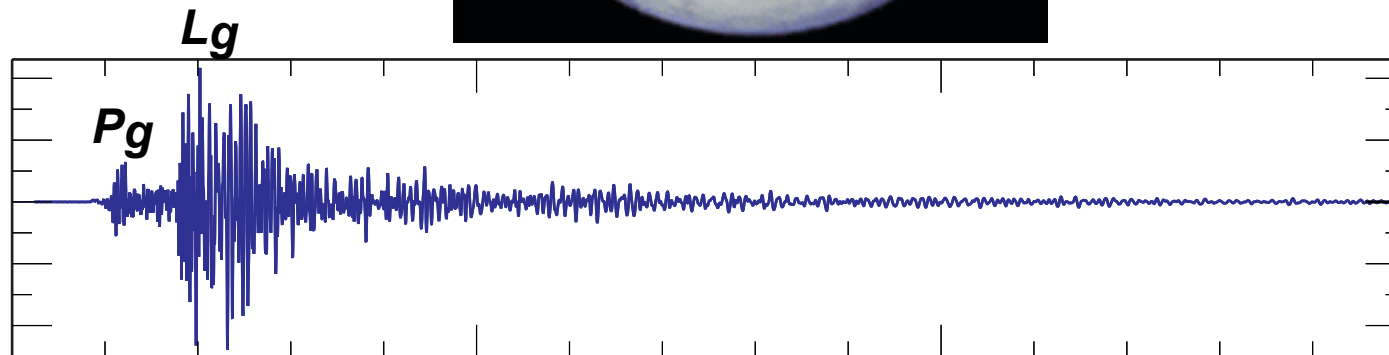


Earthquakes and Seismic Hazard in our Backyard



by Dr. Kevin Mayeda
University of California, Berkeley
Department of Earth & Planetary Sciences

Presented to the Head-Royce 6th grade class
March 10, 2008

Why do we have earthquakes?



Strange geophysical observations:

- 1) **undersea mountain ranges**

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- 2) **magnetic stripes on the ocean floor**

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- 4) **oldest ocean crust is ~200,000,000 but the oldest continental crust is ~4,400,000,000 !!**

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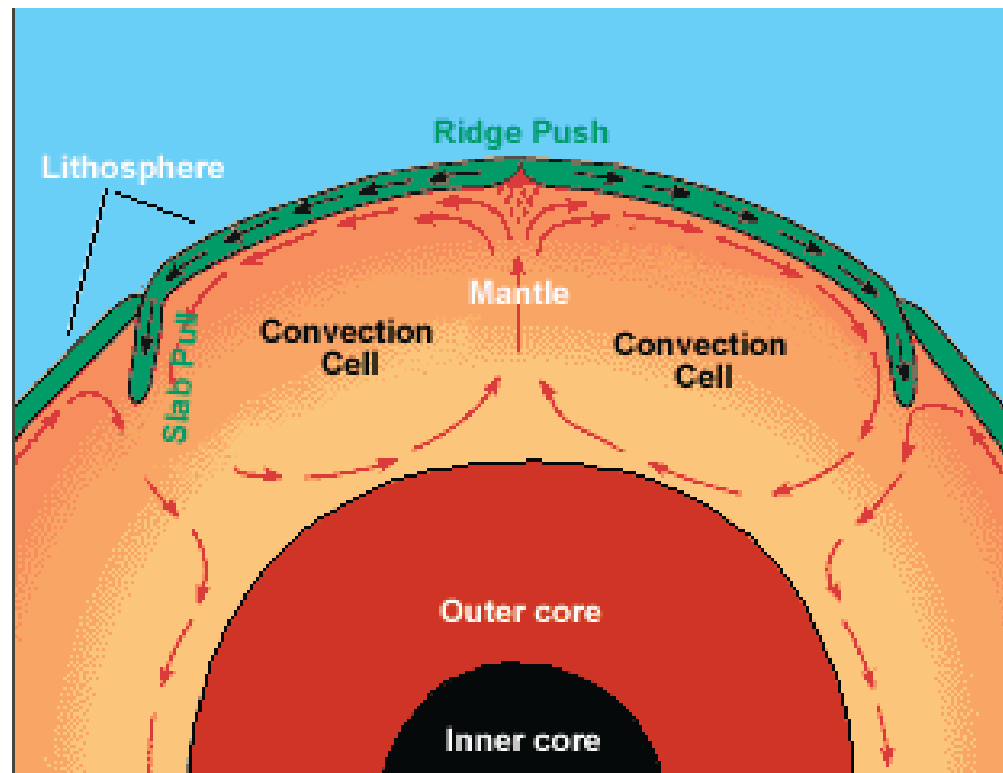
- 1) undersea mountain ranges
- 2) magnetic stripes on the ocean floor
- 3) earthquakes seem to concentrate in narrow regions
- 4) oldest ocean crust is ~200,000,000 but the oldest continental crust is ~4,400,000,000 !!
- 5) **The age of the ocean crust increases AWAY from the mid-ocean ridge.**

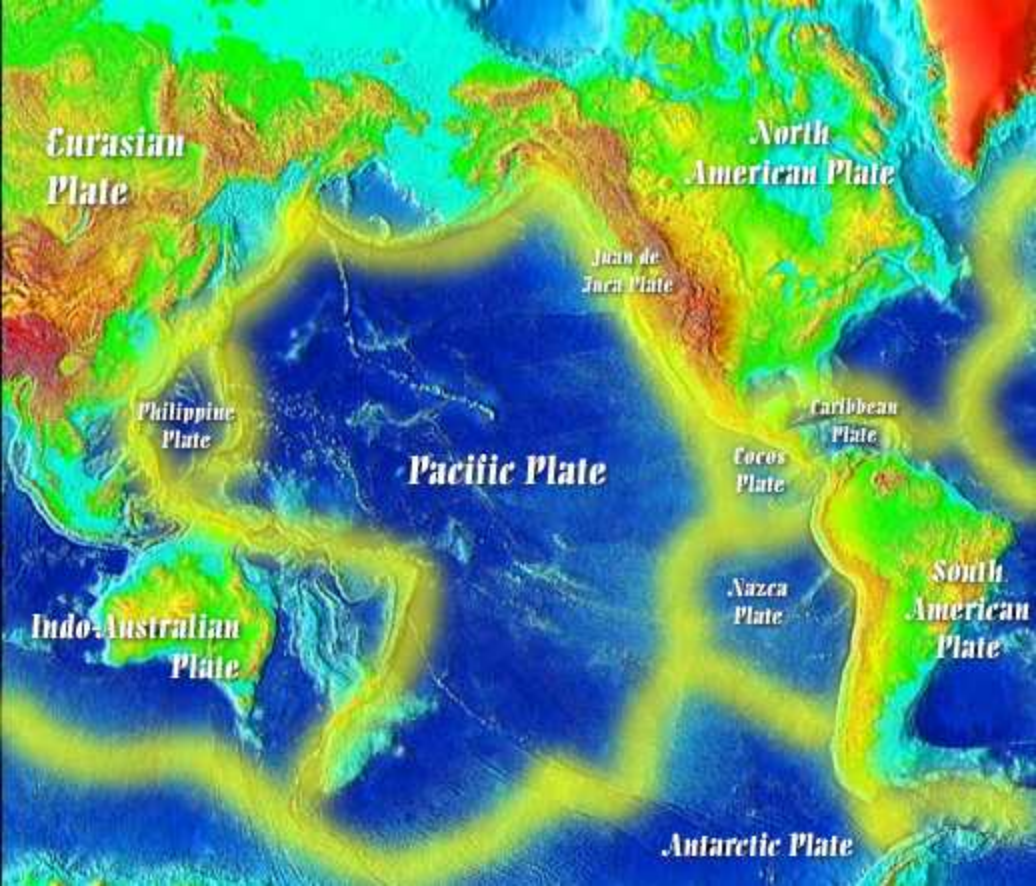
Answer: Plate Tectonics!

The Earth is trying to cool itself because of intense heat from within the core (~10,000 F) and mantle (~5000 F).

Convection cells move hot molten rock up to the surface where it cools (gets heavier), then sinks at subduction zones.

The Earth's crust floats on the top as 'plates'..., this builds up pressure at the boundaries which leads to earthquakes.





San Fernando Earthquake, magnitude=6.6

February 9, 1971



I5-I210-I14 Interchange



Roadway compression
23", most damage within 6 miles of epicenter



58 fatalities and 2000 injuries

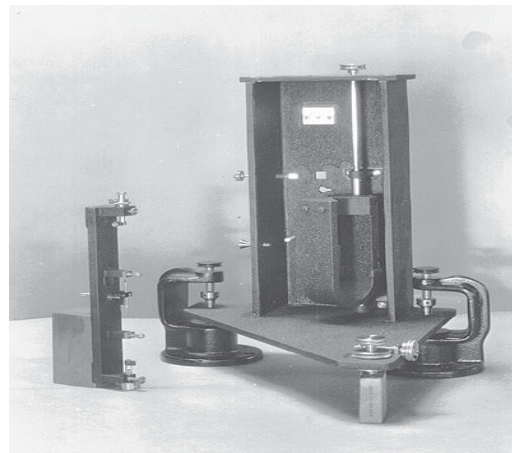
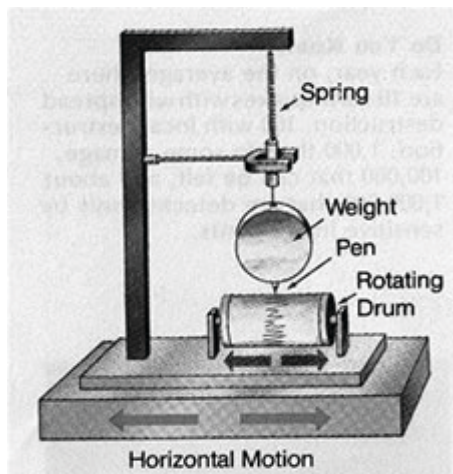
Seismometers are the tool of all seismologists



Similar to microphones, but

- they record very tiny vibrations of the Earth
- they tell us how the ground moves in all directions:
(up-down, east-west, north-south)

They are usually placed in very quiet locations: vaults, underground in tunnels, boreholes, buildings, the bottom of the ocean, and the moon!



The Chinese invented a seismometer nearly 2000 years ago!



Dragons hold steel balls that will fall into frogs' mouths when an earthquake is large enough.

How fast do seismic waves travel?



How fast do seismic waves travel?



P-waves in the crust 5.5 km/s or 12,375 mph

S-wave in the crust 3.3 km/s or 7,425 mph

P-waves in the crust travel 24 times the speed of a jumbo jet!

How fast do seismic waves travel?



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P-waves at the core-mantle boundary 13.5 km/s or 30,375 mph

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Earthquake rupture (faulting) velocity 2.3 km/s or 5175 mph

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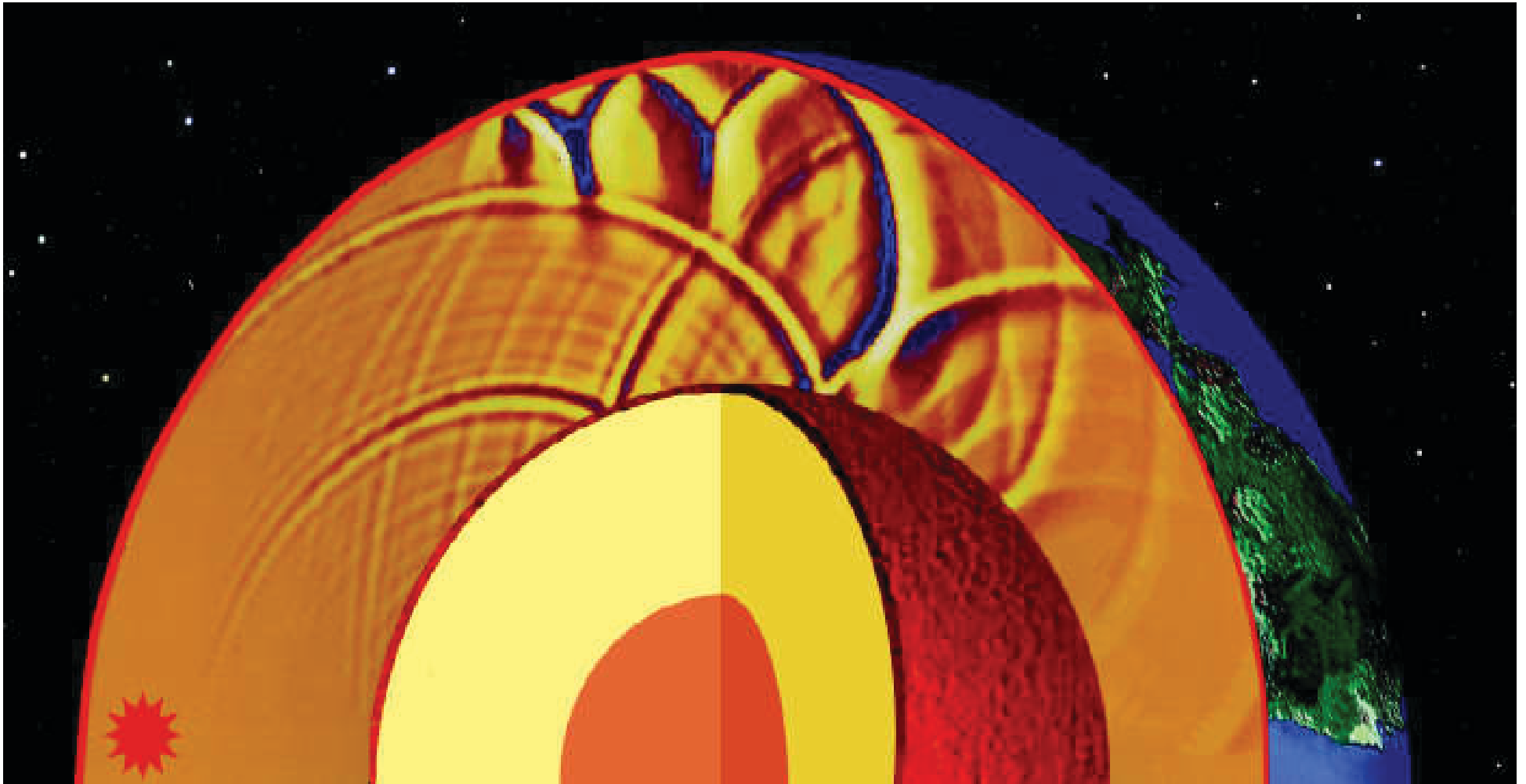
Tsunami wave in the open ocean ~500 mph

Seismologists use seismic waves to study the Earth's interior



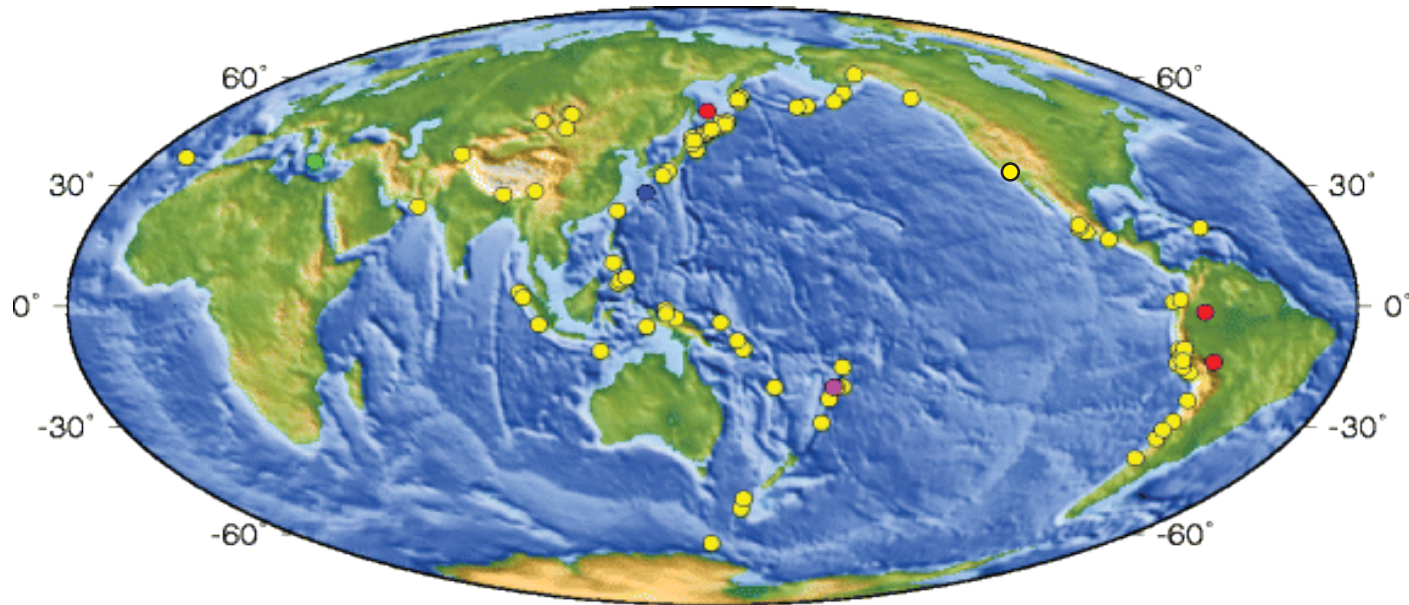
- 1) Oil & Gas Exploration
 - a) use reflected waves to image the shallow layers
- 2) Earth structure (core, mantle, lithosphere, crust)
 - a) plate tectonics
 - b) Earth evolution
- 3) Seismic Hazard Reduction
 - a) strong shaking from large earthquakes
 - b) earthquake forecasting
 - c) earthquake engineering
 - d) tsunami warning
 - e) volcano monitoring
- 4) Nuclear Explosion Monitoring

We use seismic waves generated by earthquakes and explosions to image the Earth's deep interior.

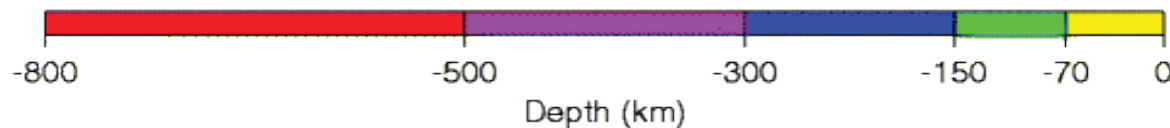


Where are the earthquakes?

Where do the biggest earthquakes occur?



Magnitude 8.0 and Greater Earthquakes Since 1900



Large earthquakes often occur around the 'Ring of Fire', but not all.

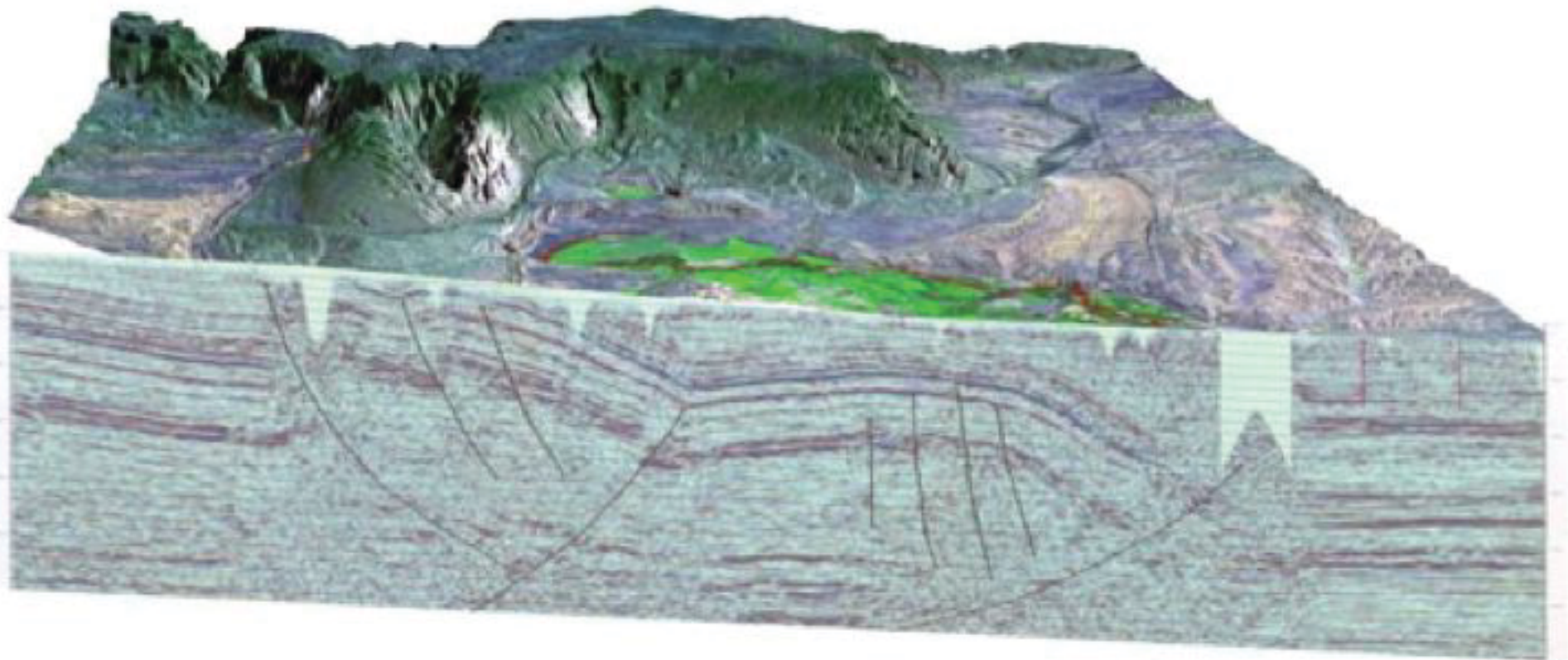
The largest events: 1960 Chile (M 9.5), 1964 Alaska (M 9.2), 2005 Sumatra (M 9.0) (1220 km, 500 secs, 2.4 km/s or 5400 mph!).

China events (1556 Shensi & 1976 Tangshan) both had close to 1 million fatalities.

We use seismic waves to look for oil and understand the Earth's crust.

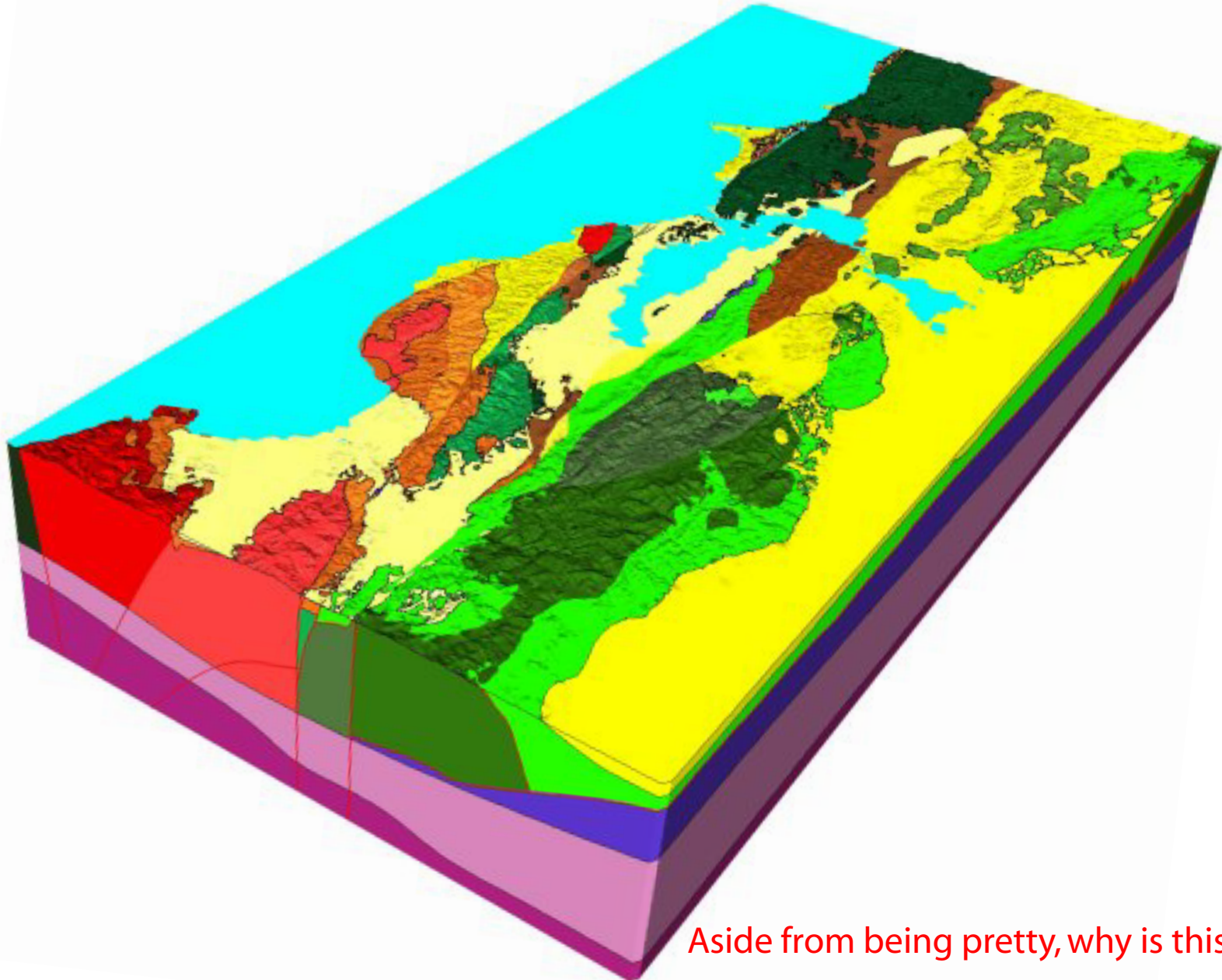


3D Seismic Reflection Profiling



Next, we use these models to predict hazard.

Seismologists work with geologists to construct a 3-D model of the SF Bay Area

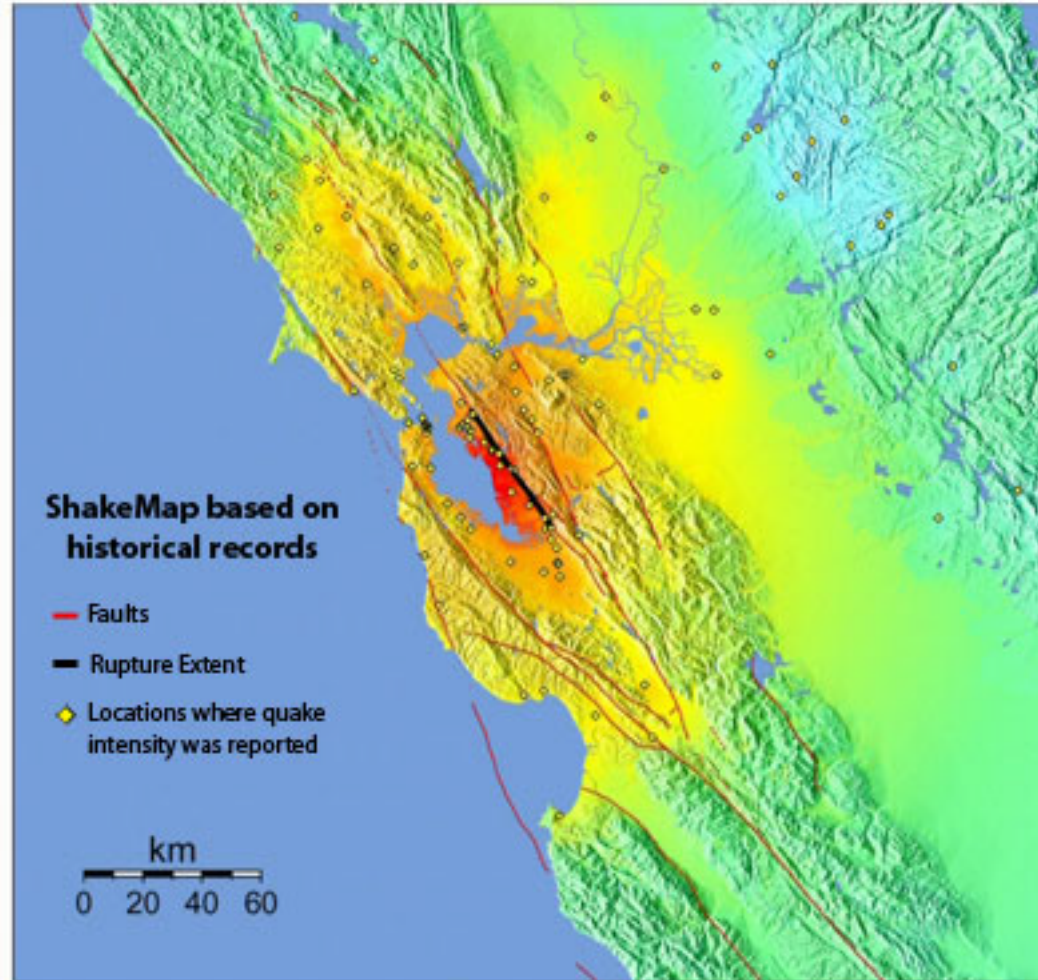


Aside from being pretty, why is this important?

What can we expect for the Hayward fault?

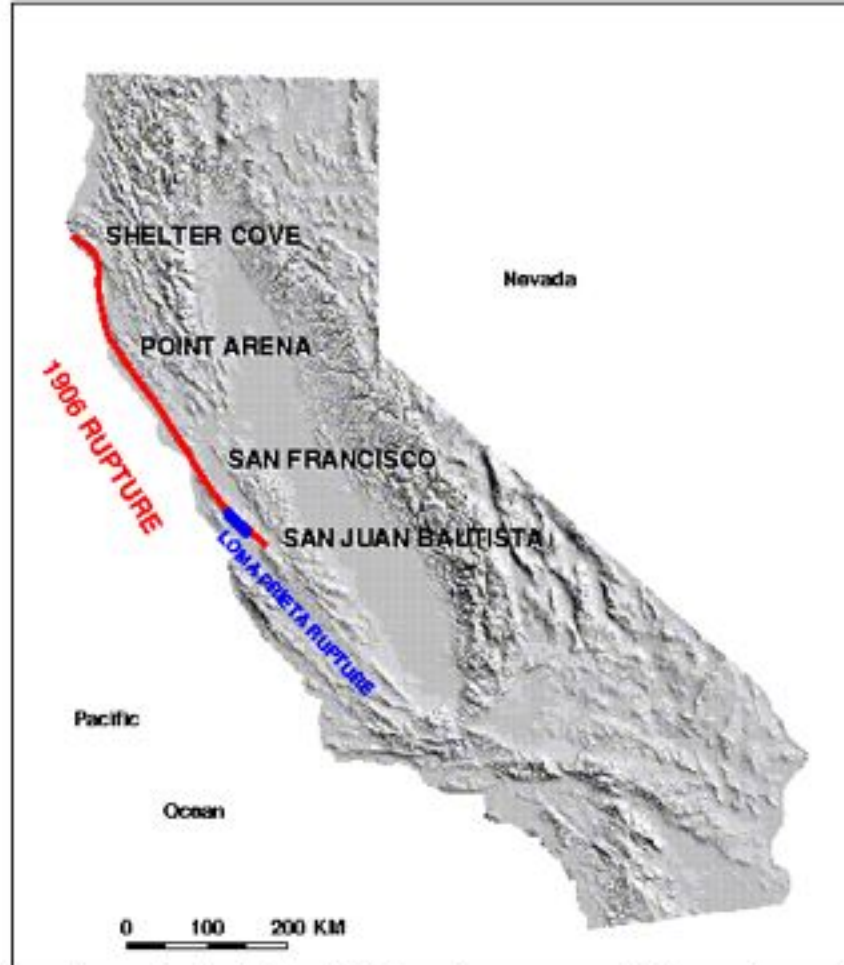


1868 M7.0 Hayward Earthquake



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+

computer video simulation next!



The following figure shows the extent of the 1906 rupture seen at the surface. (Slip on offshore segments of the San Andreas fault north and south of Shelter Cove is inferred from comparisons of geodetic observations made before and after 1906.)

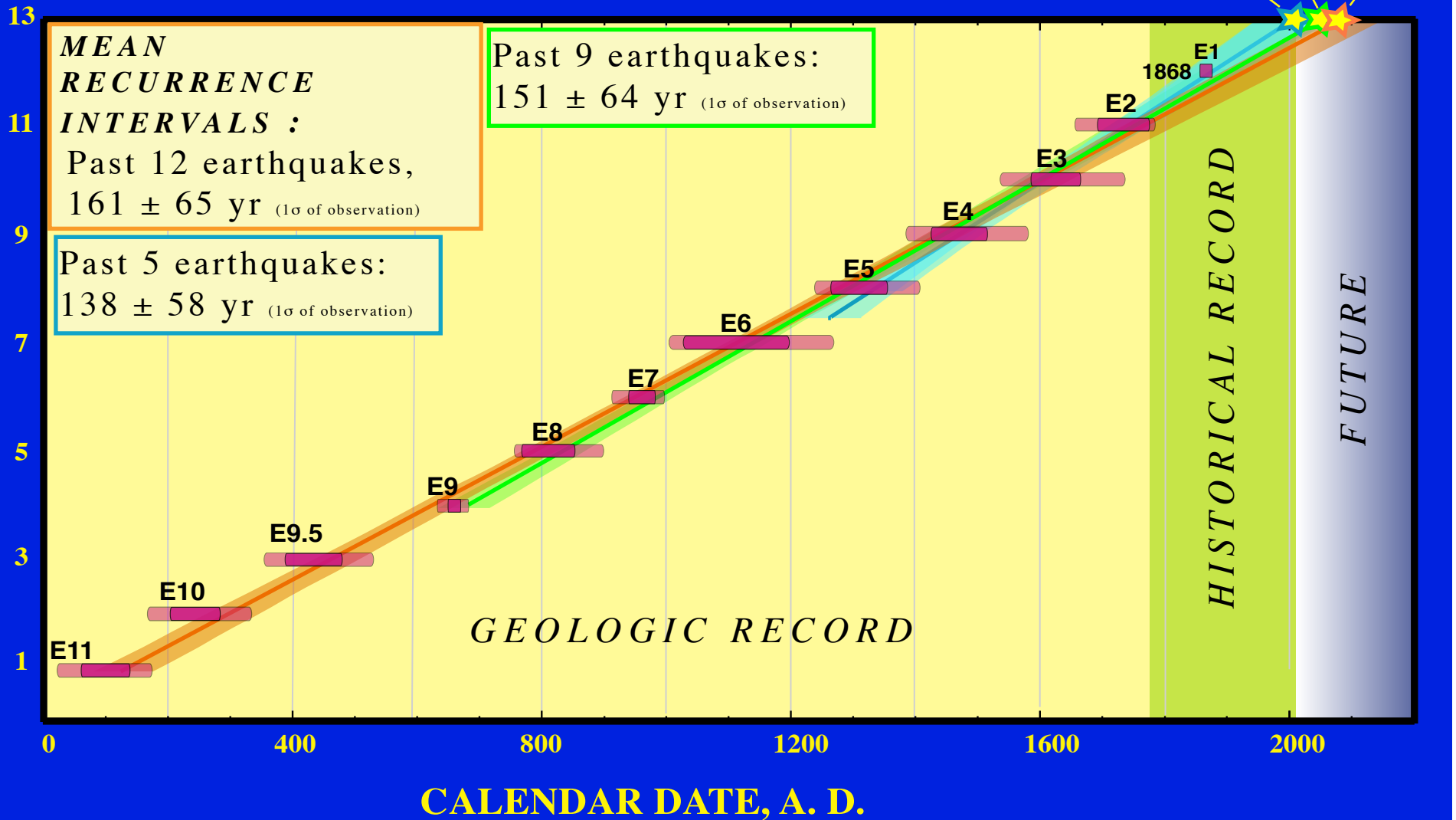
Total length is approximately 290 miles (470 kilometers).

For comparison, the 1989 Loma Prieta earthquake had a rupture length of about 25 miles (40 km)

"Violent shocks punctuated the strong shaking, which lasted some 45 to 60 seconds. The earthquake was felt from southern Oregon to south of Los Angeles and inland as far as central Nevada." - from Ellsworth (page 159).

1900-Year-Long Earthquake History on the Southern Hayward Fault

NUMBER OF EARTHQUAKES





Flour Mill



Flour Mill



Courthouse

4121 San Leandro Court House after the Earthquake 1868



Flour Mill



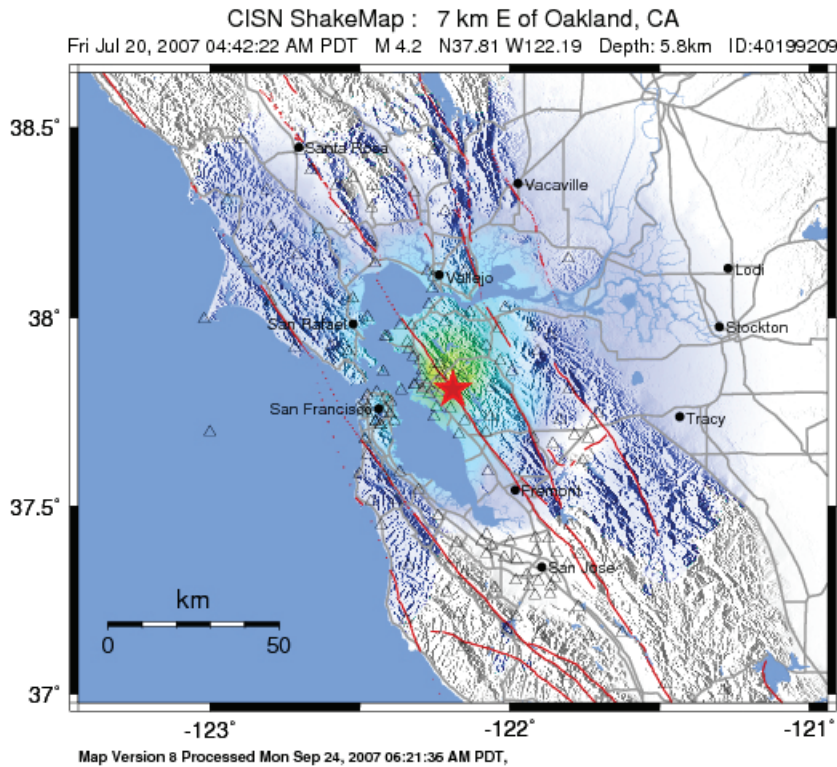
Courthouse



Downtown

San Francisco effects Earthquake 7 1868

A recent M 4.2 earthquake (July 20, 2007) south of Head-Royce resulted in lot of damage in Montclair.

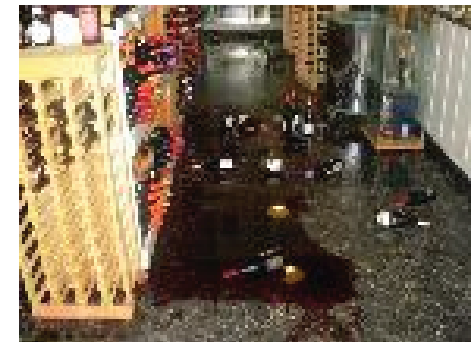


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Pelago store



Montclair Wine Shop



My house



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Over 10 years, that would mean ~9 earthquakes with magnitude 4.2 each day!

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A magnitude 7.0 earthquake slips about 90 cm, but a magnitude 4.0 earthquake slips only a few millimeters.

It is very likely that we will all experience a large magnitude earthquake in our lifetime. What can we do to prepare?



Our homes and buildings are much stronger and better designed than those in the past, however, as the videos showed, large ground motion can send furniture and smaller objects flying.

We should secure large furniture to the walls and secure breakable objects...., tell your parents!

Many injuries from earthquakes during the night time come from cut feet. Keep a pair of old shoes under your bed just in case!

It is likely that emergency help may not be available for over 72 hours following a damaging earthquake so you should have enough water and food stored in an earthquake kit.

Similarities with the Haiti Earthquake



Enriquillo-Plantain Garden fault ruptured ~50 km with a maximum offset of ~5 meters.

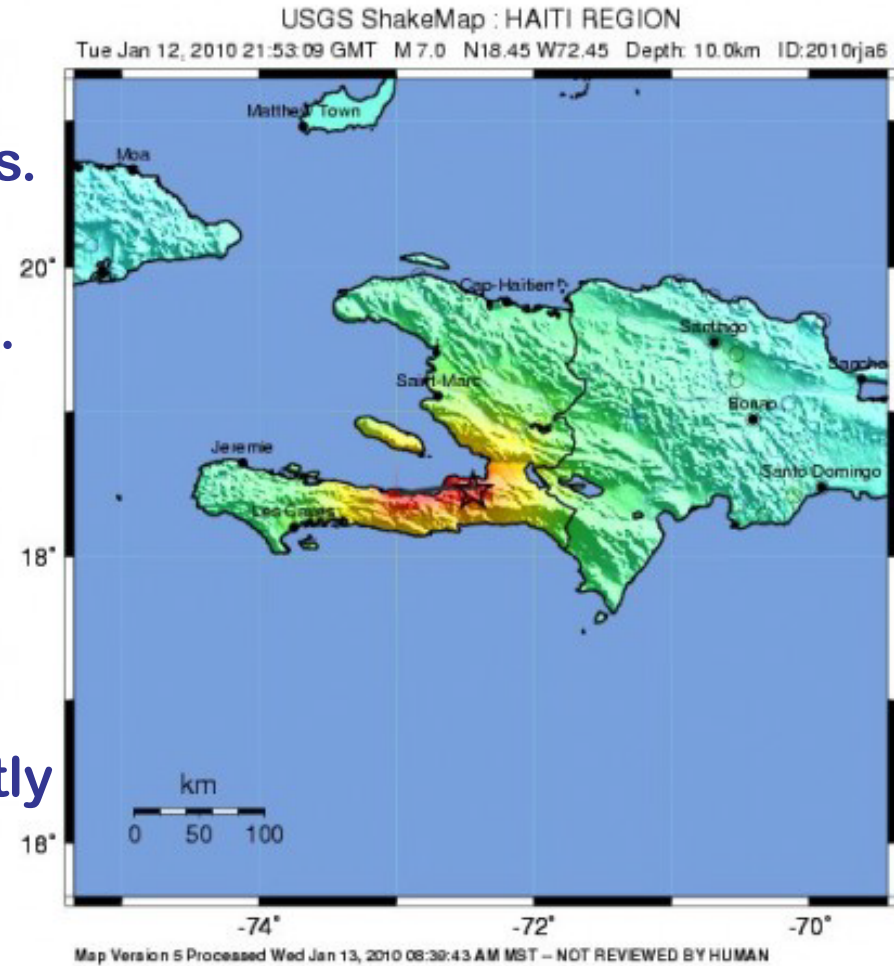
In the past ~2000 years, there have been 12 large earthquakes on the Hayward fault.

Large population center that lives within 20 km of the fault.

EPGF zone is analogous to the Hayward fault (Hwy 13).

However, building practices are significantly better here, though damage is likely to be widespread.

The Haitian earthquake serves as a huge wake-up call for those of us that live in the east bay.



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Haiti Earthquake



Haiti Presidential Palace









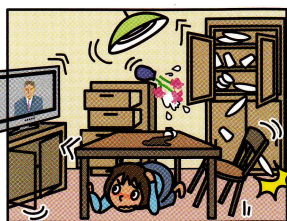
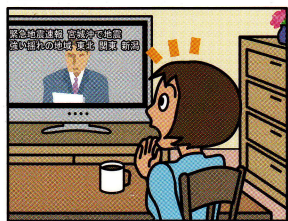
SEISMOLOGICAL RESEARCH LETTERS

Volume 80, Number 5

September/October 2009

At Home

- Protect your head and take shelter under a table
- Don't rush outside
- Don't worry about turning off the gas in the kitchen



In Public Buildings

- Follow the attendant's instructions
- Remain calm
- Don't rush to the exit



Earthquake Early Warning: Dos & Don'ts

When Driving

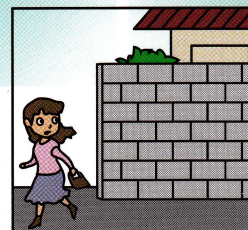
- Don't slow down suddenly
- Turn on your hazard lights to alert other drivers, then slow down smoothly
- If you are still moving when you feel the earthquake, pull over safely and stop



Remain calm, and secure your personal safety based on your surroundings!

After seeing or hearing an Earthquake Early Warning, you have only a matter of seconds before strong tremors arrive. This means you need to act quickly to protect yourself.

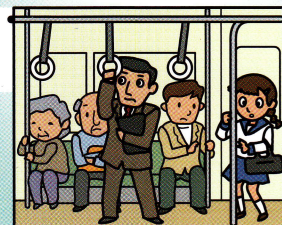
Outdoors



- Look out for collapsing concrete-block walls
- Be careful of falling signs and broken glass
- Take shelter in a sturdy building if there is one close enough

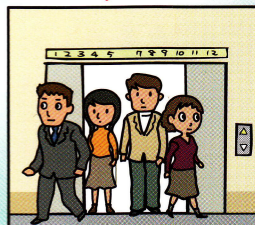
On Buses or Trains

Hold on tight to a strap or a handrail



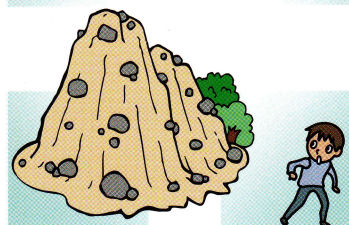
In Elevators

Stop the elevator at the nearest floor and get off immediately



Near Mountains/Cliffs

Watch out for rockfalls and landslides



What Can You Do?



- Expect no assistance for at least 72 hours.
- Water, electricity, and gas lines cross the fault.
- Highways, bridges, and tunnels will likely be damaged.
- Tree tops along the fault could snap, especially pines.
- In addition to your family's earthquake kit have a plan on where to meet, keep cash on hand.
- Neighborhood-Watch earthquake shed.
- Old shoes under your bed.
- Retrofit your home and secure large furniture!

San Francisco Earthquake $m=7.7-8.3$

April 18, 1906



San Francisco City Hall
Poor workmanship, material and design



Howard Street
Buckling caused to earth flow



Looking west from
Telegraph Hill
Most damage from fire



Thiele Building, Palo Alto

Collapse due to lack of tie between walls and frame



Stanford University Church



Fence in Marin County

8.5' Offset, fault trace is not visible



Stanford University Gym

Collapse of brick walls

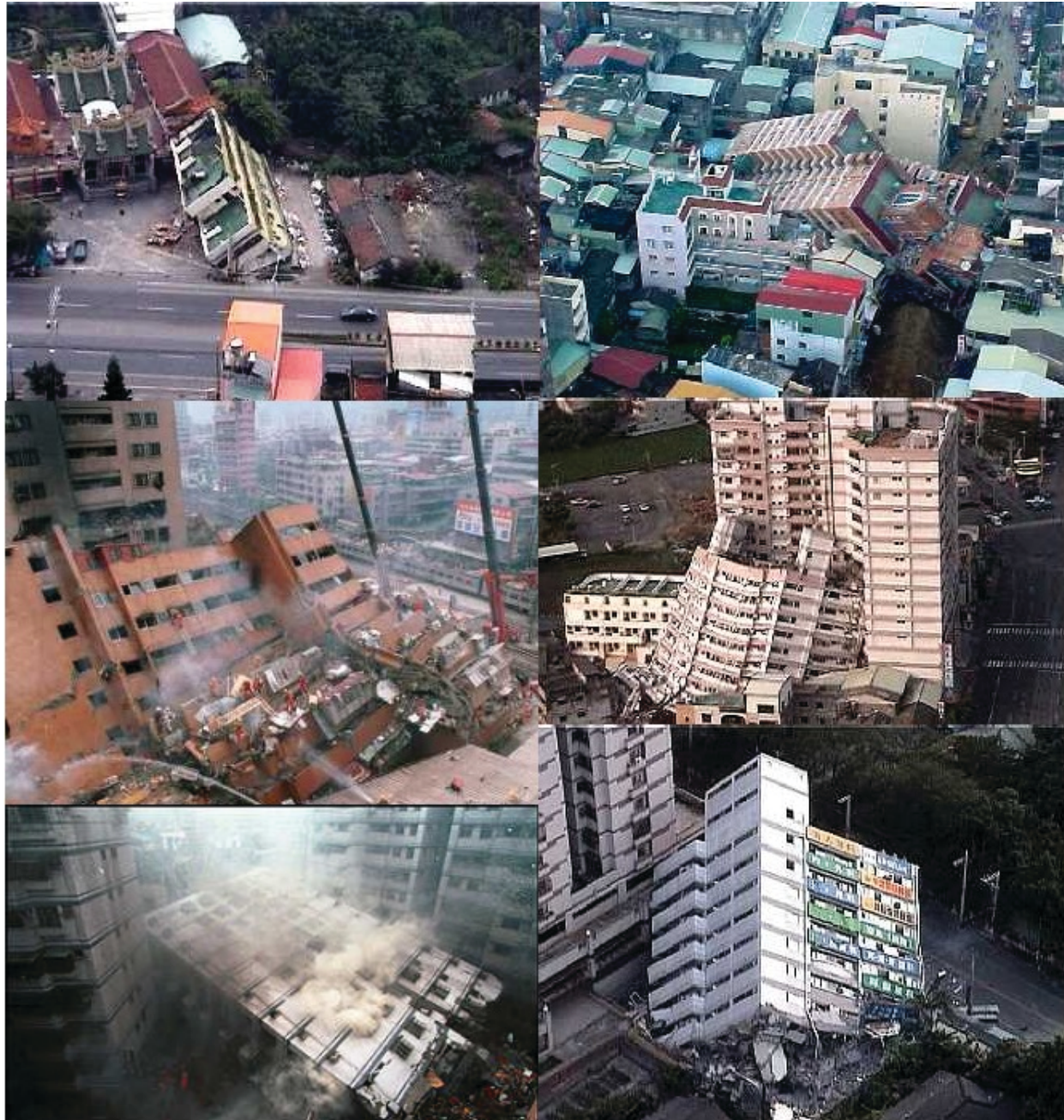


1970 Venezuela
Debris flow from the mountainside
triggered by earthquake.

2001 Bhuj, India (M 7.7)
Poor construction resulted in
a large amount of damage and
loss of life (20,000).



Earthquake hazard



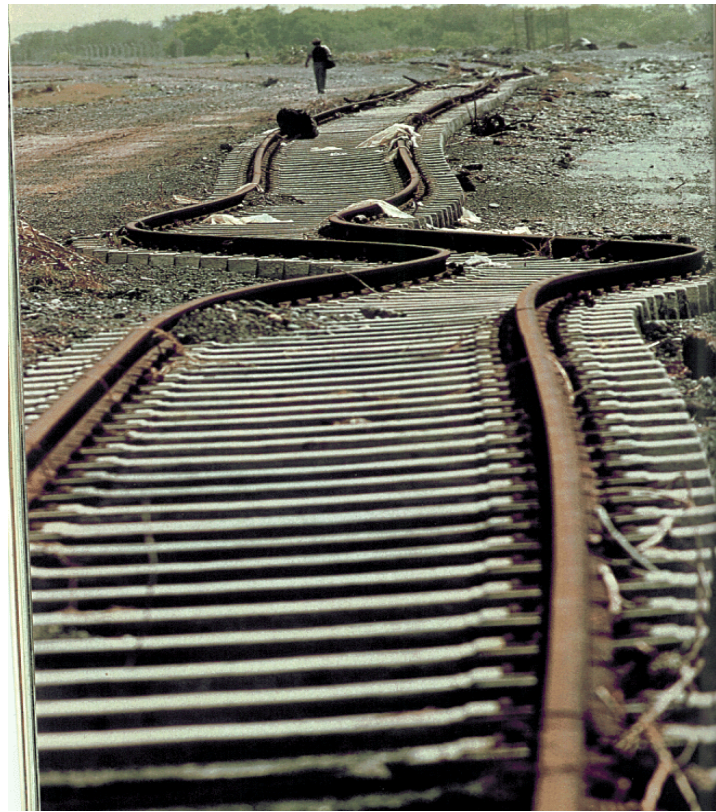
1999 Chi-Chi, Taiwan M 7.2







1964 Alaska (M 9.2) Ground failure



Unknown
Fault displacement



1964 Niigata (M 7.2) Liquefaction



1989 Loma Prieta (M 7.9)
Ground failure in Santa Cruz mountains





Northridge Earthquake, magnitude=6.7

January 17, 1994

57 fatalities and 1500 injuries



15-I14 Interchange



Photo: USGS/E.V. Leyendecker

I10 Freeway at La Cienega

Clues from Historical Place Names

One of the areas that was found to have large site-response factors due to amplifications in soft sediments, was at the collapse of the I-10 freeway at La Cienega Blvd. At present it is difficult to see but, prior to 1825, the Los Angeles River flowed through this location and the surficial geology is composed of sands and gravels from the old river channel. The place name, La Cienega, was given to the area in the 1700's, and in Spanish means "the swamp."

Loma Prieta Earthquake, magnitude= 7.0

October 17, 1989



Cypress Structure



Bay Bridge

On October 17, 1989, an earthquake measuring 7.0 on the Richter scale rocked the San Francisco Bay Area in the early evening, collapsing a portion of the San Francisco Bay Bridge and a three-quarter mile, double-decked section of the Nimitz freeway in Oakland known as the Cypress Viaduct. As well, the shaking damaged a large number of buildings in the cities of Watsonville, Santa Cruz, and Oakland and in the San Francisco districts of the Marina and South of Market. The earthquake resulted in 63 deaths, 13,757 injuries. Property losses amounted to 1,018 homes destroyed, 23,408 homes damaged; 366 businesses destroyed, 3,530 businesses damaged. The total estimated direct economic loss was valued at more than \$5.9 billion (US\$ 1989 dollars) in public and private property damage. Despite these tragic losses, the Loma Prieta earthquake was a moderate California earthquake whose epicenter was located at a distance over 50 miles south of heavily populated San Francisco and Oakland in the Santa Cruz Mountains on the San Andreas Fault. In less than fifteen seconds of ground shaking, the Loma Prieta earthquake awakened a nation to the threat to life and safety posed by strong, urban earthquakes.

How Tsunamis Work: Tsunamigenesis

