

Natural Disasters

Lecture 17

Ch 7 – EQs Throughout the United States and Canada

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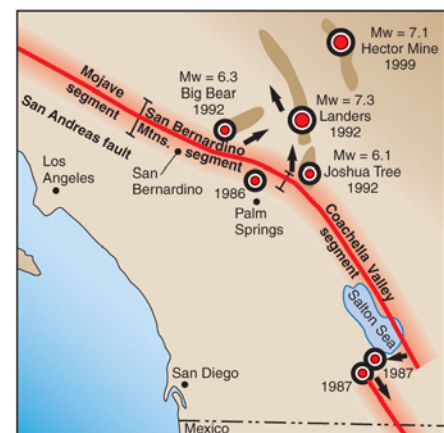
Chapter 5

5.1: Ch. 5 – EQs Throughout the United States and Canada

- **How Faults Work:** the fault movement begins at a hypocenter and then propagates outward for a **certain distance and length of time**. How much stored energy is released during an EQ depends on the **number of seconds the fault moves**. (It was previously thought that an EQ would release all the elastic strain and the buildup would begin anew.)

(Fig. 5.2)

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- **Southern San Andreas Fault:** neotectonic analyses indicate that the **last four major EQs** on the **Coachella Valley** segment occurred about **250** years apart, and the most recent one happening **~1690**, over **315** years ago!

- In 1988, this fault was given a **40%** probability of a **7.5 M_w** EQ by **2018**.

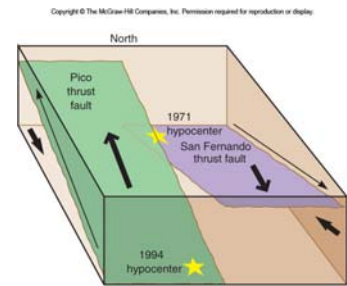
- The **Coachella Valley** segment has about 20 ft of unreleased movement. If that EQ triggers the **San Bernardino** segment (last EQ in 1812, ~14 ft of unreleased movement), the combined magnitude could be about **7.8**, and if it also triggers the **Mojave** segment (last EQ in 1857, ~15 ft of unreleased movement), the combined magnitude could reach **8.0**!

- ◆ **Thrust Faults in Southern California:** the constriction at the “Big Bend” of the San Andreas fault has caused shredding and slicing, which have split Southern California into a **complex maze of east-west oriented thrust faults (reverse faults)**, narrowing valleys and uplifting mountains.

- ◆ Many of these faults do not reach the surface and are called **blind thrusts**.

- The Los Angeles area is being **compressed** 10-15 mm/year, which could generate an EQ in the **M_w mid-6s** every 6 years, plus an EQ of an **M_w 7** every 10 years!

- **Northridge, California, 1994:** at 4:31 AM on 17 January, a huge EQ, **6.7 M_w**, the Pico **blind thrust** in the San Fernando Valley ruptured at 19 km (11.8 mile) depth, moving 3.5 m (11.5 ft) northward, as it pushed up the south-dipping fault surface! (Fig. 5.5)



- ♦ Ground acceleration was as high as **1.8 g horizontally and 1.2 g vertically**. This **intense shaking** caused the widespread failure of buildings, parking garages and bridges, that killed 57 people, injured 9,000 and caused \$40 billion in damages!

- The death toll would have been much greater if it had not been **very early** on a Federal Holiday, MLK Day! If the EQ had occurred **during working hours**, an estimated 3,000 more people may have been killed.

- The 1971 San Fernando EQ had a **M_w of 6.6** and moved toward L.A., but in 1994, the energy was away from L.A.

- ♦♦ **“The Big One”:** the EQ hazard in **Los Angeles** focuses on two fault systems: **(1) San Andreas**, east and north of L.A.; last major movement in 1857; and, **(2) east-west oriented thrust faults** that caused the 1971 San Fernando and 1994 Northridge EQs.

- ♦♦ If the **San Andreas** moved in a magnitude **8** at the same time as the **thrust faults** move in a **7**, it would be as if the **1857, 1971 and 1994 EQs** all occurred simultaneously!

♦ **USGS “significant EQ”:** a magnitude of **6.5 or greater**, or causes **deaths or considerable damage**.

♦ In the U.S., **Alaska** is the **most active EQ** state, followed by California, Hawaii and Nevada. Together, those four states make up about **90%** of all EQs of magnitude 3.5 or greater. The **least** active state is **Florida**.

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TABLE 5.4

**Most Active Earthquake States
(magnitudes 3.5 and above, 1974–2003)**

State	Number of Earthquakes
1. Alaska	12,053
2. California	4,895
3. Hawaii	1,533
4. Nevada	778
5. Washington	424
6. Idaho	404
7. Wyoming	217
8. Montana	186
9. Utah	139
10. Oregon	73
Top 10 states total	20,702
Bottom 40 states total	378

Source: US Geological Survey.

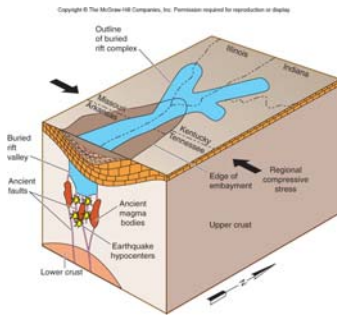
● **Intraplate EQs:** there are **clusters of EQ epicenters** in the so-called “stable” (intraplate) regions of the central and eastern U.S. far away from the active tectonic plate edges.

● **New Madrid, MO, 1811-1812:** a succession of EQs rocked the sparsely settled central part of the **Mississippi River** at the time of the “War of 1812”. Between 16 December 1811 and 15 March 1812, a total of **1,874 EQs** (8 violent, 10 very severe) were recorded by an amateur seismologist, Jared Brooks.

● The EQs (**7.0 to 7.5 M_w**) were felt from Canada to the Gulf of Mexico and from the Rocky Mountains to the Atlantic seaboard, where clocks stopped, bells rang and plaster cracked.

♦ The area was sparsely populated in 1811-1812, but today:

(1) the area is **heavily** populated (e.g., St. Louis, Memphis);
 (2) most buildings are **not** EQ-proofed; (3) the wide extent and thickness of **soft** sediments will amplify seismic vibrations;
 (4) a very **large area** will be subject to shaking. The USGS predicts a **90%** chance of a **6-7 M_w EQ** in the next **50** years.



- The **New Madrid** region is an **ancient rift valley**, known as the **Reelfoot rift**. It formed about 500 million years ago and became a **failed rift**. Today it is occupied by the **Mississippi River**. (Fig. 5.37)

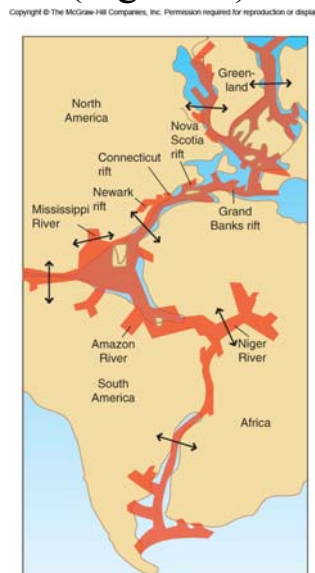
◆ The opening Atlantic Ocean basin pushes North America to the west-southwest. This **compresses** the weakness of the **ancient rift valley faults** and creates EQs.

● **Intraplate EQs - Eastern North America:** the large EQs occur at sites of **ancient rift valleys** that developed 180-220 million years ago when **Pangaea** was torn apart. Some rift arms **succeeded and combined** to create the Atlantic Ocean. Other rift arms **failed** and left behind weakened zones within continents.

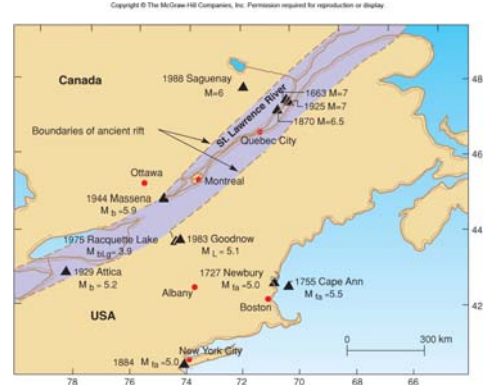
◆ **New England EQs:** there is a long record of significant EQs, many related to the faults that **bound former rift valleys**. The next **6+ M_w EQ** to strike the eastern U.S. will likely be **more destructive** than for a similar EQ in the western U.S., as the EQ energy is more effectively transmitted in the **older, more solid rocks**. This would extend the damage area.

● Furthermore, consider: (1) **high** population density of the east; (2) large number of **older buildings** not designed to withstand EQ shaking; (3) the high concentration of **industrial and power-generating facilities**, including **nuclear reactors**!

(Fig. 5.39)



- **St. Lawrence Valley EQs:** this is another river that occupies an **ancient, now-buried rift valley** and is responsible for most of the significant EQs (many reaching M_w 7) in southeastern Canada. (Fig. 5.40)



- There is a very active area near **Charlevoix (northeast of Quebec City)**, where EQs of **6-7 M_w** have occurred in 1534, 1663, 1791, 1860, 1870 and 1925. About 350 million years ago, a **meteorite impact** occurred here, causing intensive **fracturing of the area**. Again, the **compressional** forces of the opening Atlantic may be **reactivating these fractures**.

- **Hawaii EQs:** the underground movement of **magma** generates EQs up to **7.9 M_w** by forcefully rupturing **brittle rocks**. The land is uplifted as **magma** is injected and dropped down when **magma** is removed. These sudden EQ-generating events can also trigger **tsunami**.

- **Human-Triggered EQs:** by pumping water underground under pressure, extracting coal, oil and gas, by building dams and impounding water, and by underground nuclear explosions.

- ◆ **Sichuan, China, 2008:** at 2:28 PM on 12 May, the ongoing collision of **India pushing into Asia** created a **7.9 M_w EQ**. When the shaking ended 2 minutes later, about 90,000 people were dead and 5 million homeless. The world's largest dam, **"Three Gorges,"** located only about 350 miles east of the epicenter, may have been a "trigger" for this EQ due to the sheer **weight of water** behind the dam. Natural and/or human EQ?