Active Deformation of the San Francisco Bay Area

- **The Cause**: Plate tectonics in California
- **The Culprit**: The San Andreas fault system
- **The Consequences**: Earthquakes and the earthquake cycle along the San Andreas
- **The Connection**: Earthquakes and landscapes as a result of deformation along the San Andreas fault
- **The “Cure”**: Understanding, forecasting and living with earthquakes in the Bay area

BASP Lecture - 08/13/2001
available at: [www.seismo.berkeley.edu/~burgmann/education.html](http://www.seismo.berkeley.edu/~burgmann/education.html)

**Fundamental Questions**

- “Is California going to fall in the ocean?” or “What is the long-term tectonic development of the San Andreas fault system?”
Fundamental Questions

- “When is the next Big One?” or “Can we predict earthquakes based on our understanding of the history and mechanics of San Andreas faulting”?

The Cause: Plate Tectonics

- Evolution of the Pacific - North America plate boundary

Press and Sievers, 2001
At the Root of it All: Plate Tectonics

- Evolution of the Pacific - North America Plate Boundary
- The San Andreas fault system

The Culprit: The San Andreas Fault System

- Where are the faults and how do they move?
- Plate tectonics predicts lateral motion between Pacific and North American plates
- Faults that move laterally (rather than up and down) are called strike-slip faults
Strike-slip Faults

- No shortening
- No uplift

The San Andreas fault is a *right-lateral fault*
Right-lateral Hayward Fault

The SAF System in the Bay Area

- Where is deformation taking place in the Bay Area?
- Look at geology, landscapes, and location of earthquakes
Only Strike-slip Faults in Bay Area?

- Where do the hills come from?

Thrust faults in the Bay area
The Consequences:
Earthquakes

Elastic Strain Accumulation
Earthquakes represent the shaking associated with fault rupture.

Demonstrating the Earthquake Cycle

- You can produce steady sliding (creep) and stick slip (earthquakes) in a simple table top experiment.
Earthquakes vs. Fault Creep

Downtown Hayward, 1868

http://www.seismo.berkeley.edu/seismo/geotour/stadium.html

Current Seismicity Information at Your Finger Tips

quake.wr.usgs.gov/QUAKES/CURRENT/index.html
www.seismo.berkeley.edu/seismo/
neic.usgs.gov/neis/current/
The Connection: Earthquakes and the Bay Area

- The hills, the valleys, the Bay, the soils, the climate, flora, and fauna are all linked to earthquakes shaping the earth through geologic time

Why Study Earthquakes?

- Evidence of plate tectonics and the evolution of geology and landscapes
- Earthquake hazard and mitigation
- Earthquake forecasting and prediction
The “Cure”: Understanding Earthquakes in Bay Area

Bay Area Earthquake History

• 16 M > 6 Quakes in 80 years before 1906
• 5 M > 6 Quakes in 95 years after 1906

• Good or bad news?
Living in an Earthquake’s Shadow

- **San Andreas F.**
  - 1906 $M_w=7.7$
  - Ruptured from San Juan Bautista to Cape Mendocino
  - Relieved large amount of stress
  - Is the spring loaded again?

Dating Earthquake Fossils: Paleoseismology

- Digging up faults
- Date earthquakes using $^{14}$C
  Extend earthquake record back 1000s of years
Geodesy Measures Active
Strain Accumulation

- GPS allows us to measure strain accumulation
- We can determine fault slip rates

Forecasting Earthquakes

- We can not predict earthquakes.
- Using historic and pre-historic earthquake patterns, fault slip rates, and geodetic measurements we can estimate probability of future earthquakes
Earthquake Hazard Factors

- The substrate matters!
- Stable bedrock is good
- Mud and fill is bad

Shaking Hazard Maps

- Shaking hazard & damage depend on:
  - Earthquake magnitude
  - Distance to earthquake
  - Quality of construction
  - Soil properties

- You can view shaking intensities from many scenario earthquakes for all cities on the web.
- Of course, quality of construction is as important

www.abag.ca.gov/bayarea/eqmaps/eqmaps.html