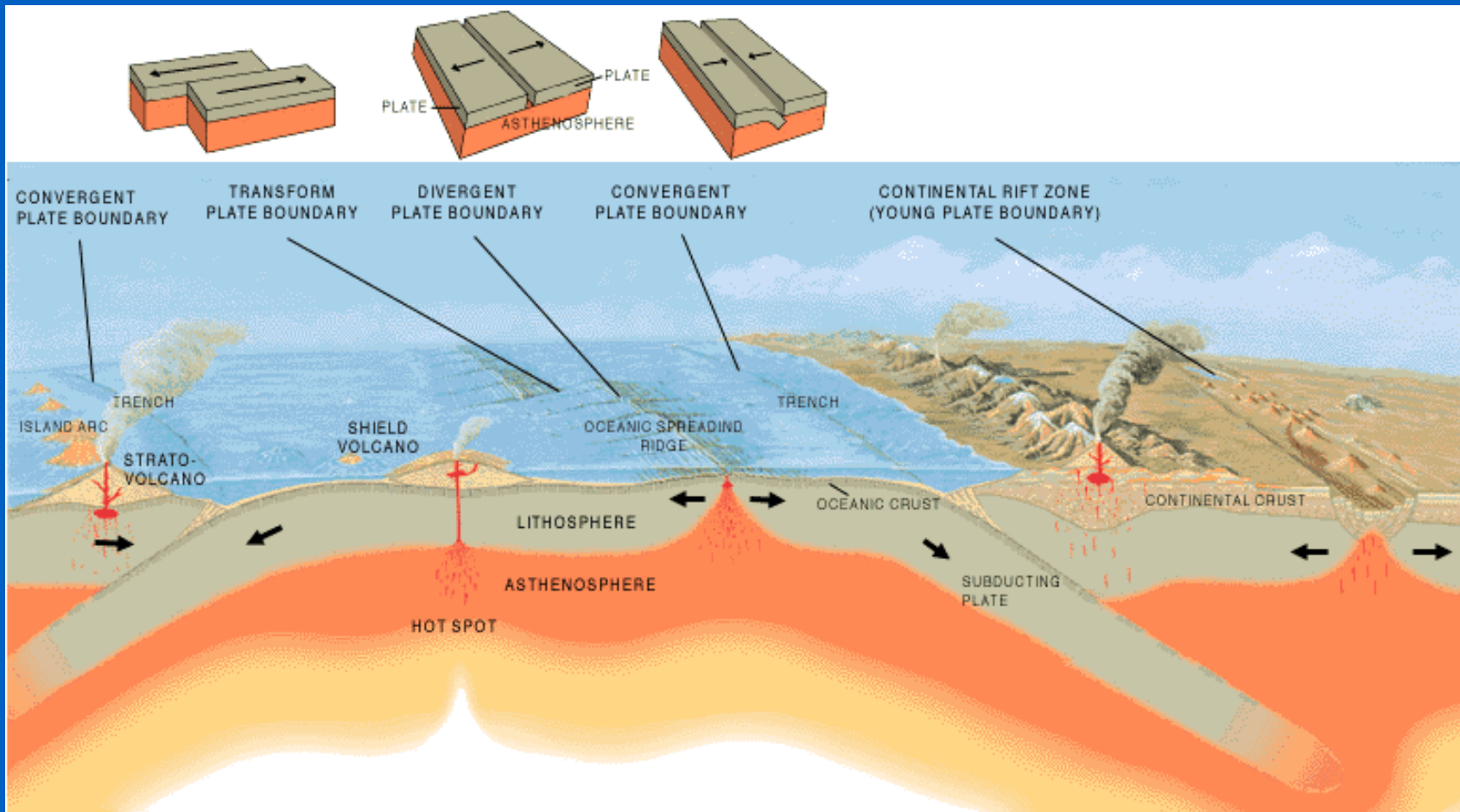
# Global Distribution of Earthquakes



# Plate Tectonics



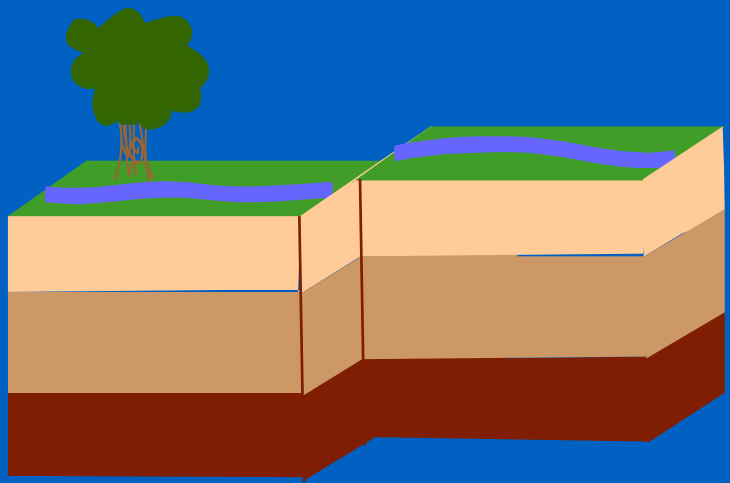
# Plate Boundaries



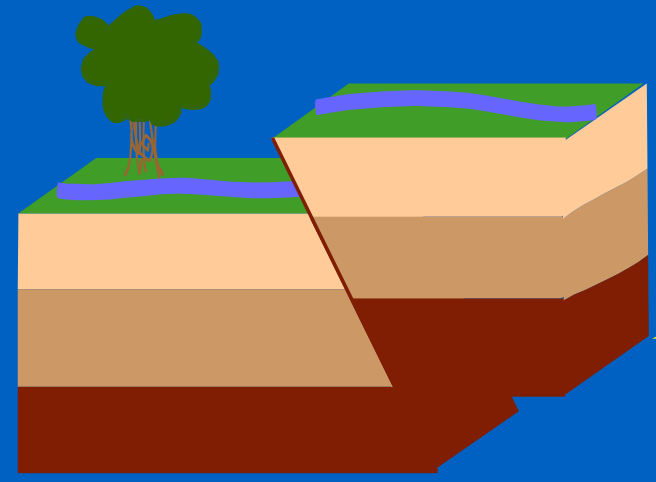




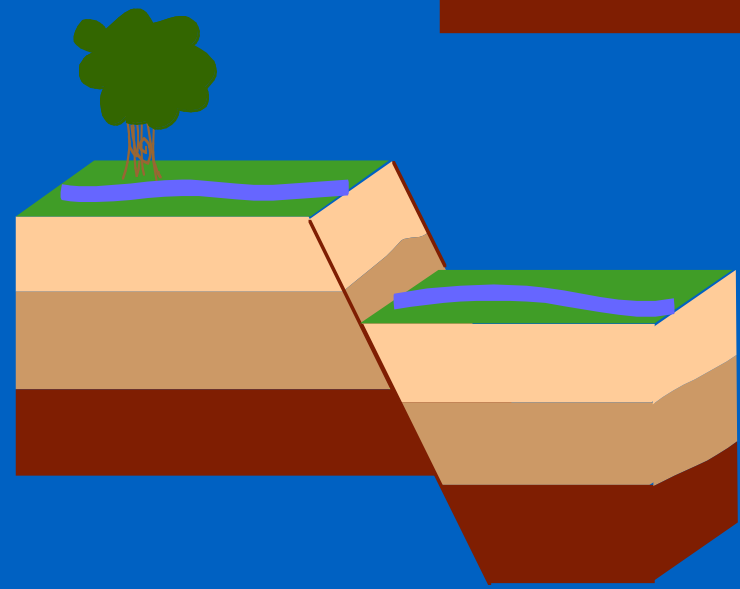
# Three Types of Faults



Strike-Slip



Thrust



Normal

# Strike-slip Fault Example



# Strike-slip Fault Example





# Normal Fault Example



Dixie Valley-Fairview Peaks, Nevada earthquake  
December 16, 1954





# Thrust Fault Example



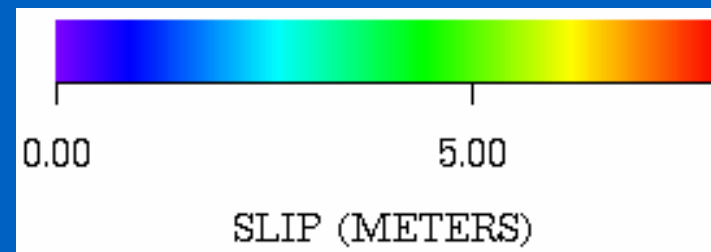
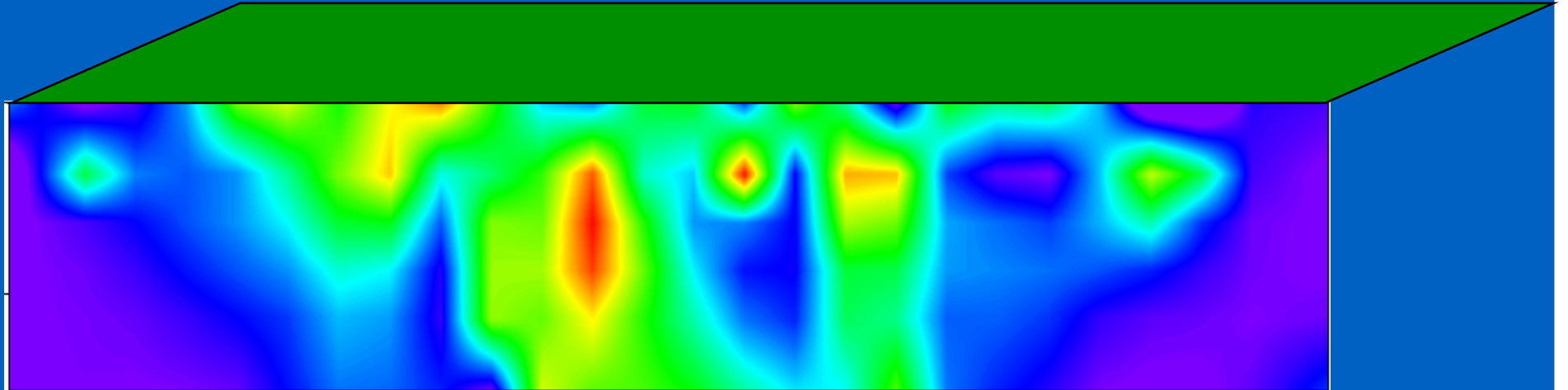
# Thrust Fault Example





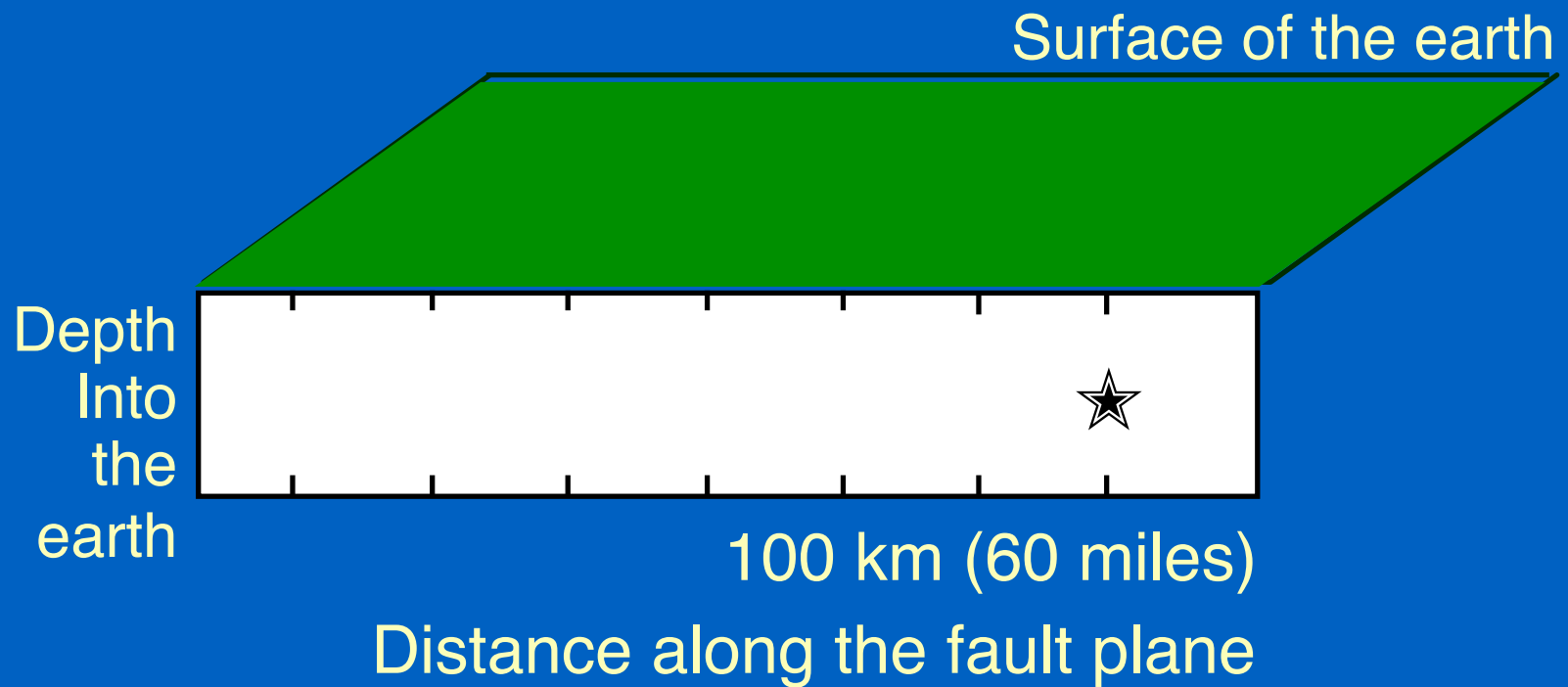
# Rupture on a Fault

Total Slip in the M7.3 Landers Earthquake



# Slip on an earthquake fault

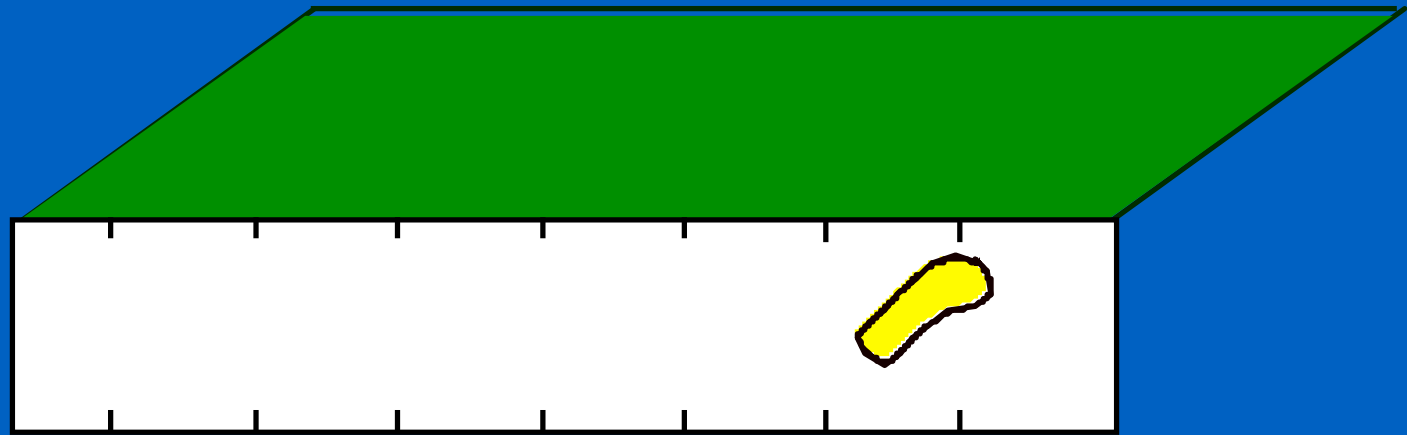
**START**





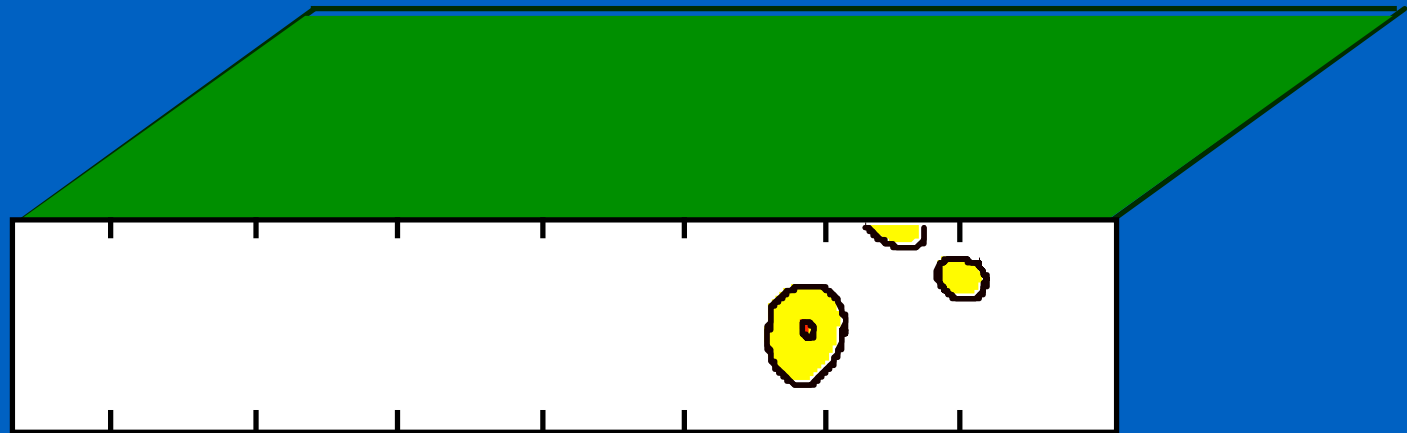
# Slip on an earthquake fault

## Second 2.0



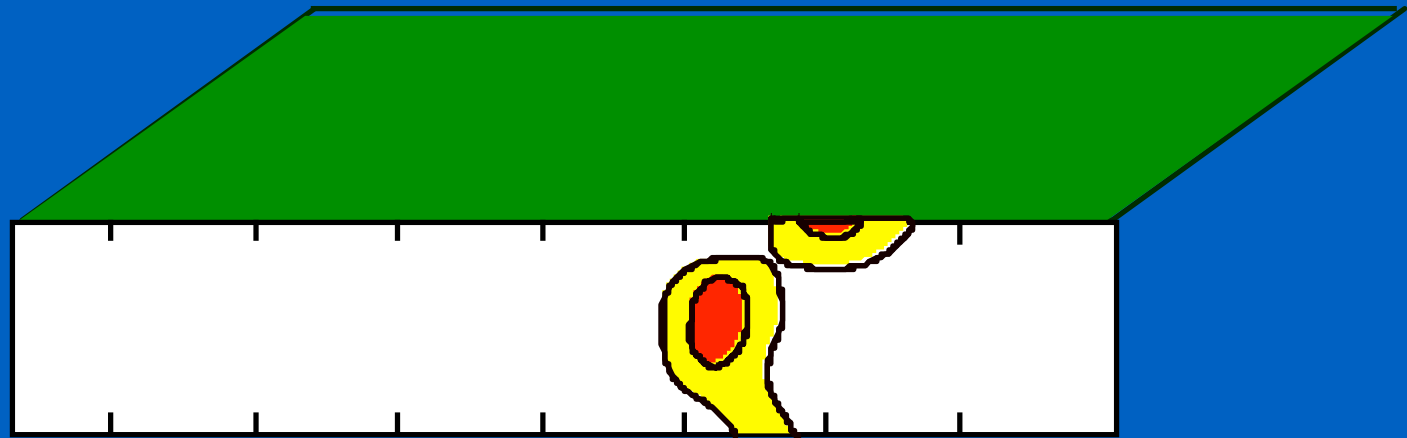
# Slip on an earthquake fault

## Second 4.0



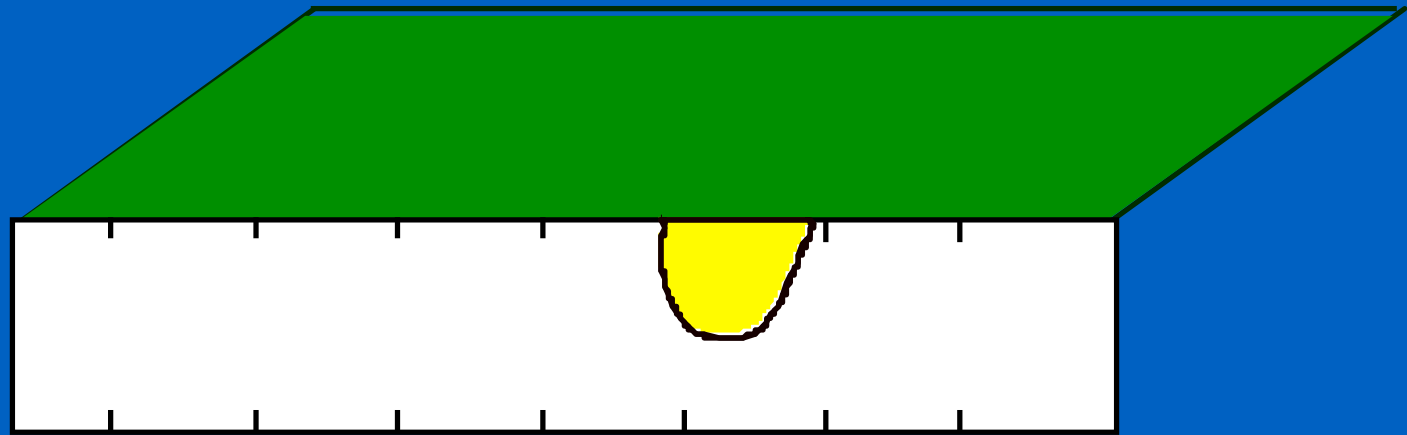
# Slip on an earthquake fault

## Second 6.0



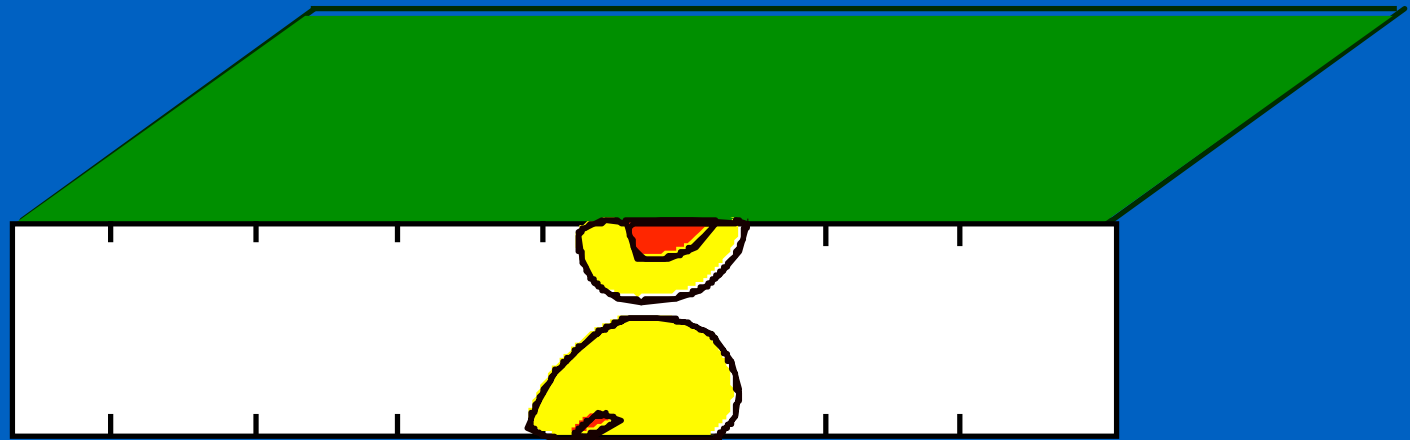
# Slip on an earthquake fault

## Second 8.0



# Slip on an earthquake fault

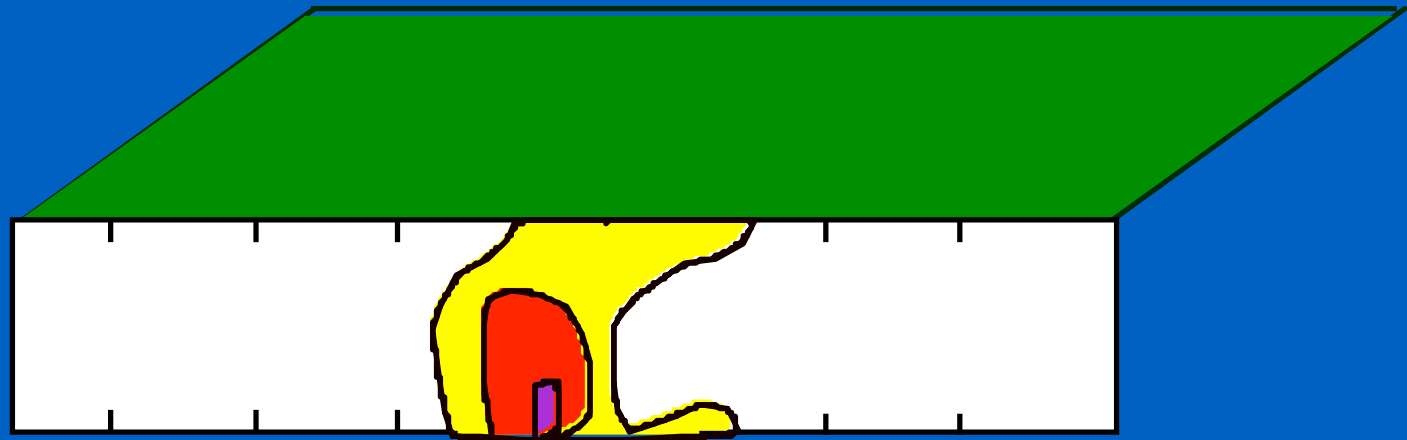
## Second 10.0





# Slip on an earthquake fault

## Second 12.0



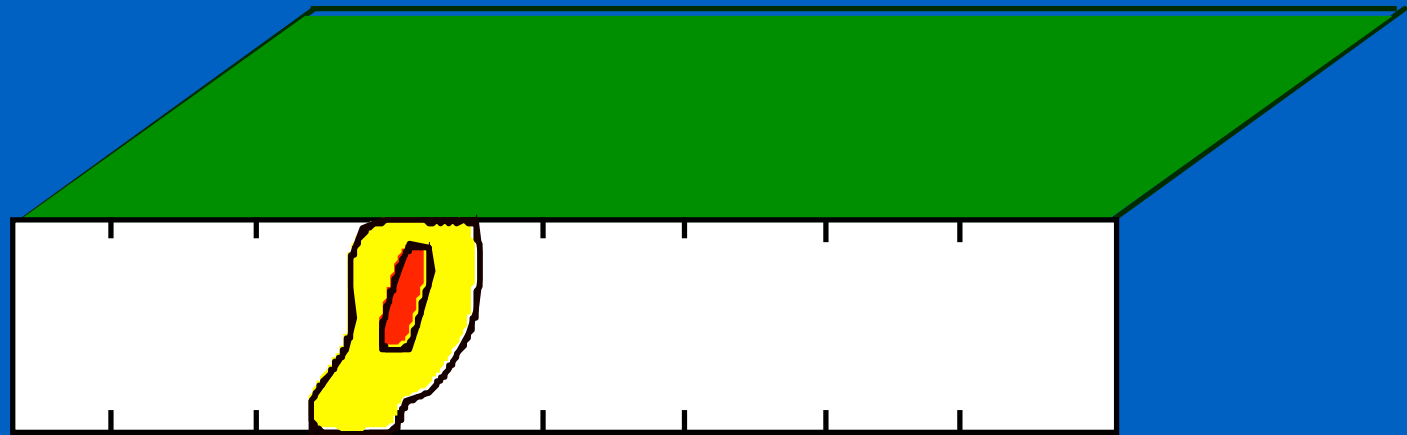
# Slip on an earthquake fault

## Second 14.0



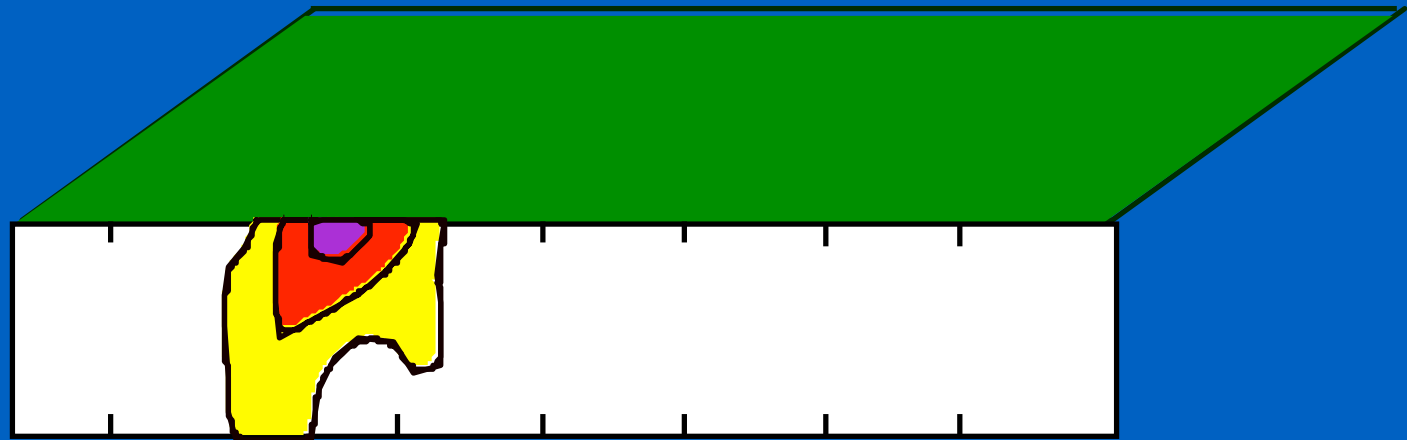
# Slip on an earthquake fault

## Second 16.0



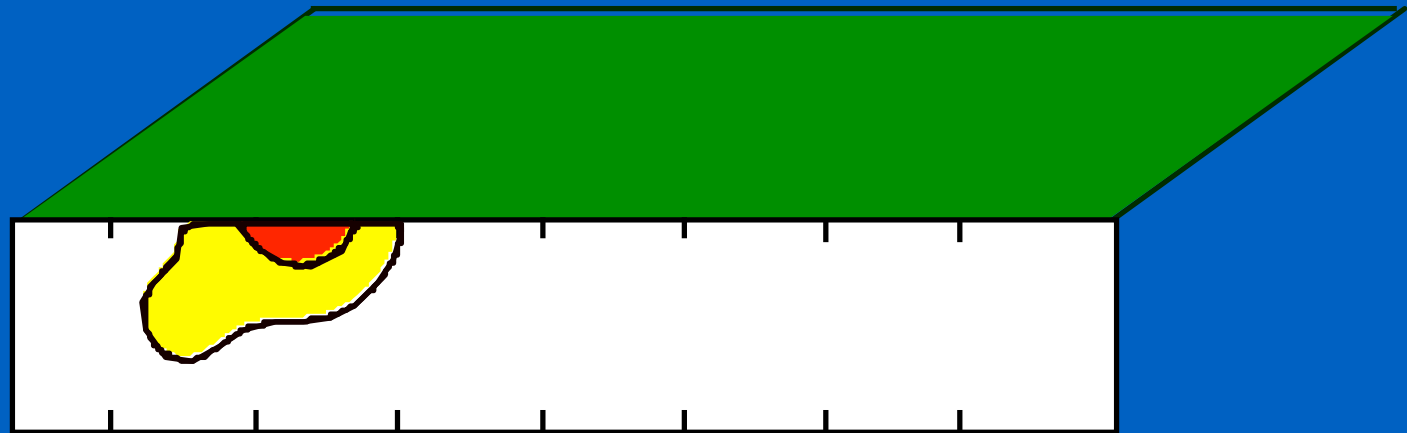
# Slip on an earthquake fault

## Second 18.0



# Slip on an earthquake fault

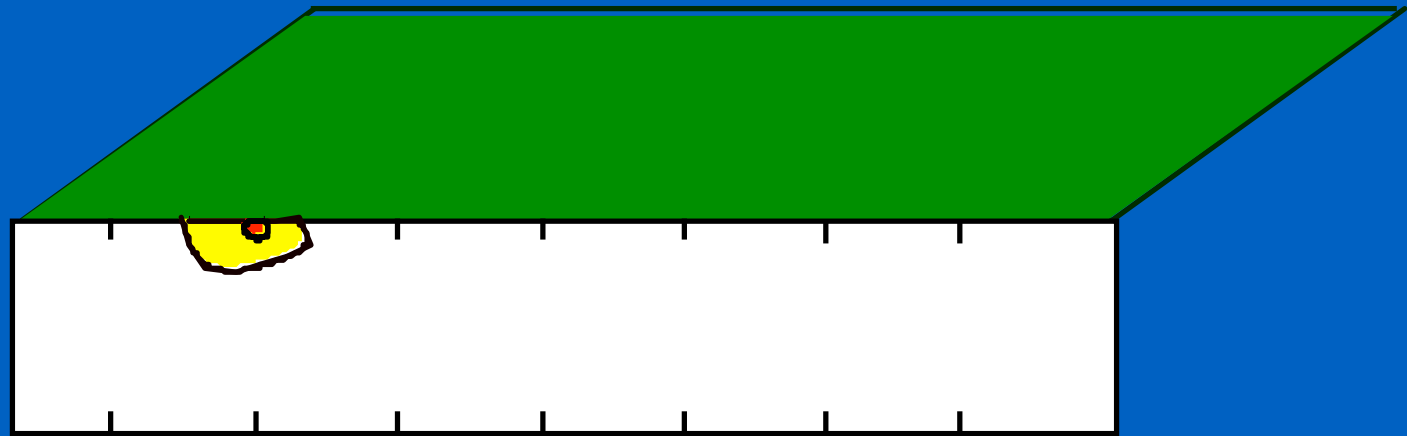
## Second 20.0





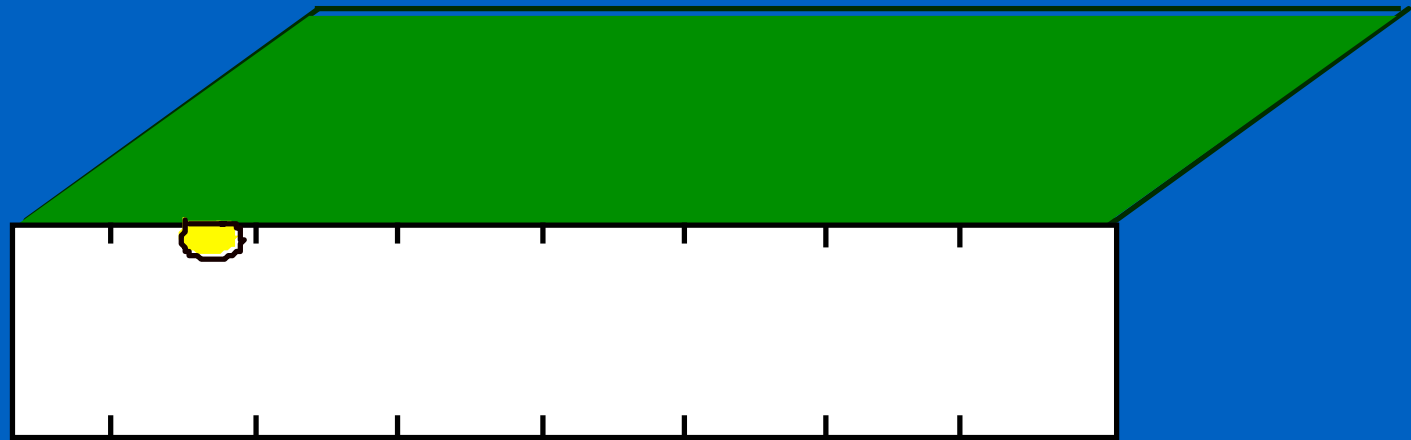
# Slip on an earthquake fault

## Second 22.0

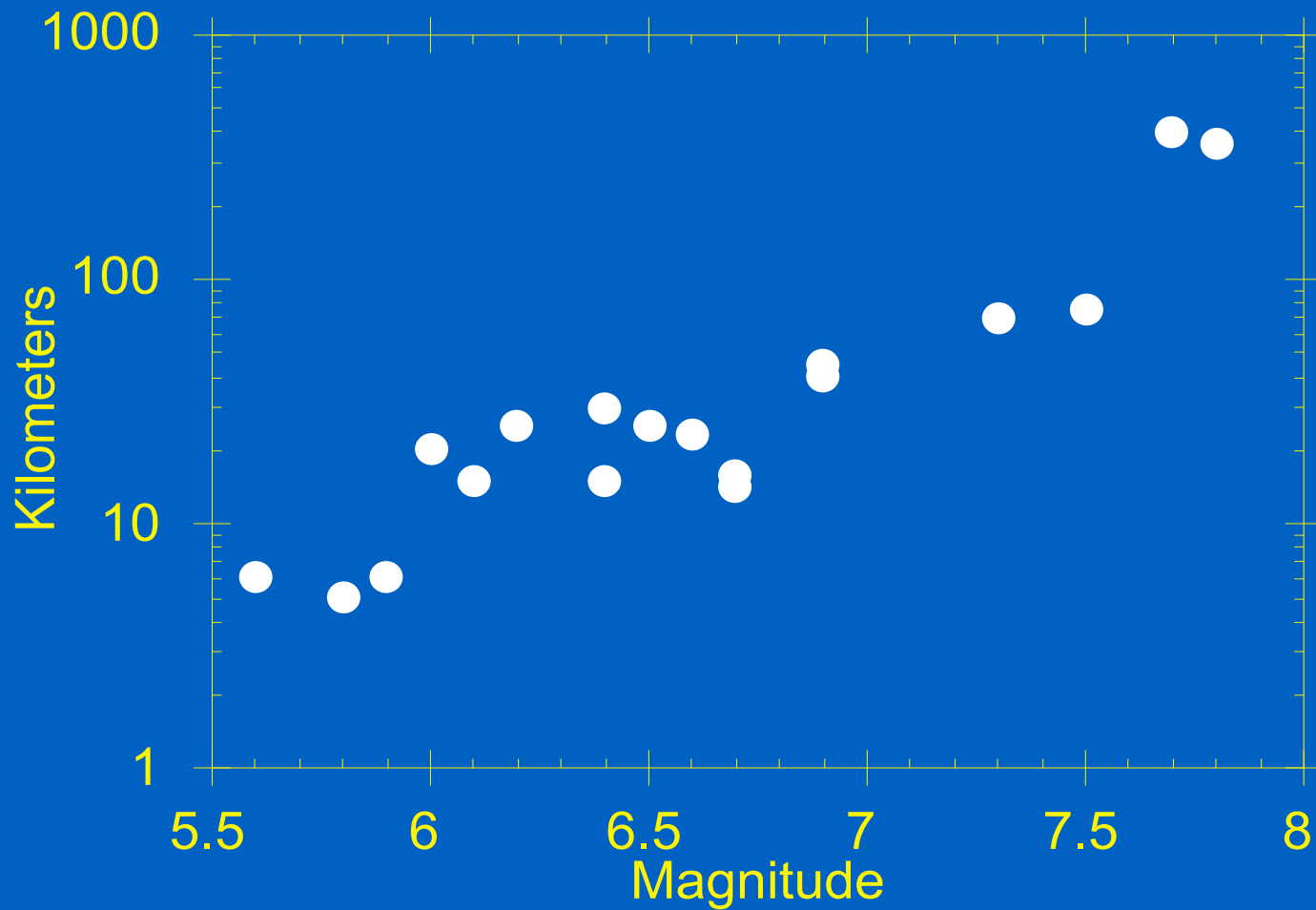


# Slip on an earthquake fault

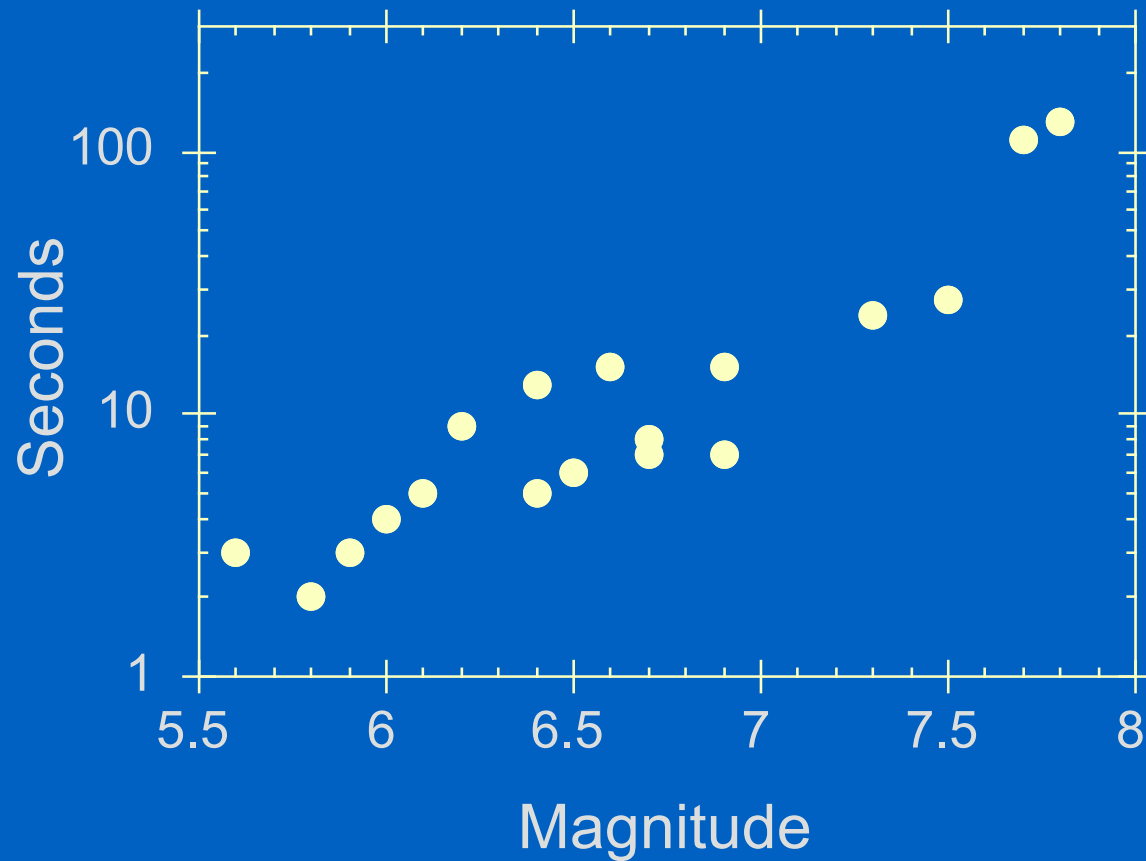
## Second 24.0



# Bigger Faults Make Bigger Earthquakes



# Bigger Earthquakes Last a Longer Time



# What Controls the Level of Shaking?

- **Magnitude**
  - More energy released
- **Distance**
  - Shaking decays with distance
- **Local soils**
  - amplify the shaking



Is there such a thing as  
“Earthquake Weather”???

**NO!**



# Earthquake Effects - Ground Shaking



 USGS

Northridge, CA 1994



# Earthquake Effects - Ground Shaking



Northridge, CA 1994



# Earthquake Effects - Ground Shaking



Loma Prieta, CA 1989



# Earthquake Effects - Ground Shaking



Kobe, Japan 1995

# Earthquake Effects - Ground Shaking



Kobe, Japan 1995



# Earthquake Effects - Surface Faulting



Landers, CA 1992



# Earthquake Effects - Liquefaction



Source: National Geophysical Data Center



Niigata, Japan 1964



# Earthquake Effects - Landslides



Source: National Geophysical Data Center



Turnagain Heights, Alaska, 1964 (upper left inset);  
Santa Cruz Mtns, California, 1989

# Earthquake Effects - Fires



Loma Prieta, CA 1989



# Earthquake Effects - Tsunamis

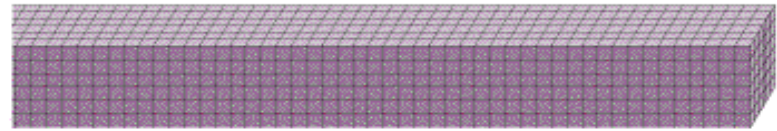
## 1957 Aleutian Tsunami



Photograph Credit: Henry Helbush. Source: National Geophysical Data Center

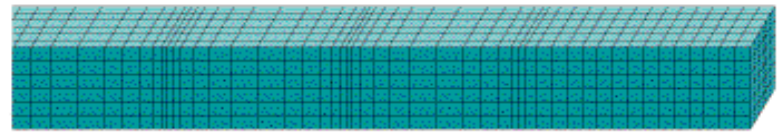
# Seismic Waves

## Seismic Waves

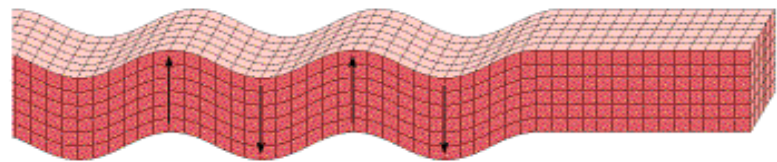


(a) Undisturbed material

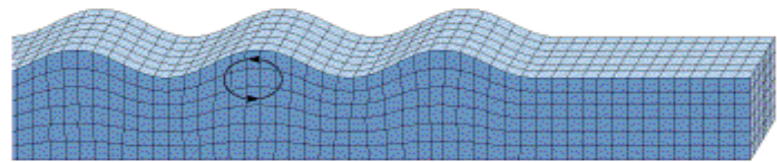
Compression    Compression    Compression    Undisturbed material  
|                    |                    |  
Expansion        Expansion



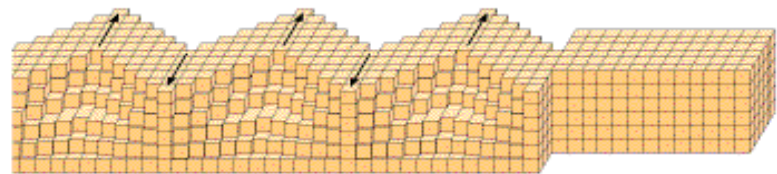
(b) Primary wave



(c) Secondary wave



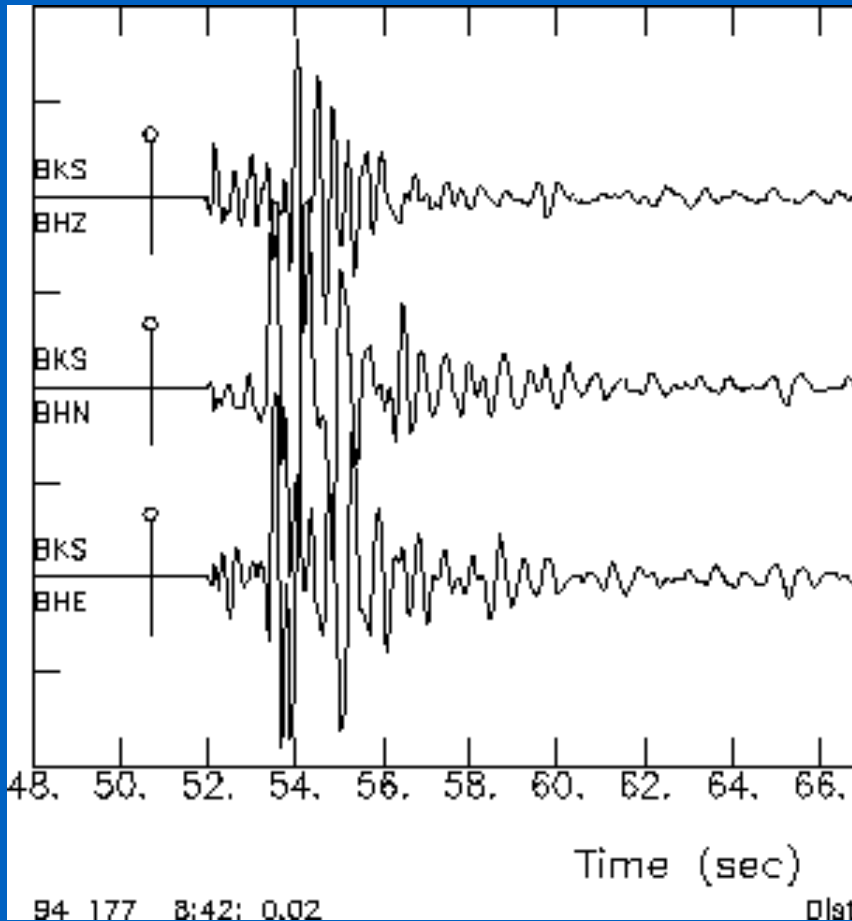
(d) Rayleigh wave



(e) Love wave

© 1995 West Publishing Company

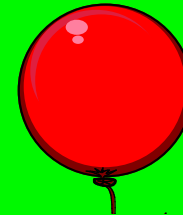
# Earthquake Magnitude



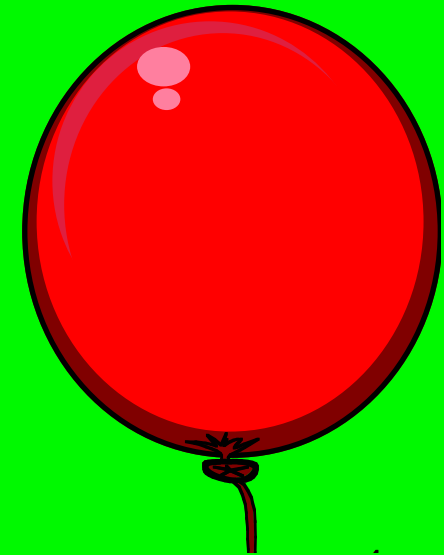
**M5**



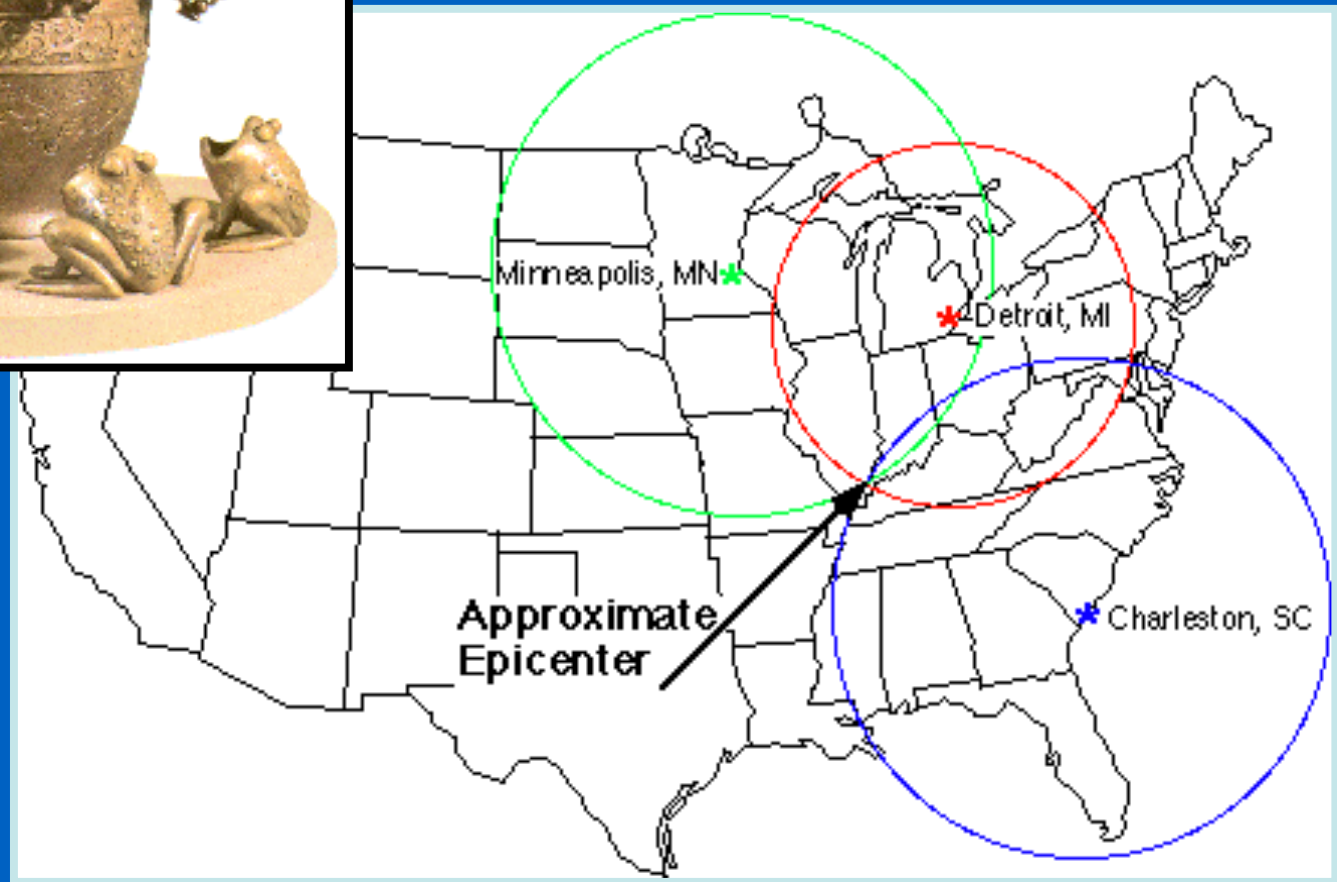
**M6**



**M7**



# Earthquake Location



# The San Andreas Fault



# Pacific-North American Plate Boundary





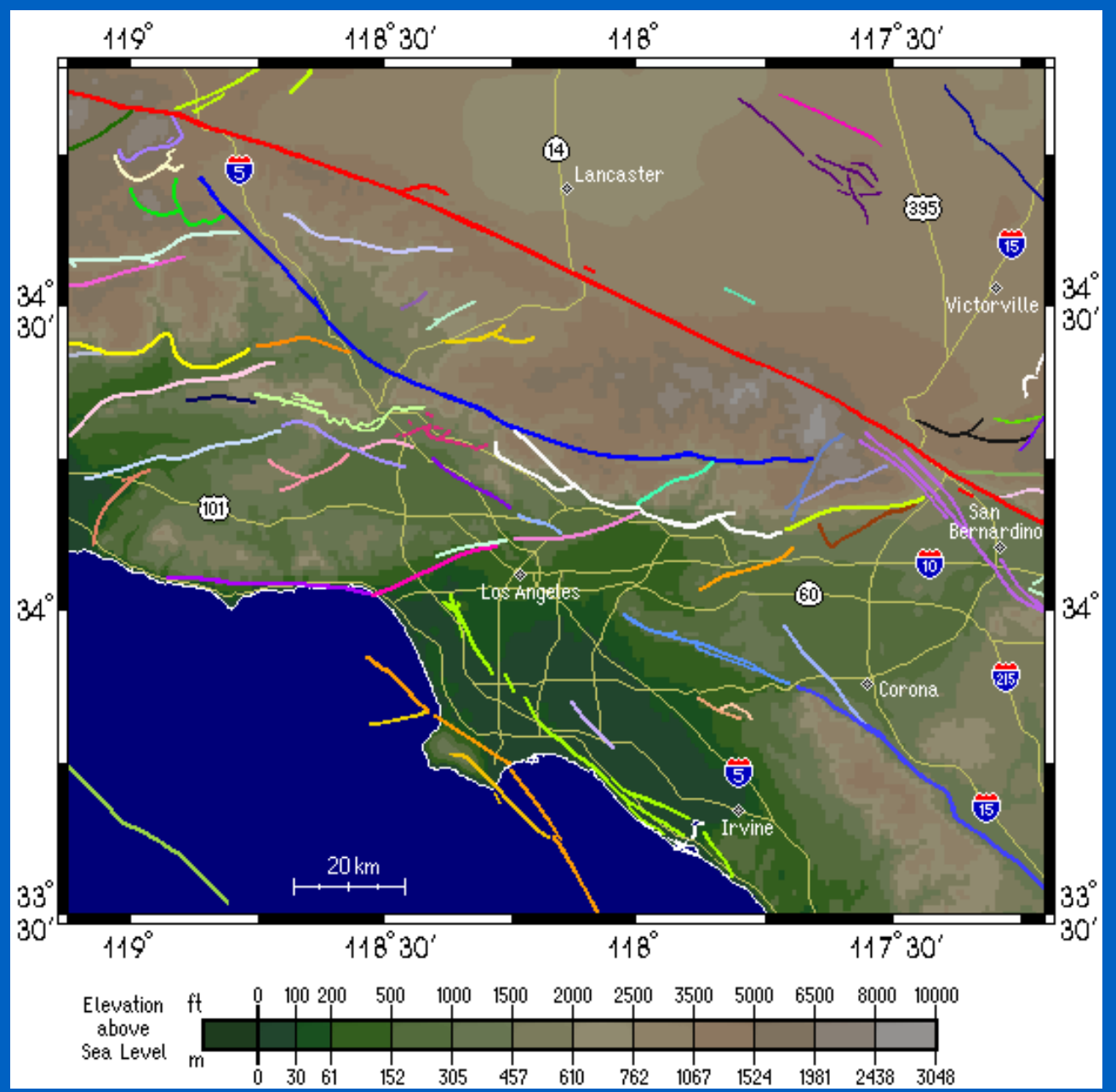


**Will California eventually  
fall into the ocean???**

**NO!**



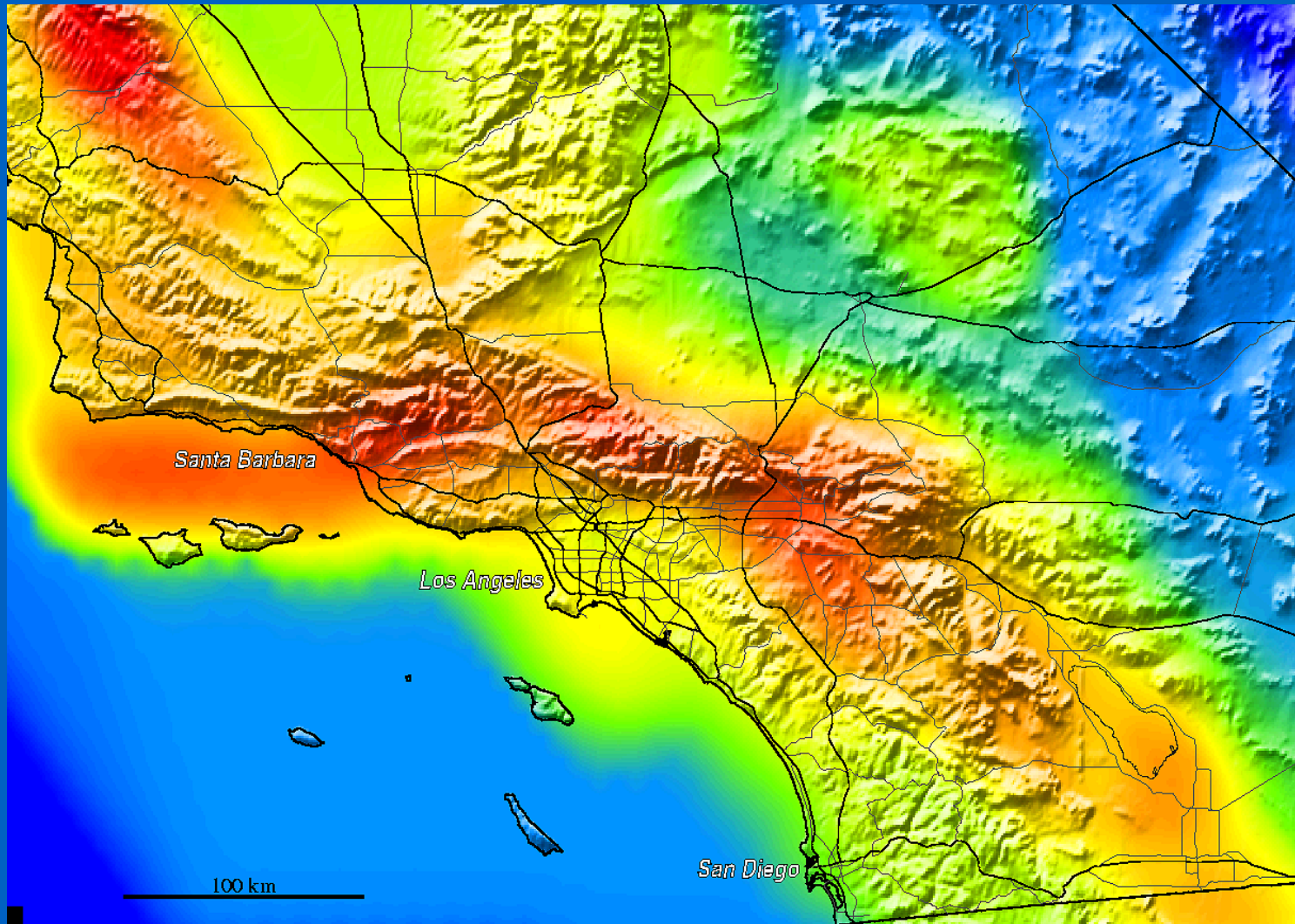
# Faults of Southern California



Source: SCEC Data Center



# Shaking Hazard in Southern California



# Faults in Our Local Area - Arcadia



## Sierra Madre Fault Zone

**THRUST** fault

55 KM long

Last ruptured in last 10,000 YEARS

SLIP RATE: between 0.36 and 4 mm/yr

PROBABLE MAGNITUDES: MW6.0 - 7.0 (?)

Dips to the north

# Faults in Our Local Area - Arcadia



Source: SCEC Data Center

## Raymond Fault

**STRIKE-SLIP** fault

**26 KM** long

**Last ruptured in last 10,000 YEARS**

**SLIP RATE:** between **0.10** and **0.22 mm/yr**

**PROBABLE MAGNITUDES:** **MW6.0 - 7.0**

**Dips to the north**

At least **eight** surface-rupturing events have occurred along this fault in the last 36,000 years

# Faults in Our Local Area - Arcadia



## Clamshell-Sawpit Canyon fault

**THRUST** fault

18 KM long

Last ruptured in last 1.6 million YEARS

SLIP RATE: ???

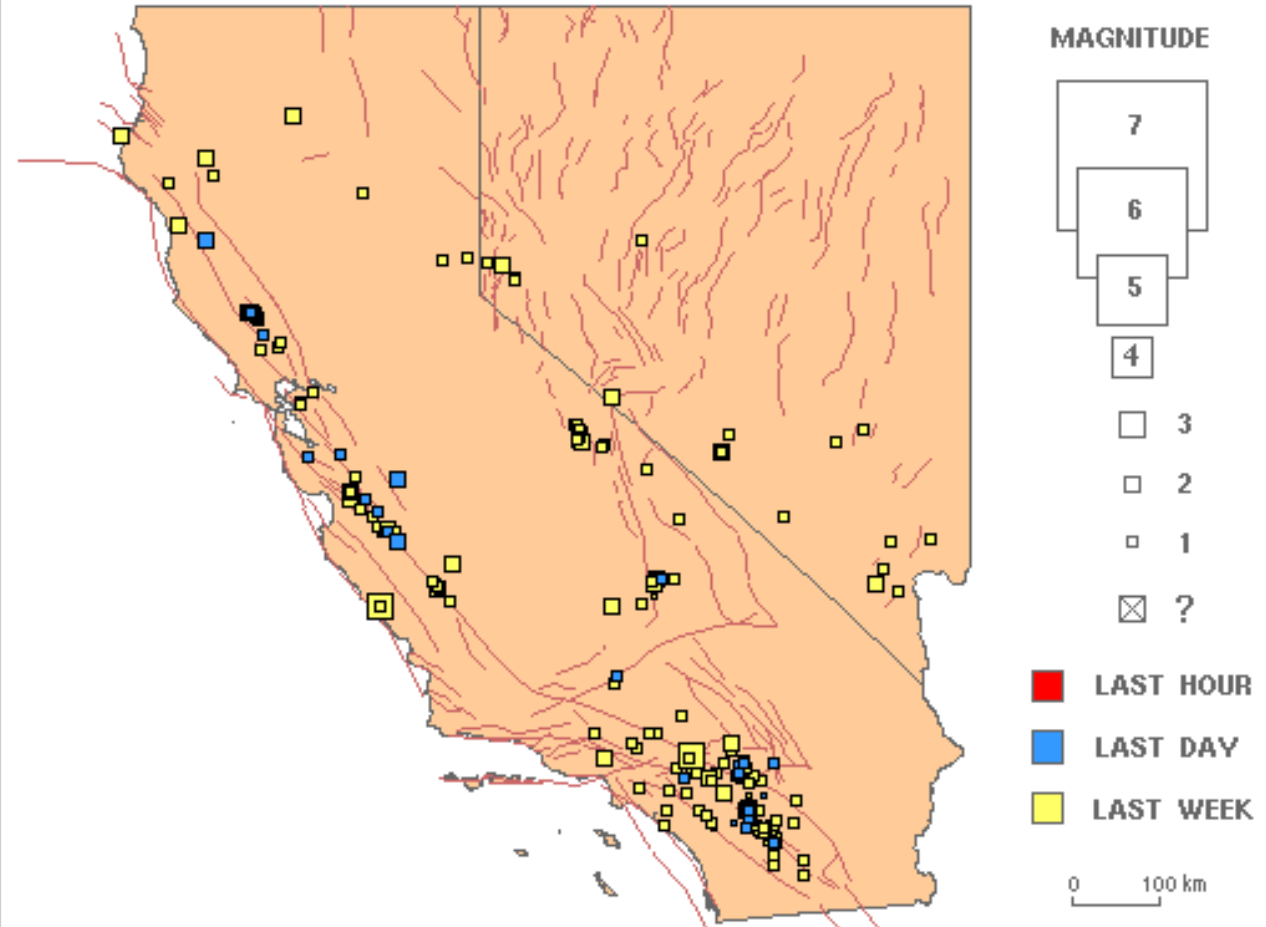
PROBABLE MAGNITUDES: ???

Dips to the north

# Real-time Earthquake Information

## Index Map of Recent Earthquakes in California-Nevada

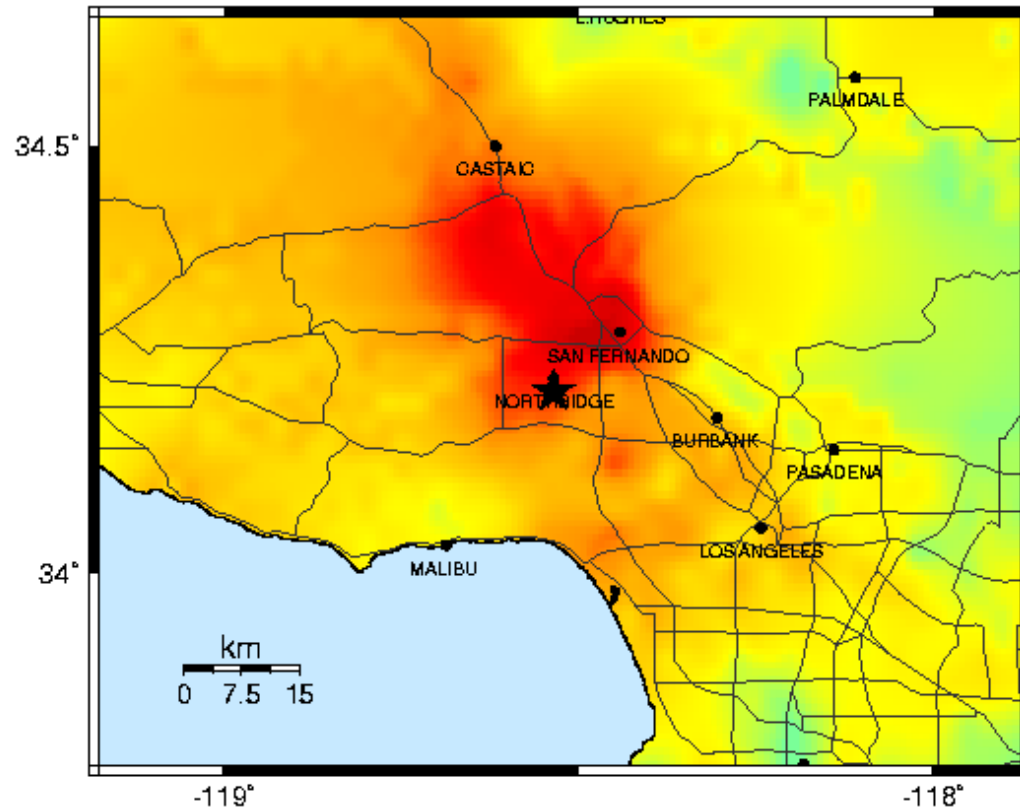
USGS·UCB·Caltech·UCSD·UNR



# ShakeMaps

## TriNet Rapid Instrumental Intensity Map for Northridge Earthquake

Mon Jan 17 04:30:55 AM PST M 6.7 N34.21 W118.54 ID:Northridge



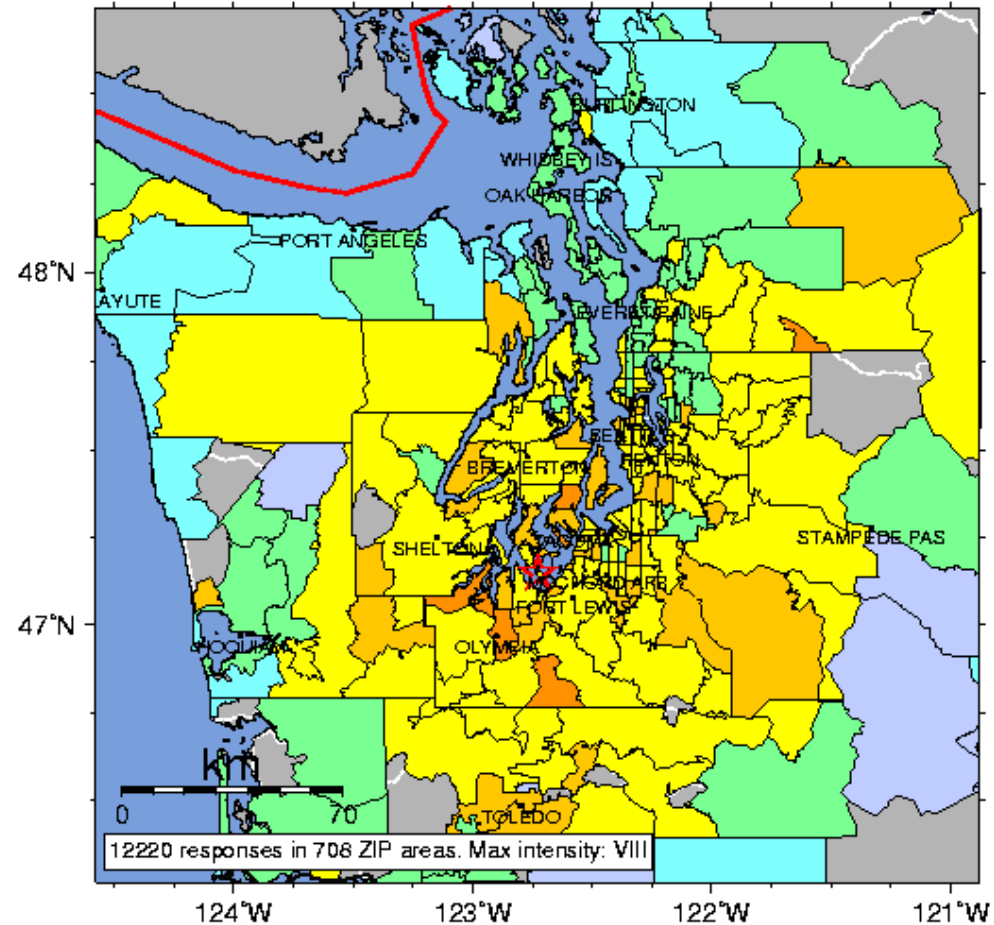
PROCESSED: Tue Jul 25 02:36:57 PM PDT, Produced by ShakeMap V2

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+

# Did You Feel It?

## Community Internet Intensity Maps

Community Internet Intensity Map (10 miles NNE of Lacey, Washington)  
 ID:2281854 10:54:33 PST FEB 28 2001 Mag=6.8 Latitude=N47.15 Longitude=W122.73



INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy





# USGS Earthquake Hazards Program

U.S. Department of the Interior  
U.S. Geological Survey

Where to go for more information:

<http://pasadena.wr.usgs.gov/>

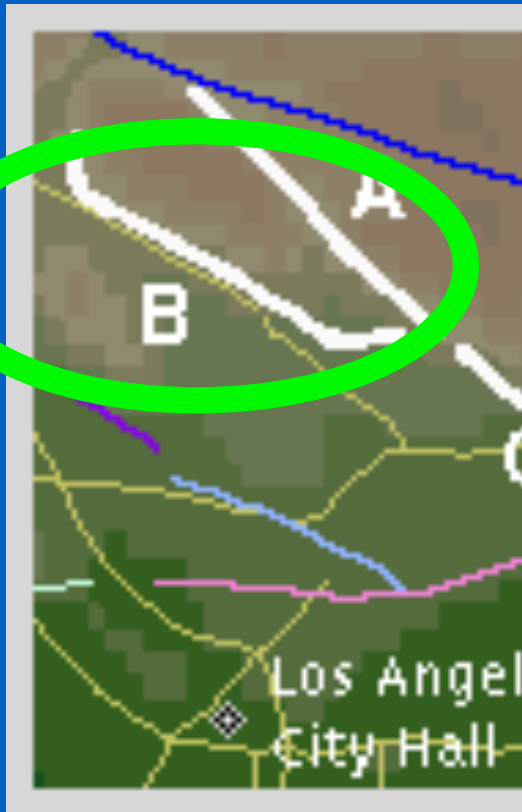
<http://earthquake.usgs.gov/>

# The End





# Faults in Our Local Area - La Canada



**TYPE OF FAULTING:** reverse

**LENGTH:** the zone is about 55 km long;  
total length of main fault segments is about 75 km,  
with each segment measuring roughly 15 km long

**MOST RECENT SURFACE RUPTURE:** Holocene,  
10,000 years to present

**SLIP RATE:** between 0.36 and 4 mm/yr

**INTERVAL BETWEEN SURFACE RUPTURES:**  
several thousand years (?)

**PROBABLE MAGNITUDES:** MW6.0 - 7.0 (?)

**OTHER NOTES:** This fault zone dips to the north.