Earthquakes Refresher and Cupertino DPW support

October 3, 2019
Jim Oberhofer KN6PE

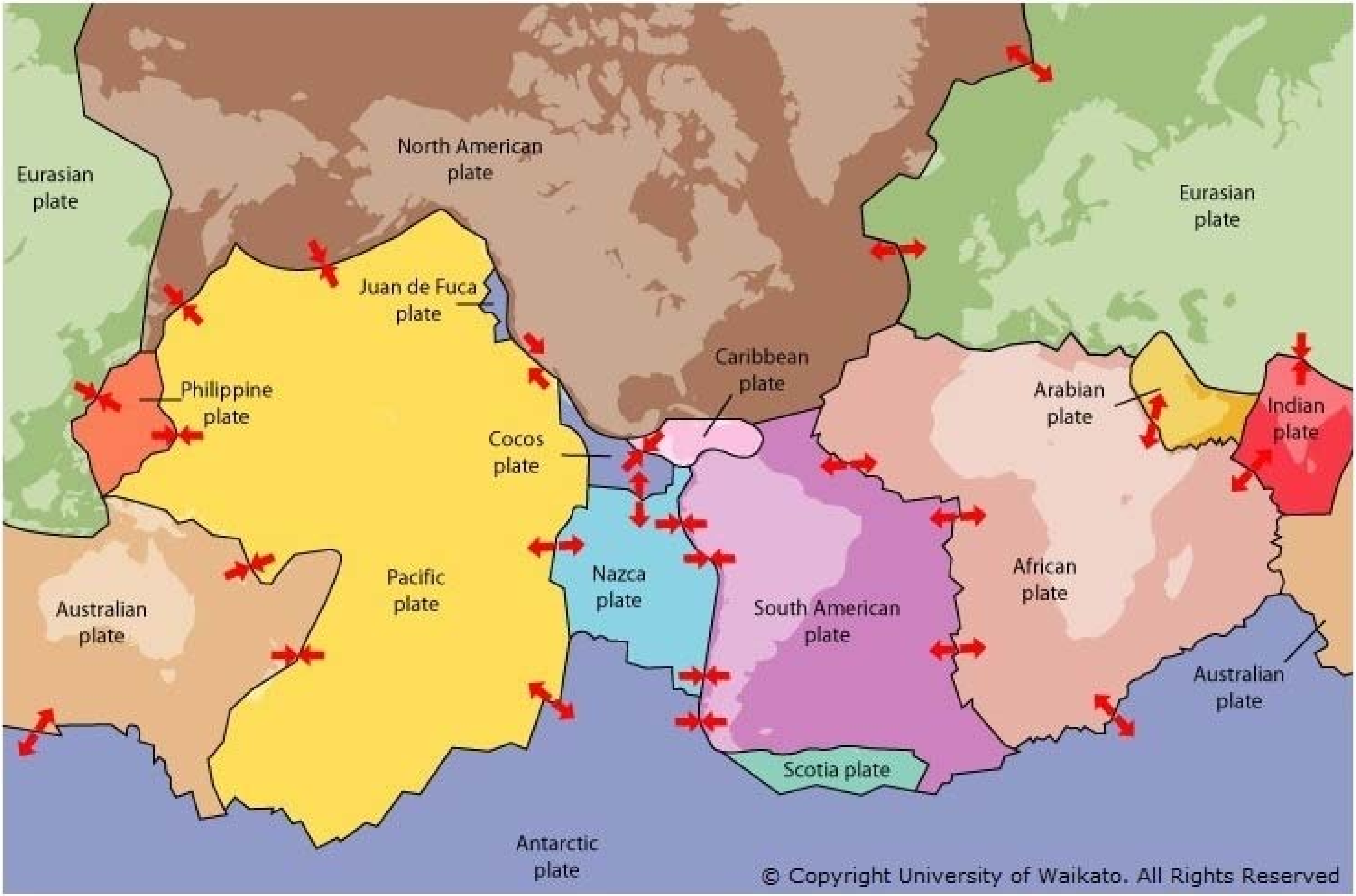
Topics for tonight

1. Earthquake Refresher
    - Plate tectonics and boundaries
    - Faults and Fractures
    - Waves
    - Geology
2. Cupertino Department of Public Works
    - Situation
    - Areas of Interest
3. Looking for problems
    - Utility Poles
    - Roads
    - Bridges

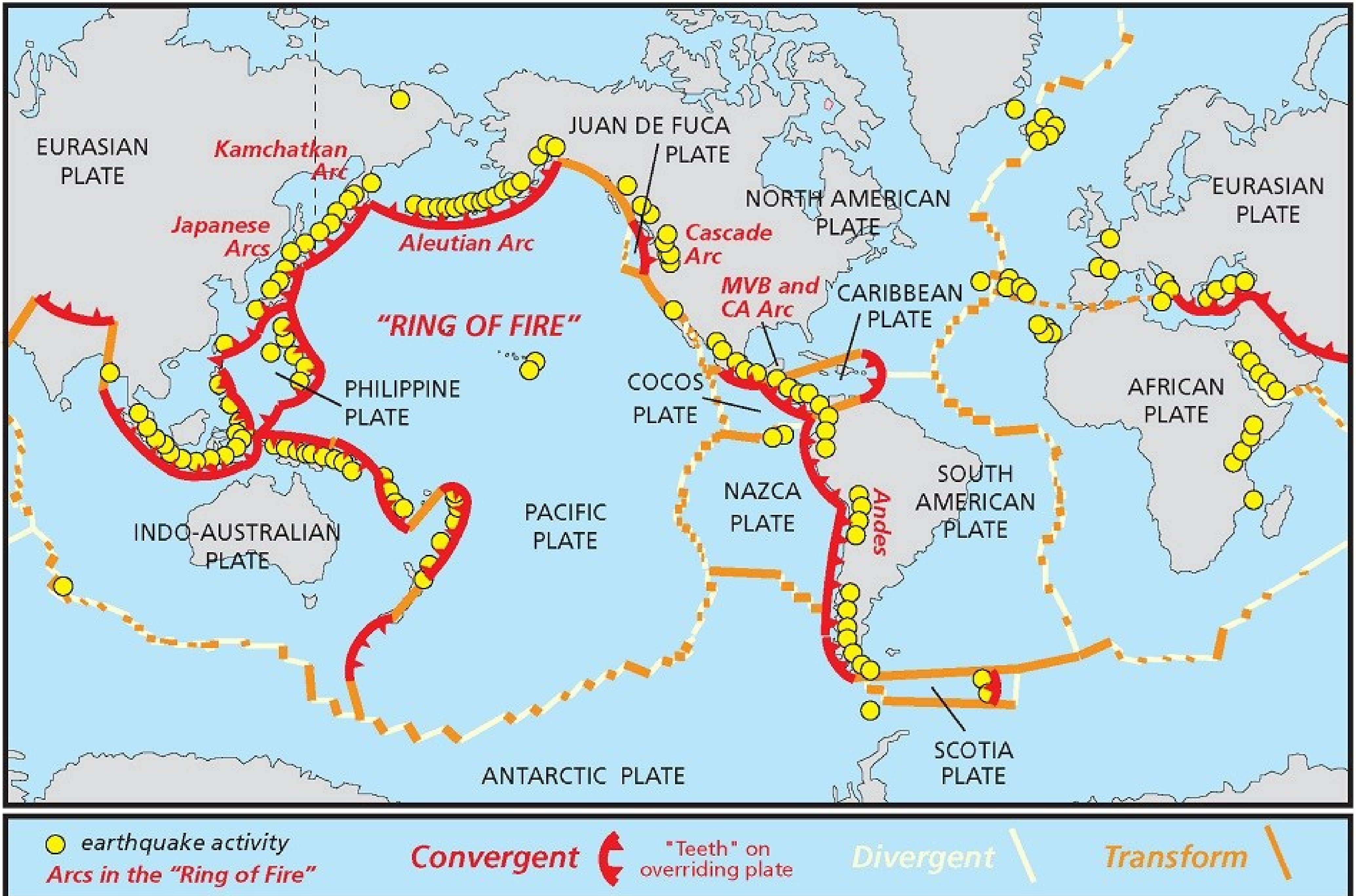
Plate Tectonics

- Plate tectonics describes how the Earth's outer shell is divided into several plates that glide over the rocky inner layer (mantle) above the core.
- The Earth has a dozen or so major plates and several minor plates.
- Tectonic plates are constantly on the move.
  - Fastest: 15 centimeters (6 inches) per year
  - Slowest: less than 2.5 centimeters (1 inch) per year.
- Many potentially catastrophic geologic phenomena – earthquakes, volcanic eruptions, and tsunamis – originate at the narrow boundary zones between plates.

Tectonic Plates and Plate Boundaries



All the action is at the edges



All the action is at the edges

Three basic things happen where plate edges meet:

1. Plates can move apart (**divergent** plate boundaries)
2. Plates can push against each other (**convergent** plate boundaries)
3. Plates can slip past each other (**transform** plate boundaries)

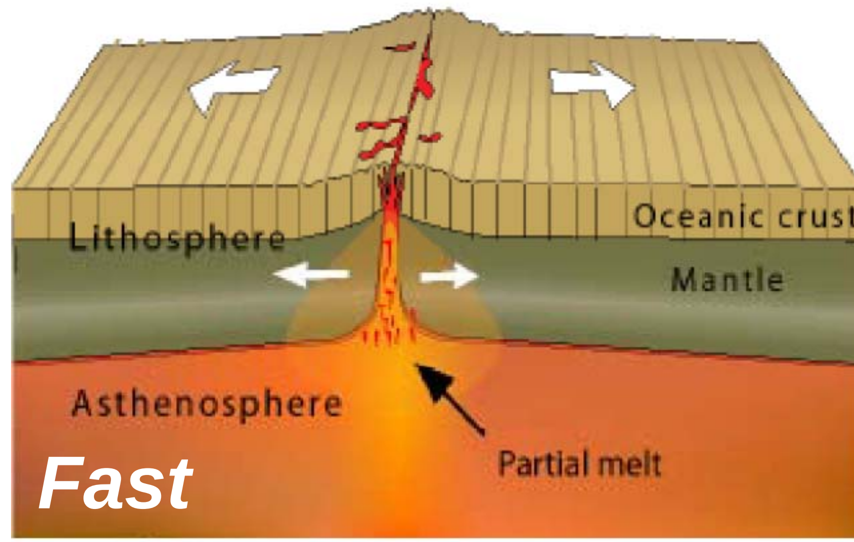
Types of plate boundaries

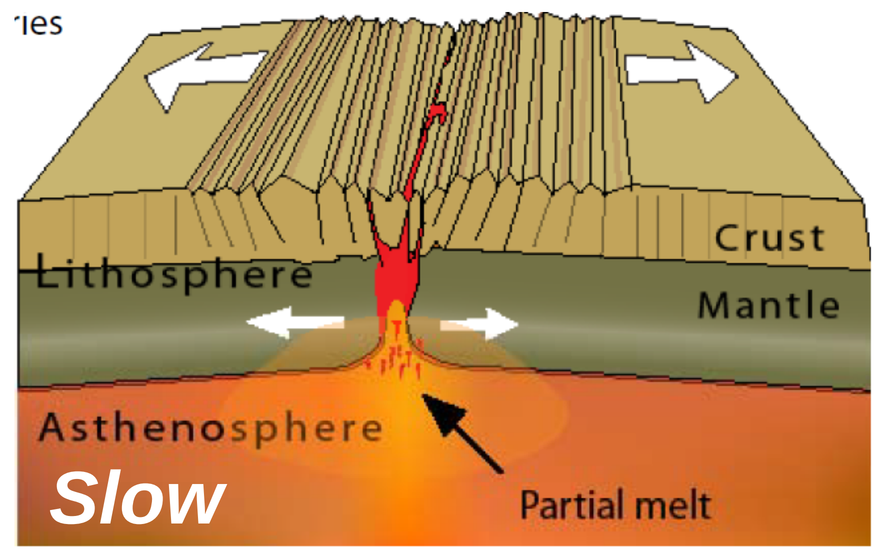
Move Apart / Divergent Plate Boundaries

Hot mantle rock rises and partial melting occurs. New crust is created by the magma pushing up from the mantle.

Fast-spreading ridges; High heat and magma input making the ridge buoyant; East Pacific Rise.

Slow-spreading ridges form valleys on the ridge crests; Lower heat input; Mid-Atlantic Ridge.

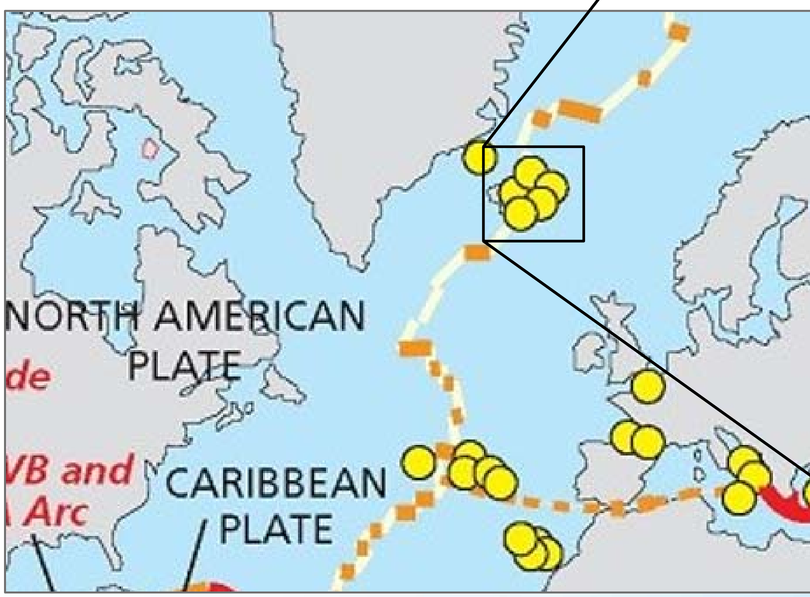


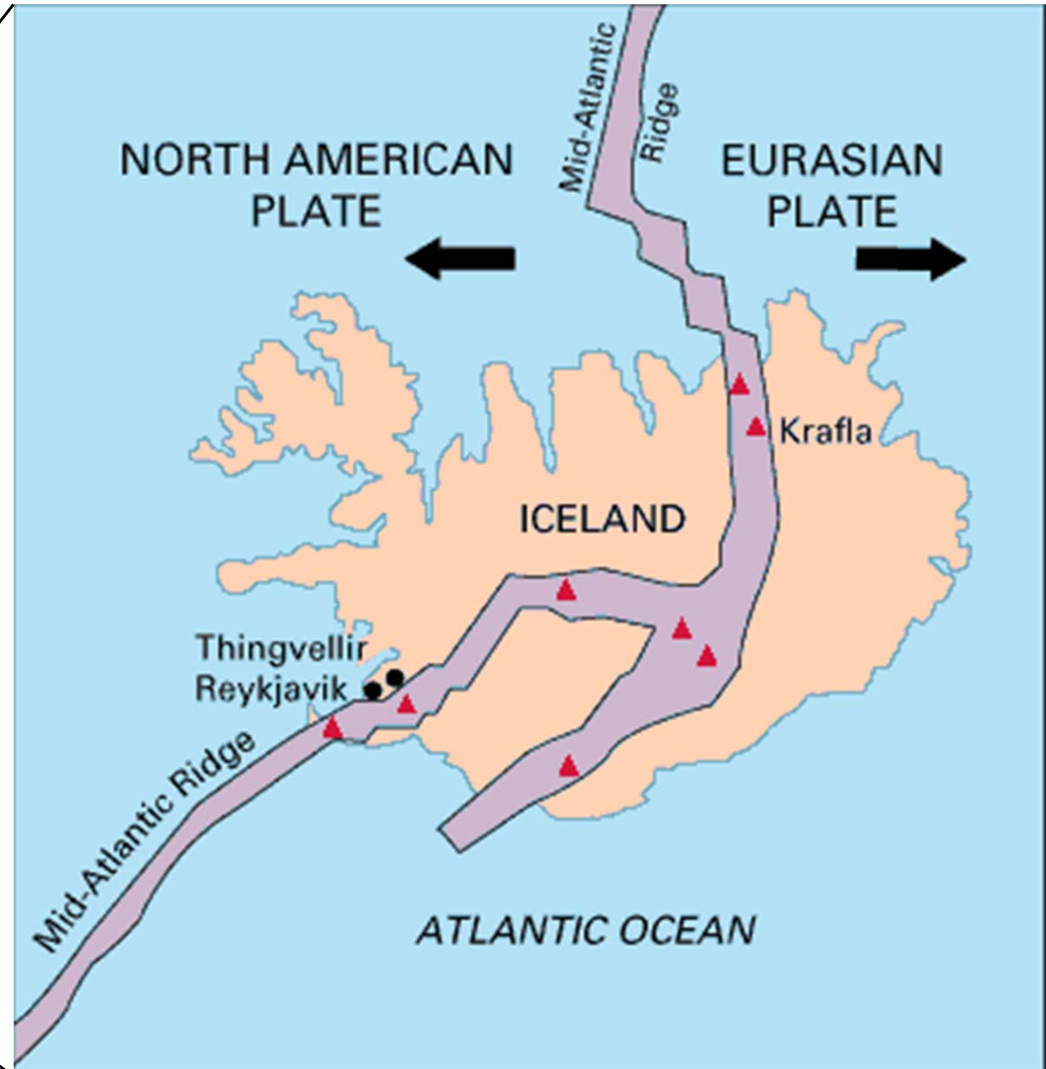


Types of plate boundaries

Divergent Plate Boundaries

Iceland straddles the Mid-Atlantic Ridge and is splitting along the spreading center between the North American and Eurasian Plates. Spread rate is 2 to 20 cm per year.





Types of plate boundaries

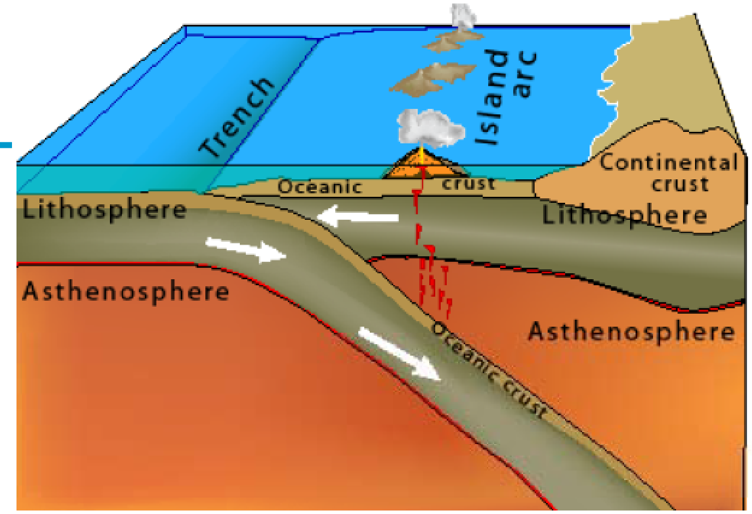
Push together / Convergent Plate Boundaries

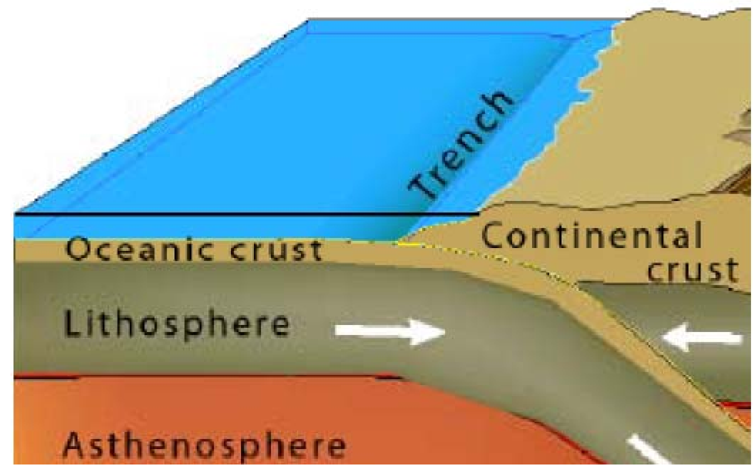
Crust is destroyed as two plates move towards each other. The heavier plate dives (subducts) beneath the more buoyant plate.

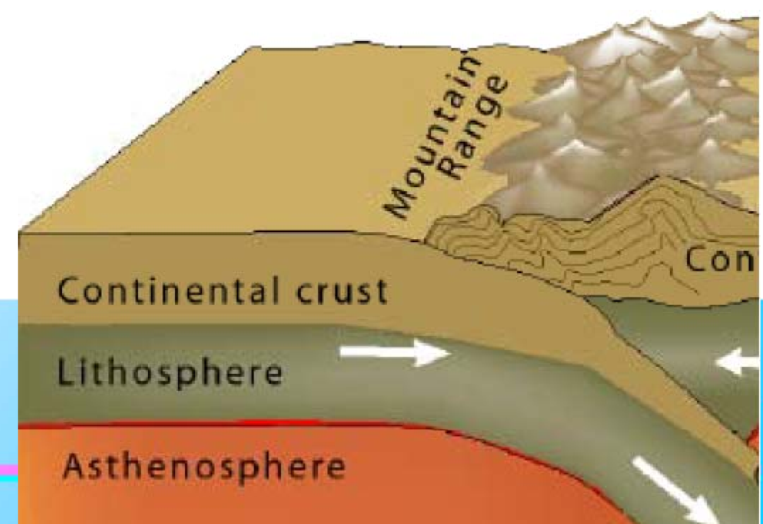
Oceanic-Ocean convergence; The Marianas Trench

Oceanic-Continental convergence; Juan de Fuca plate subducting beneath the Pacific Northwest

Continental-continental convergence; The Himalayan mountain range







Types of plate boundaries

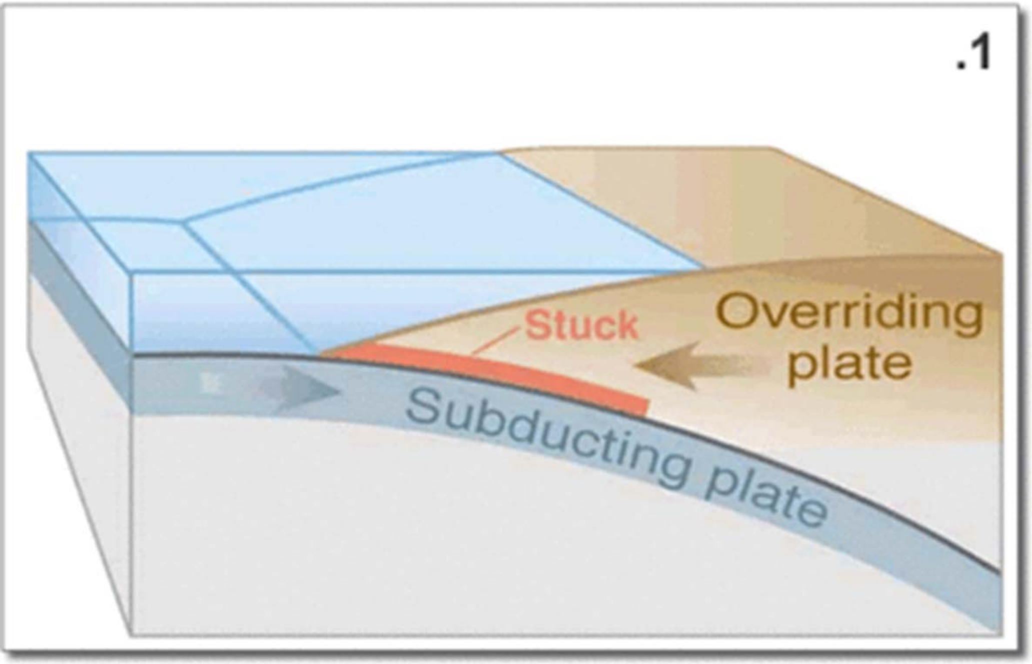
Cascadia Subduction Zone

Juan de Fuca plate is subducting under the North American Plate and produces **volcanoes**

Types of plate boundaries

Cascadia Subduction Zone

Juan de Fuca plate is subducting under the North American Plate and produces **volcanoes** and **tsunamis**

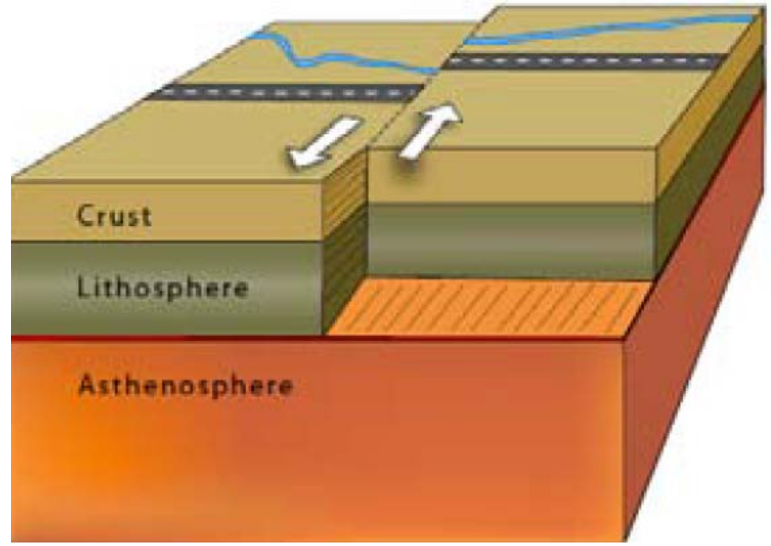


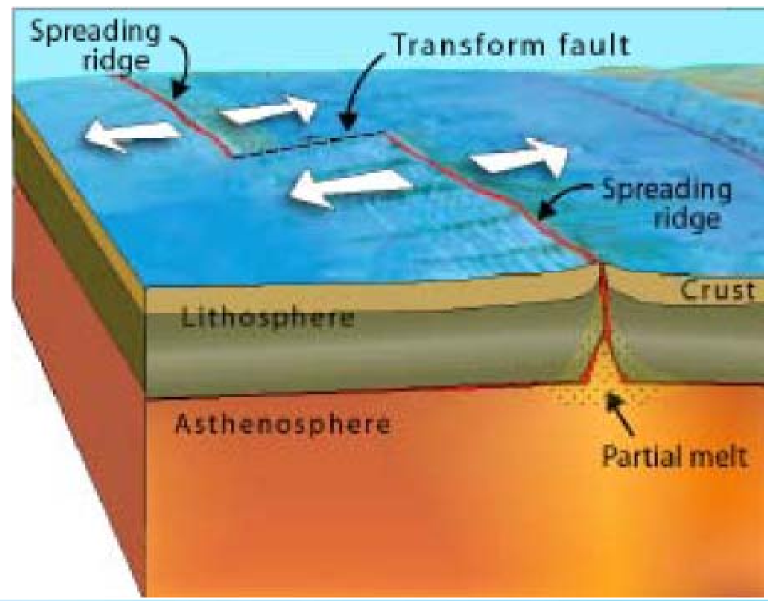
Types of plate boundaries

Slide past each other – Transform Plate Boundaries

Two plates slide against each other. Offsets are seen on roads and streams that cross the fault (San Andreas Fault, California)

Transform faults also form the margin between offset spreading ridges.



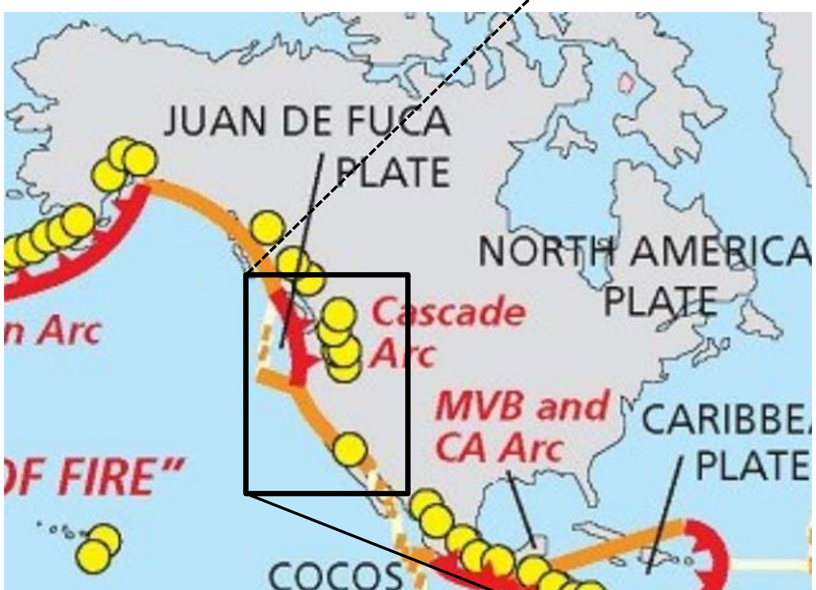


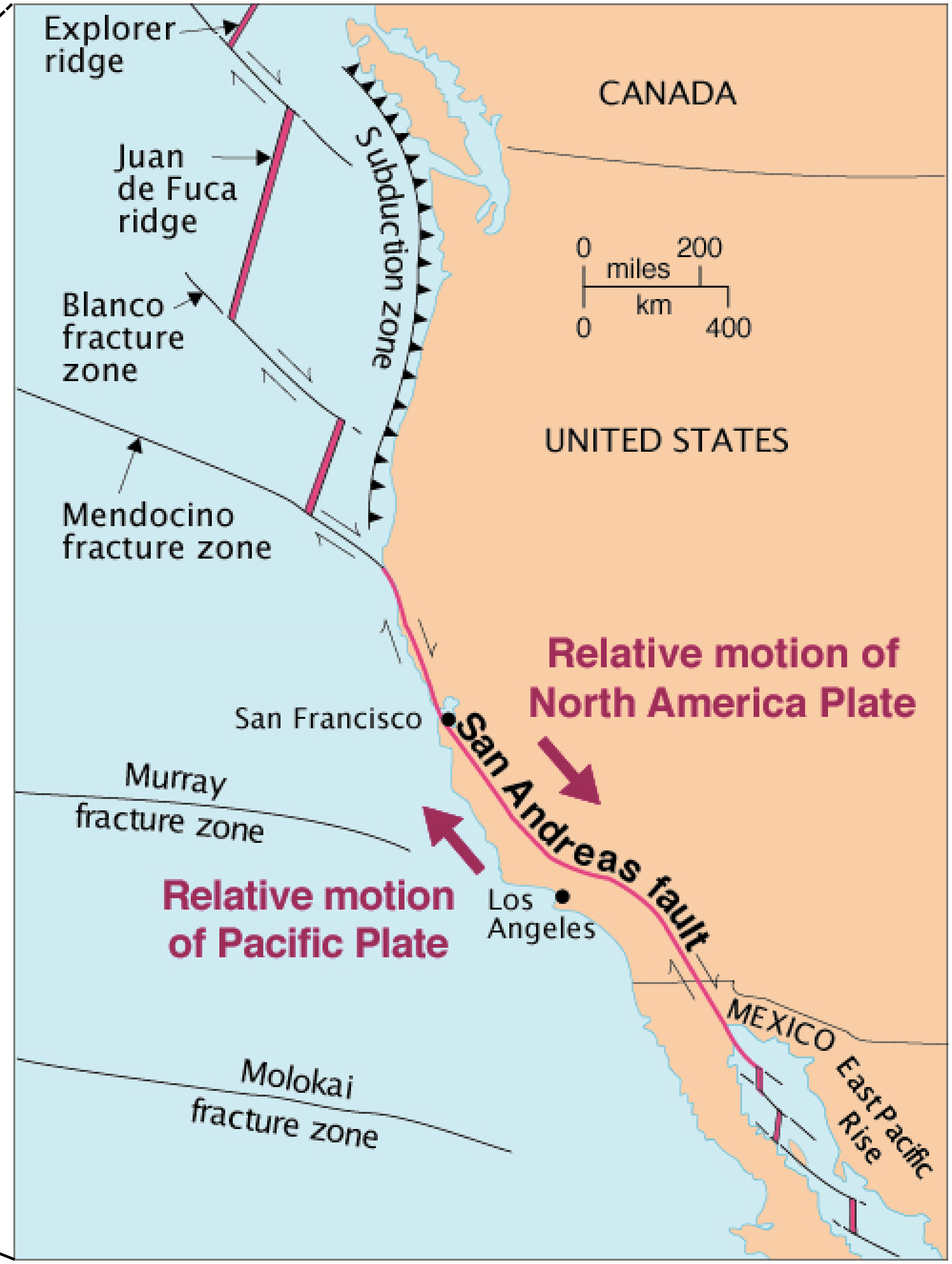
Types of plate boundaries

Transform Boundaries

San Andreas Fault:

- formed 28-30 million years ago
- total slip to date: 186-220 mi
- motion between plates: ~2 in/yr





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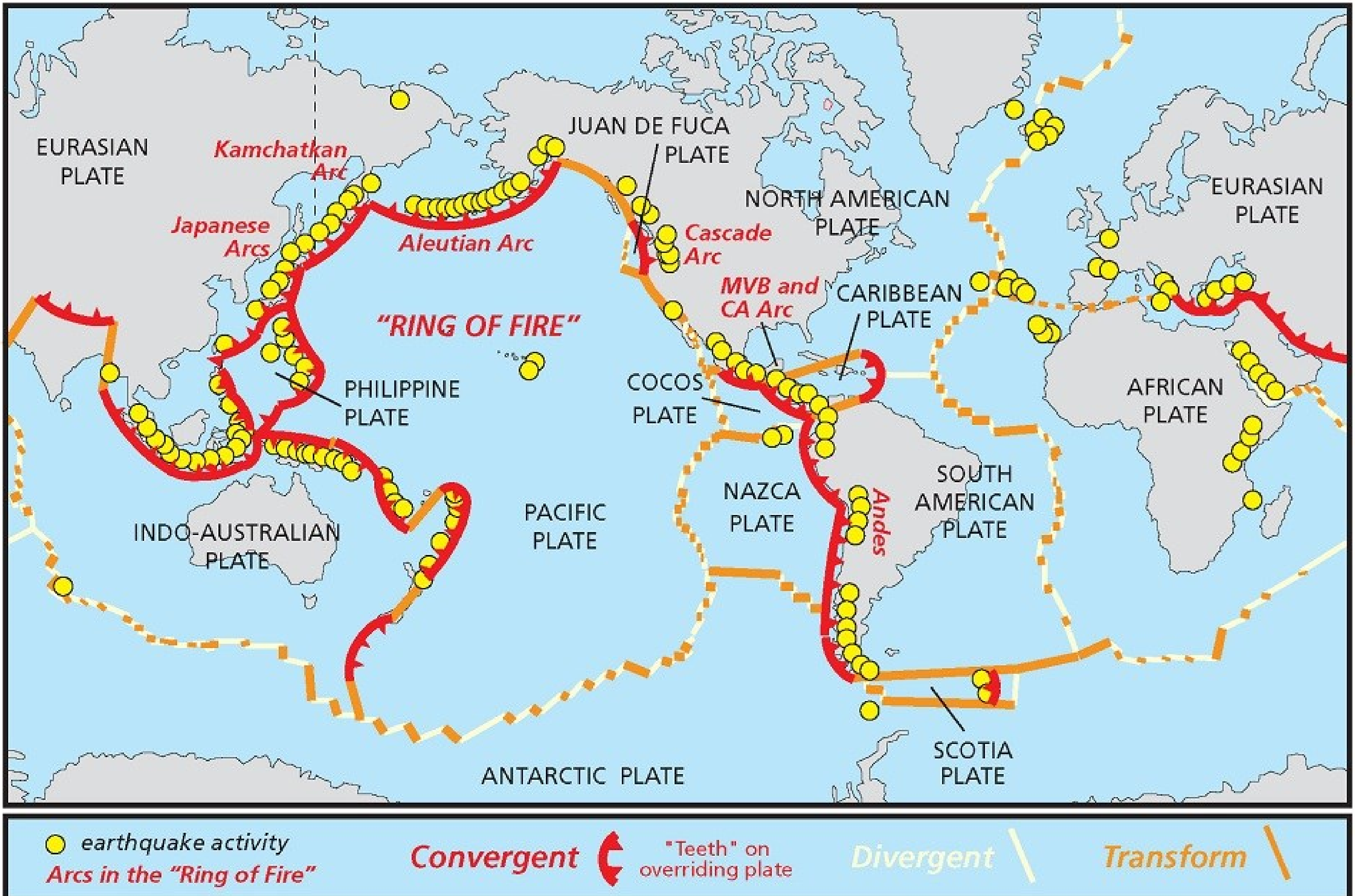
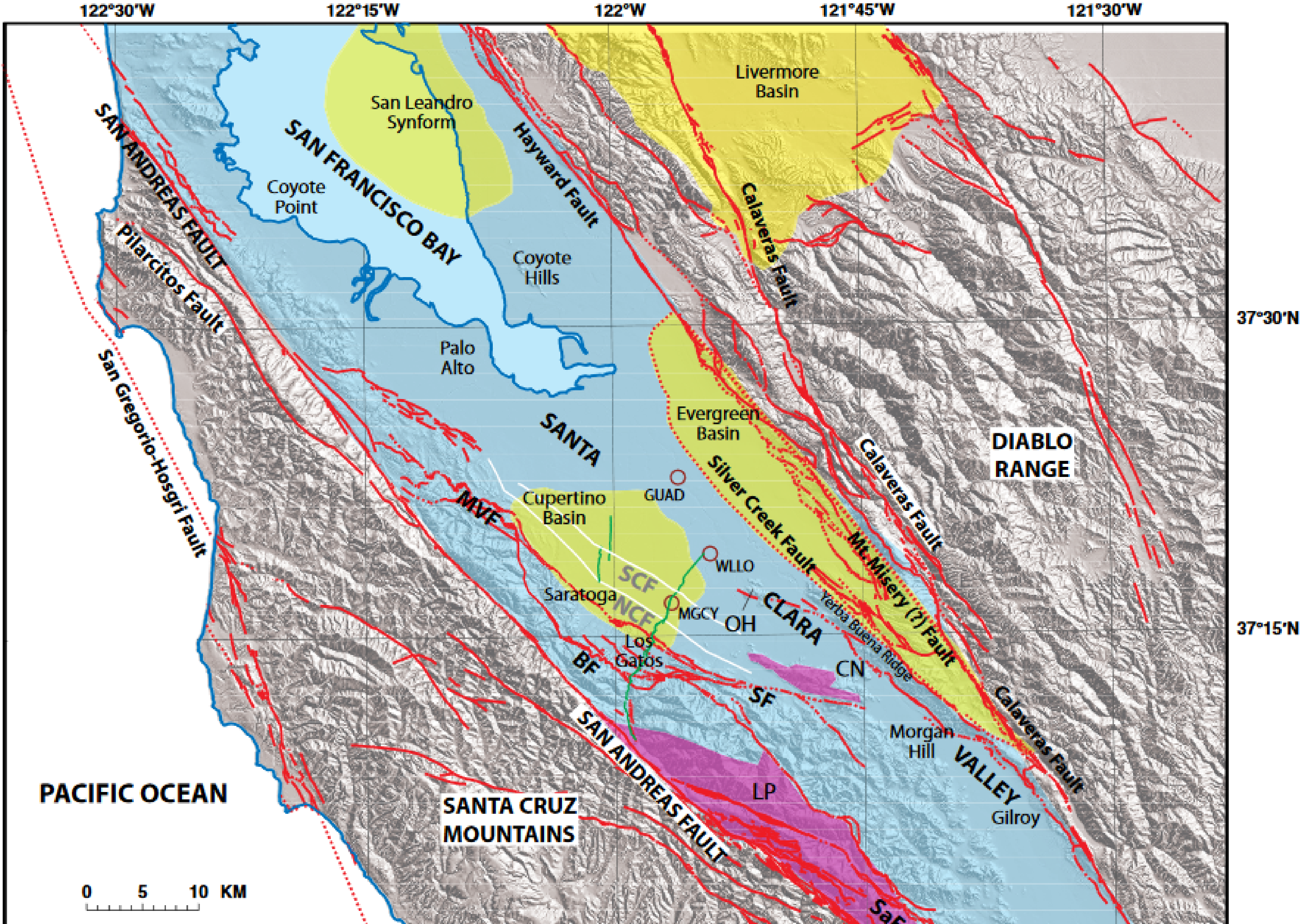


Faults and Fractures

Its all about the Geology



Faults and Fractures

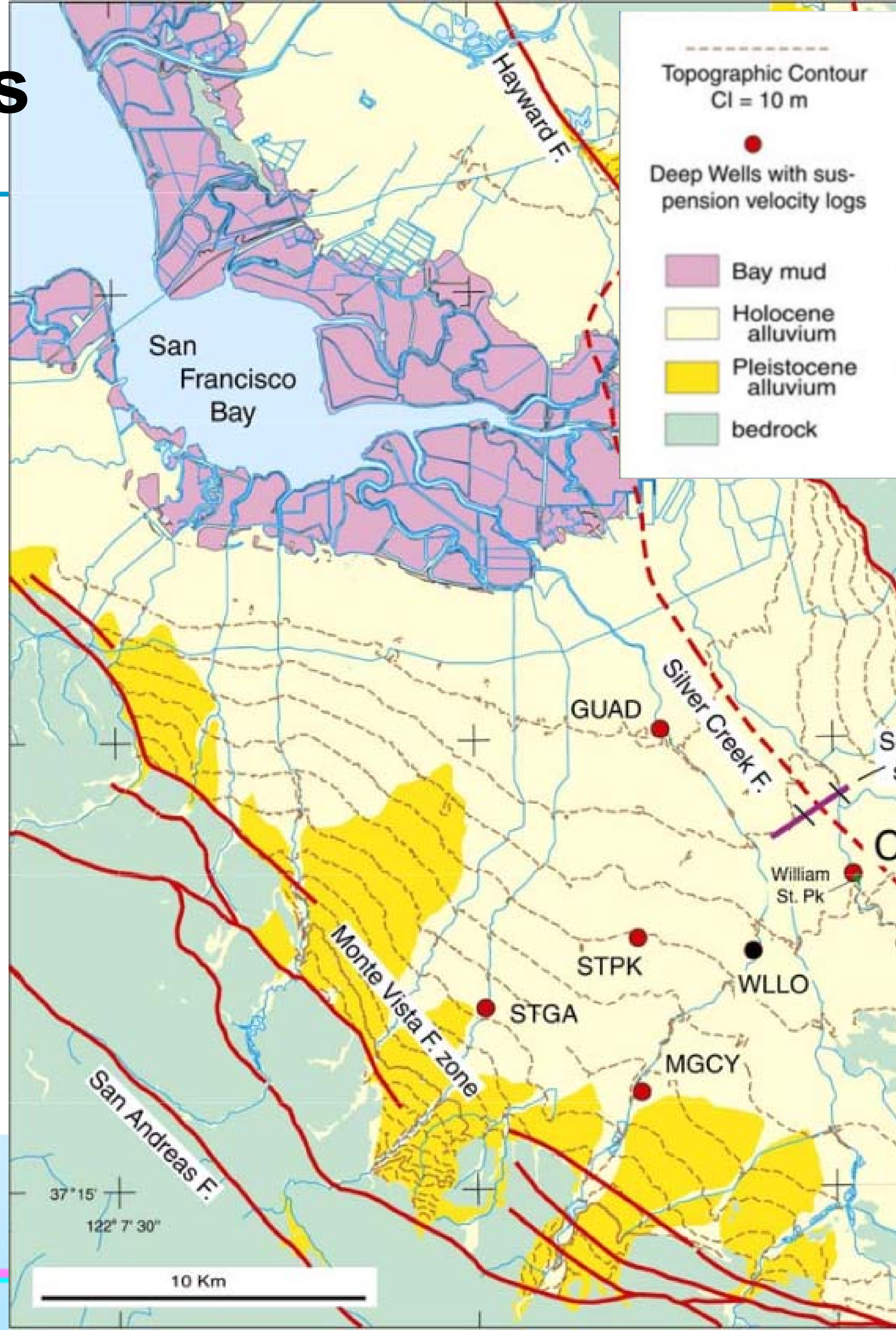
Its all about the Geology

Alluvium

- deposits of clay, silt, sand, and gravel left by flowing streams in a river valley or delta, typically producing fertile soil.

Bedrock

- lies under loose softer material called regolith within the surface of the Earth's crust
  - Below Moffett field: bedrock is encountered at 1,400 feet



Faults and Cupertino Geology

Cupertino General Plan, Appendix E

- Bedrock vibrates a lot less than sediments
- Buildings on solid bedrock tend to shake less than buildings on sediments or reclaimed land.
- Cupertino has experienced landslides.
- Cupertino is not situated on bedrock.

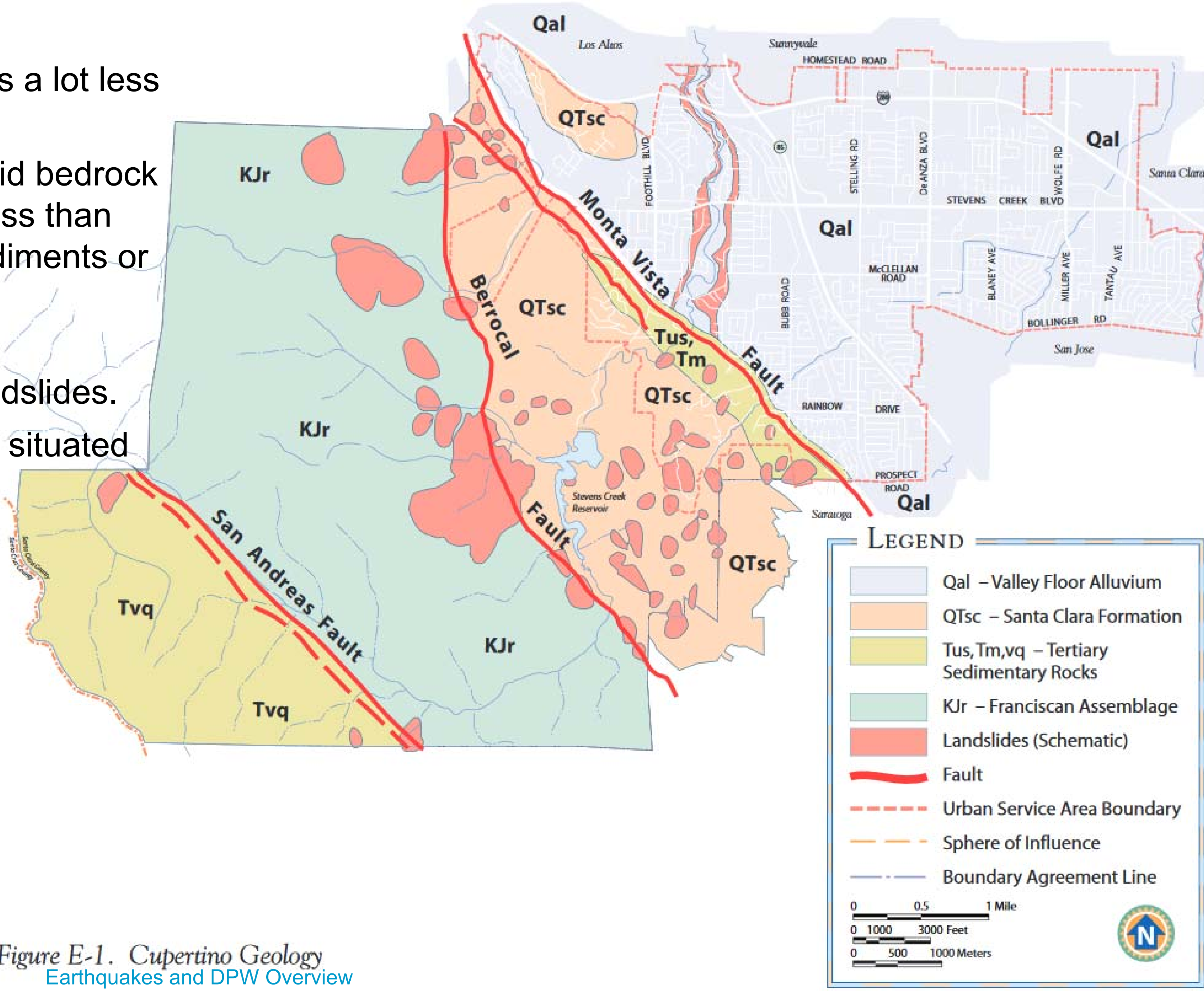


Figure E-1. Cupertino Geology

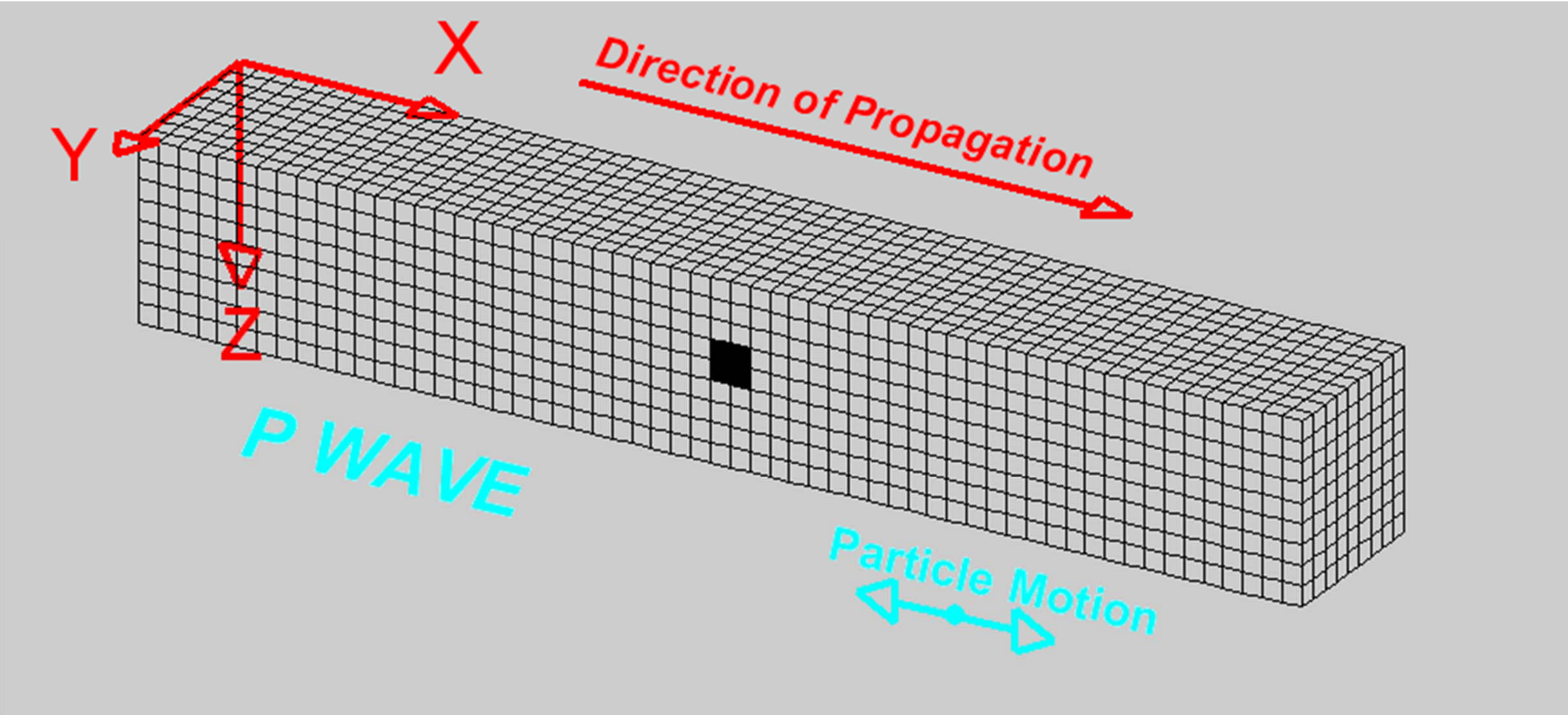
Seismic Waves

- Body Waves – travels through the earth
  - P Waves
  - S Waves
- Surface Waves – travels on the surface of the earth
  - Rayleigh Waves
  - Love Waves

Seismic Waves

P Waves (Compressional, Primary)

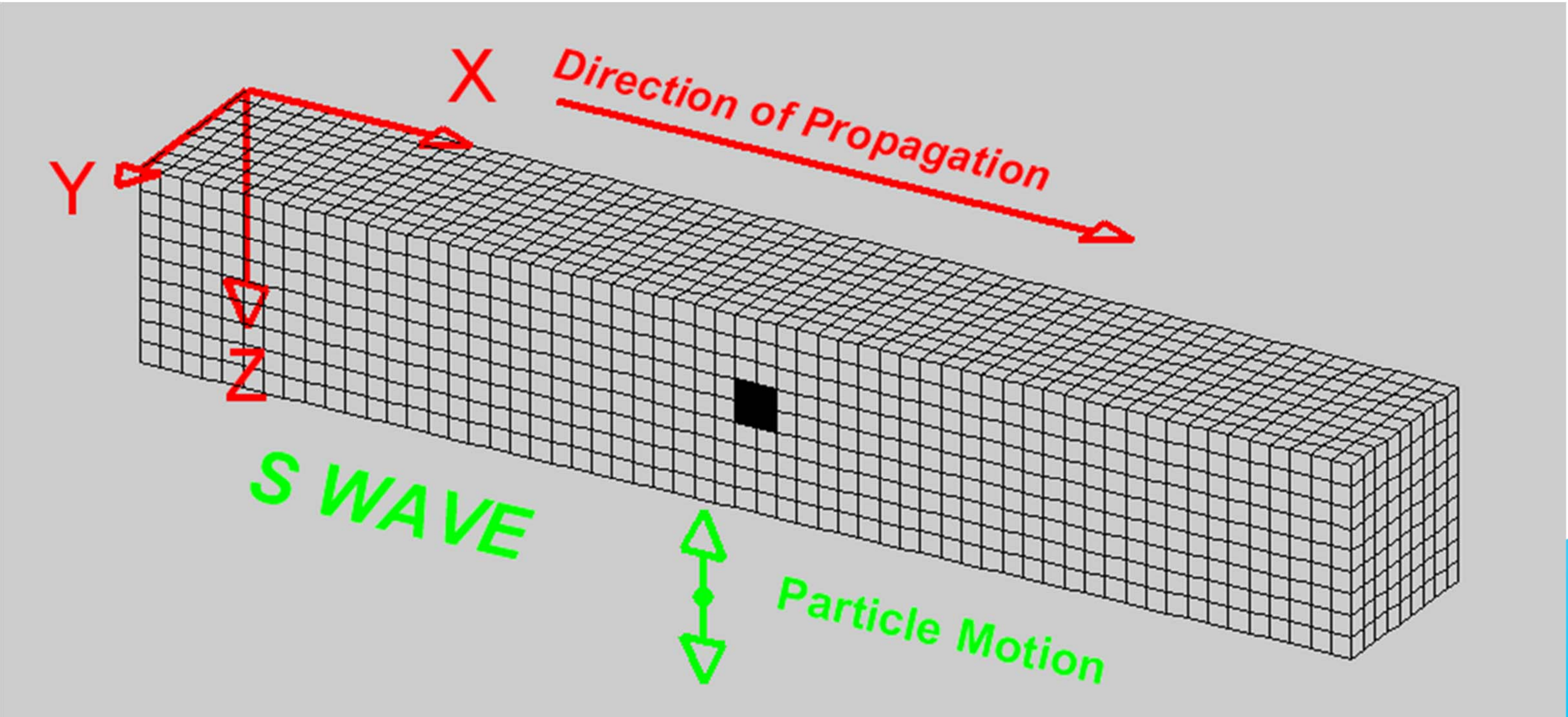
- fastest propagation; first to hit; travels at 4 - 8 km/sec
- propagates outwards in all directions; travels through the interior of the Earth
- shakes the ground in the direction they are propagating
- generally do not cause much damage (unless it is a *BIG Earthquake!*)



Seismic Waves

S Waves (Shear, Secondary)

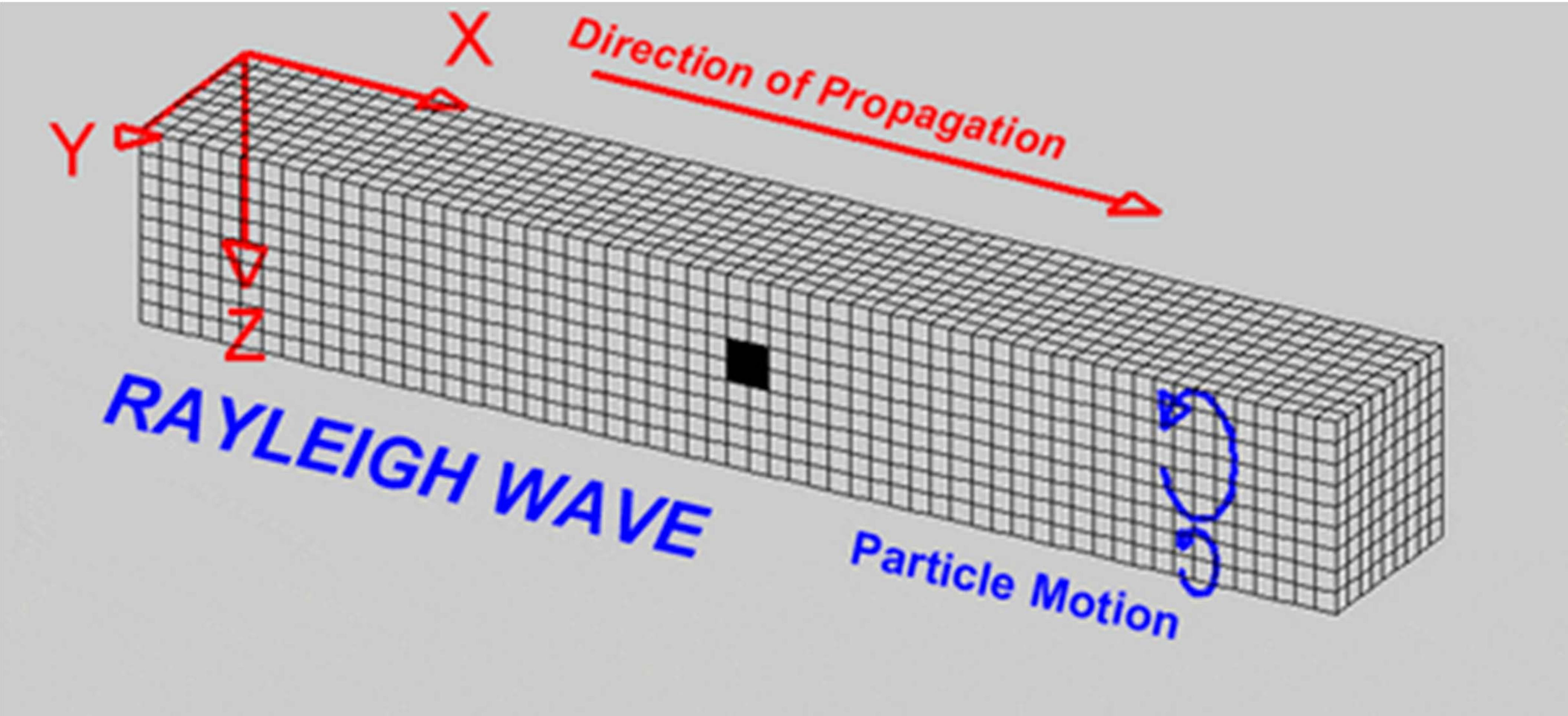
- follows the P Wave; travels at 2.5 - 4 km/sec
- propagate outwards in all directions; travels through solids, but not liquids, gas.
- shakes perpendicularly to the direction of travel (i.e. right angles to their path)
- generally do not cause much damage (*unless it is a BIG Earthquake!*)



Seismic Waves

Surface Waves / Rayleigh

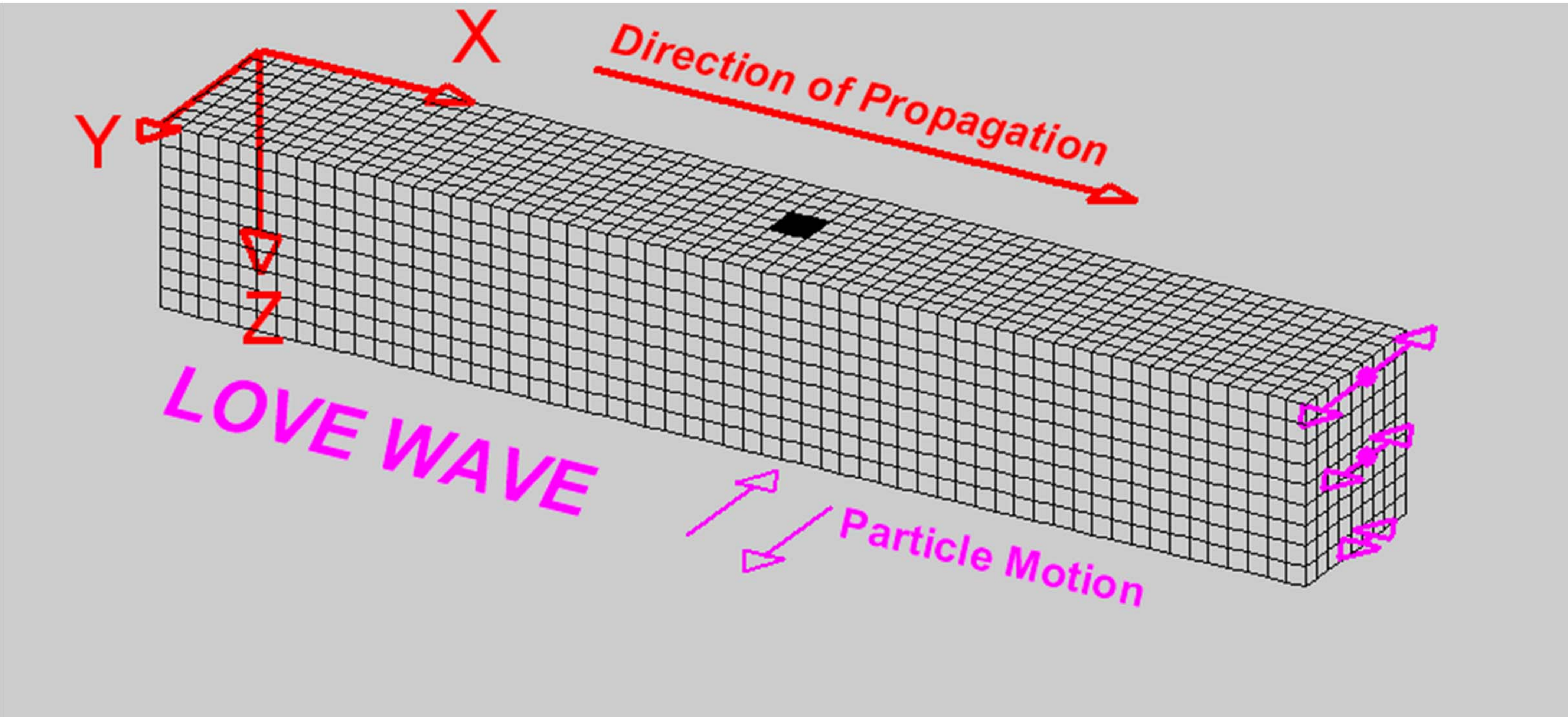
- arrives after the main P and S waves
- only moves along the surface
- creates a rolling, up and down motion
- cause the most surface destruction



Seismic Waves

Surface Waves / Love

- arrives after the main P and S waves
- only moves along the surface.
- creates a side-to-side motion causing the ground to twist from side to side
- cause the most surface destruction



Seismic Waves and Ground Shaking

1989 M6.9 Loma Prieta Earthquake

https://escweb.wr.usgs.gov/content/learn/topics/shakingsimulations/1989/lp1989plan_hires.mp4

1906 M7.8 San Francisco Earthquake

https://escweb.wr.usgs.gov/content/learn/topics/shakingsimulations/1906/sf1906plan_hd.mp4

https://escweb.wr.usgs.gov/content/learn/topics/shakingsimulations/1906/sf1906sanjose_hd.mp4

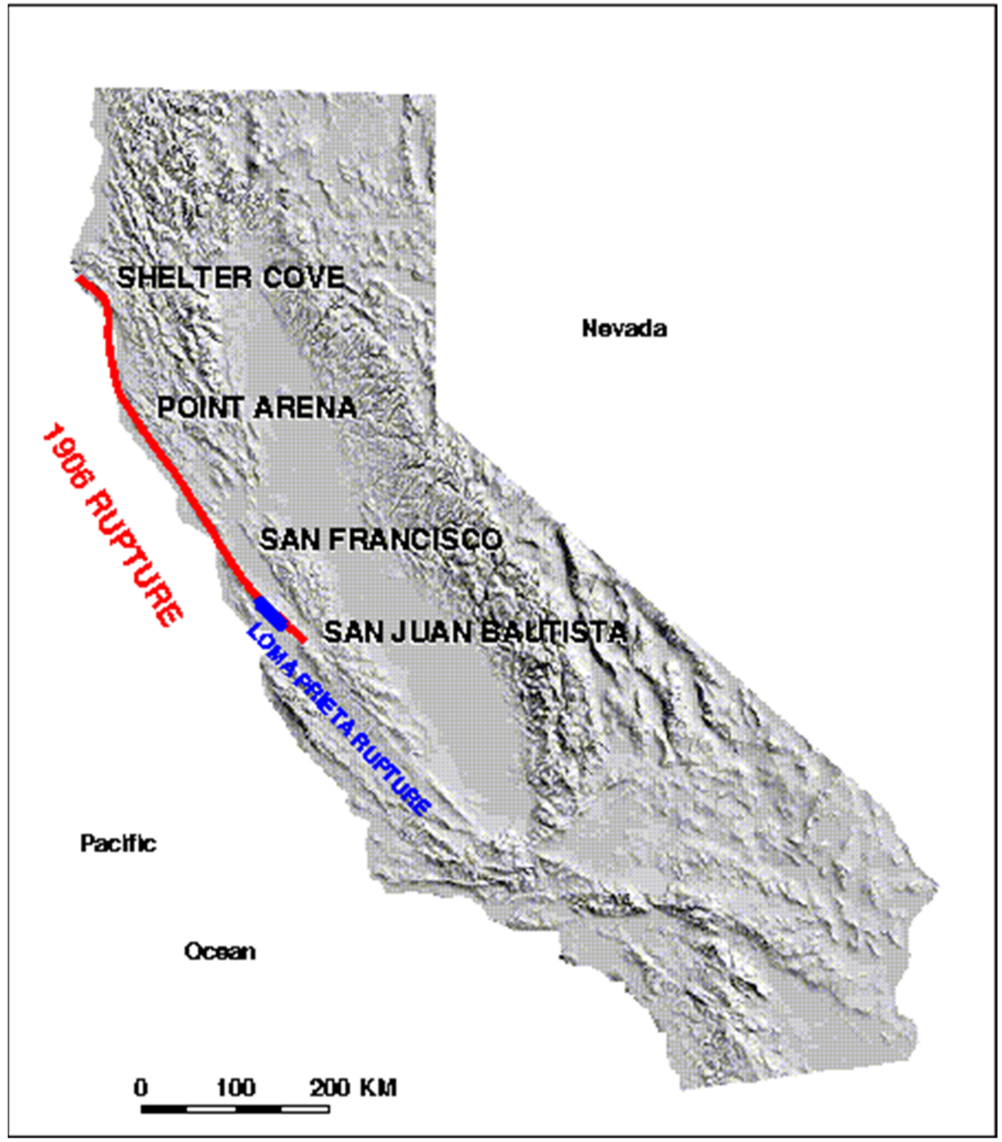
NOTE: The deformation in the ground surface has been exaggerated 1000 times to make it visible. Thus, one mile of deformation represents a little more than 5 feet of actual ground movement.

How long was the 1906 rupture?

- The 1906 earthquake had a rupture length of 296 miles (477 km).

By comparison…

- The 1989 Loma Prieta earthquake had a rupture length of about 25 miles (40 km).

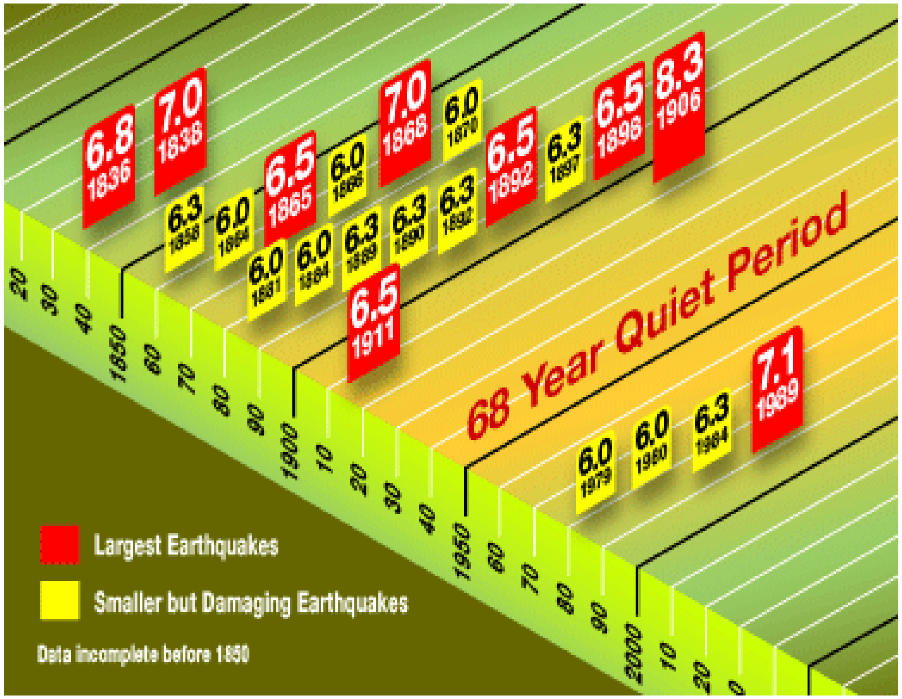


Bay Area Earthquakes

1836	6.8	South San Francisco Bay Region	
1838	7.0	San Andreas fault	San Francisco Peninsula
1865	6.5	San Andreas fault	
1868	7.0	Hayward fault zone	Hayward Earthquake
1892	6.5	Undetermined fault	Vacaville Earthquake
1898	6.5	Rogers Creek fault	Mare Island Earthquake
1906	8.3	San Andreas fault	Great San Francisco Eq
1911	6.5	Calaveras fault	Morgan Hill Earthquake

68 year quiet period — 1911 to 1979

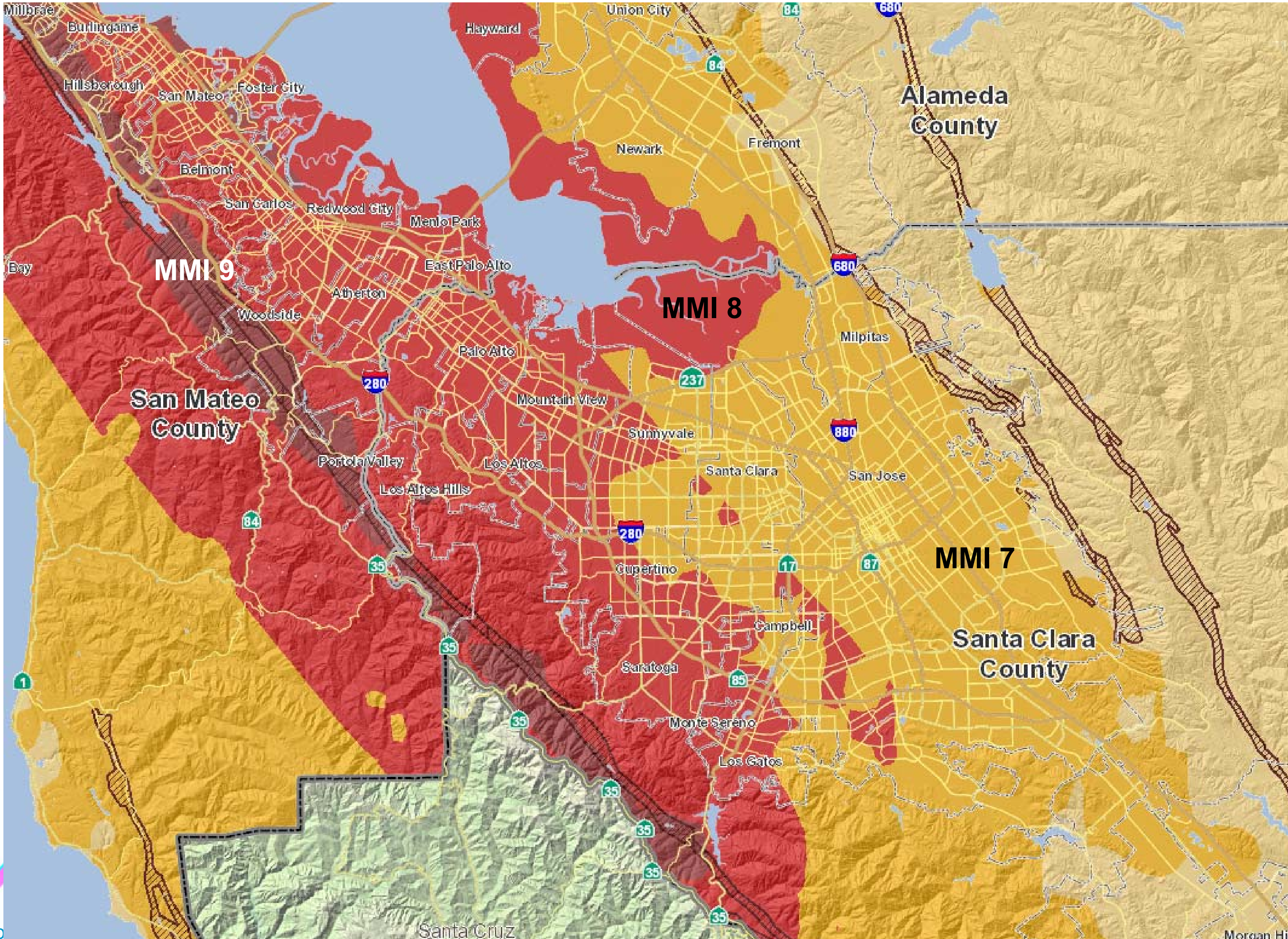
1979	6.0	Undetermined fault	Coyote Lake Earthquake
1980	6.0	Mt. Diablo-Greenville fault	Livermore Earthquake
1984	6.3	Calaveras fault	Morgan Hill Earthquake
1989	7.1	San Andreas fault	Loma Prieta Earthquake
2001	5.1	West Napa fault	Napa Earthquake
2007	5.6	Calaveras fault	
2014	6.0	West Napa fault	South Napa Earthquake



- 68 year "quiet period" in the San Francisco Bay Region -- the period from 1911 to 1979 experienced no earthquakes over magnitude 6.0.
- It is also during this time period that the region experienced it's greatest population growth.

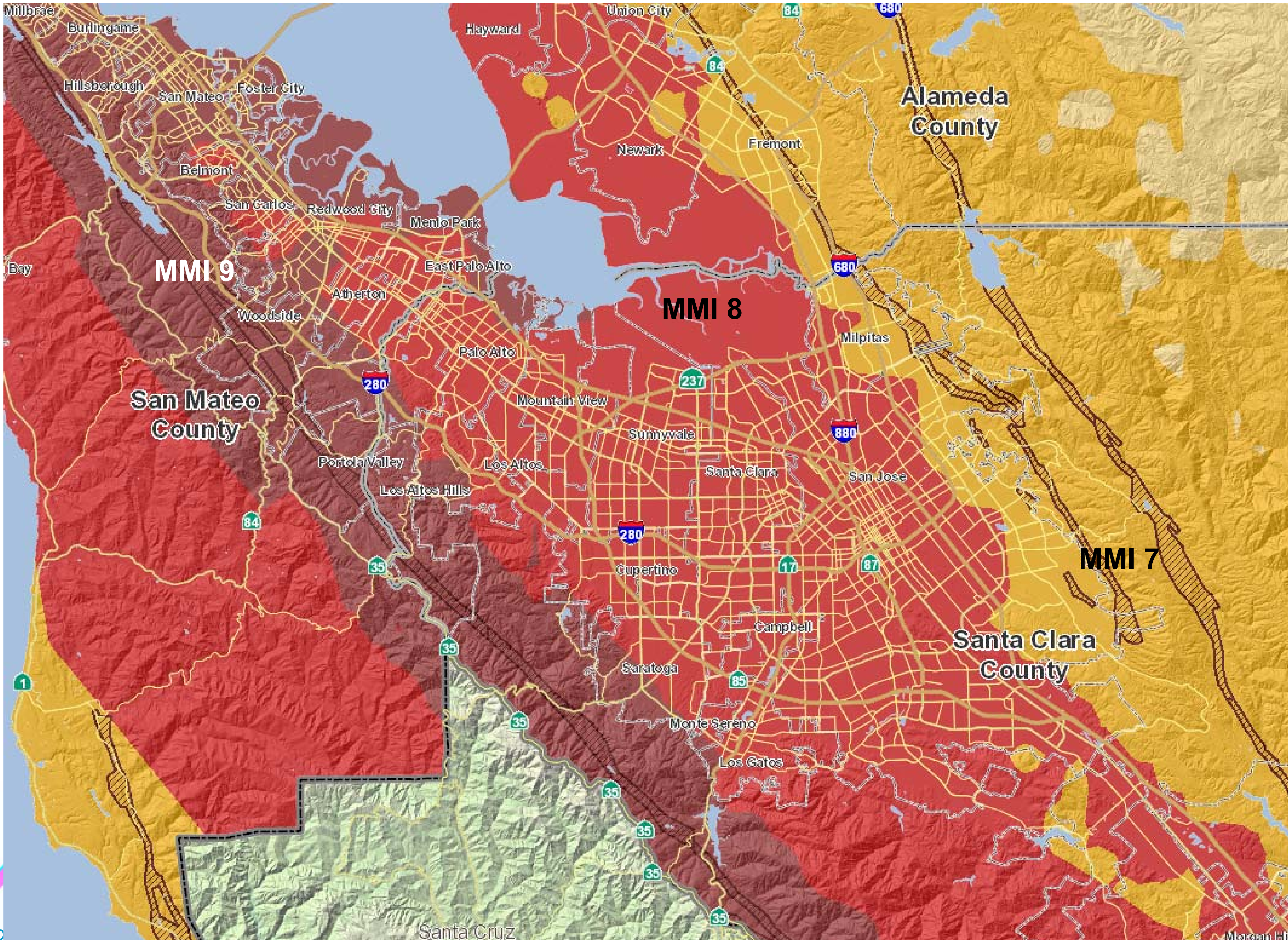
San Andreas Fault

Peninsula (M7.2); ABAG Assessment



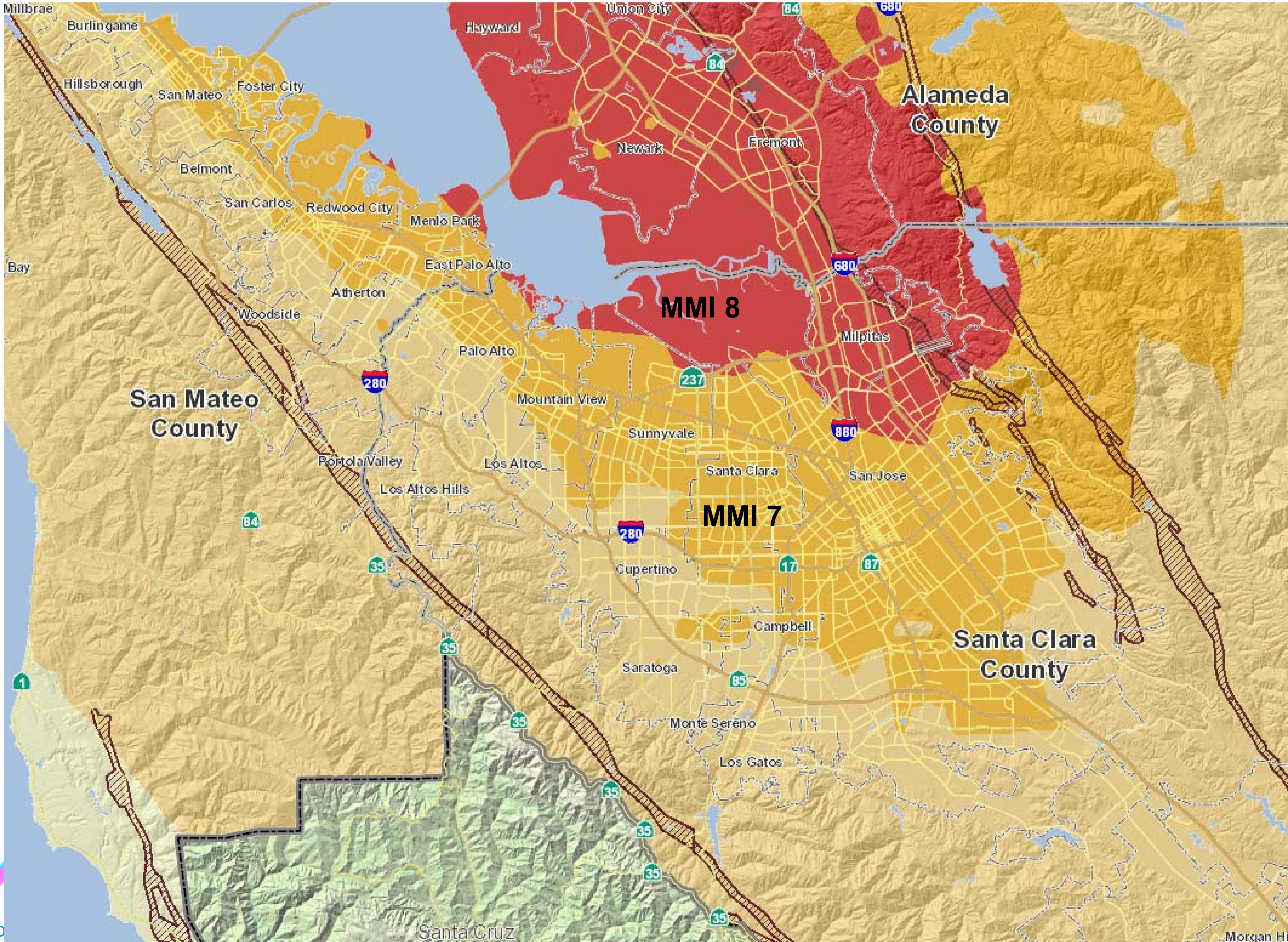
San Andreas Fault

All northern Segments (M7.8); ABAG Assessment



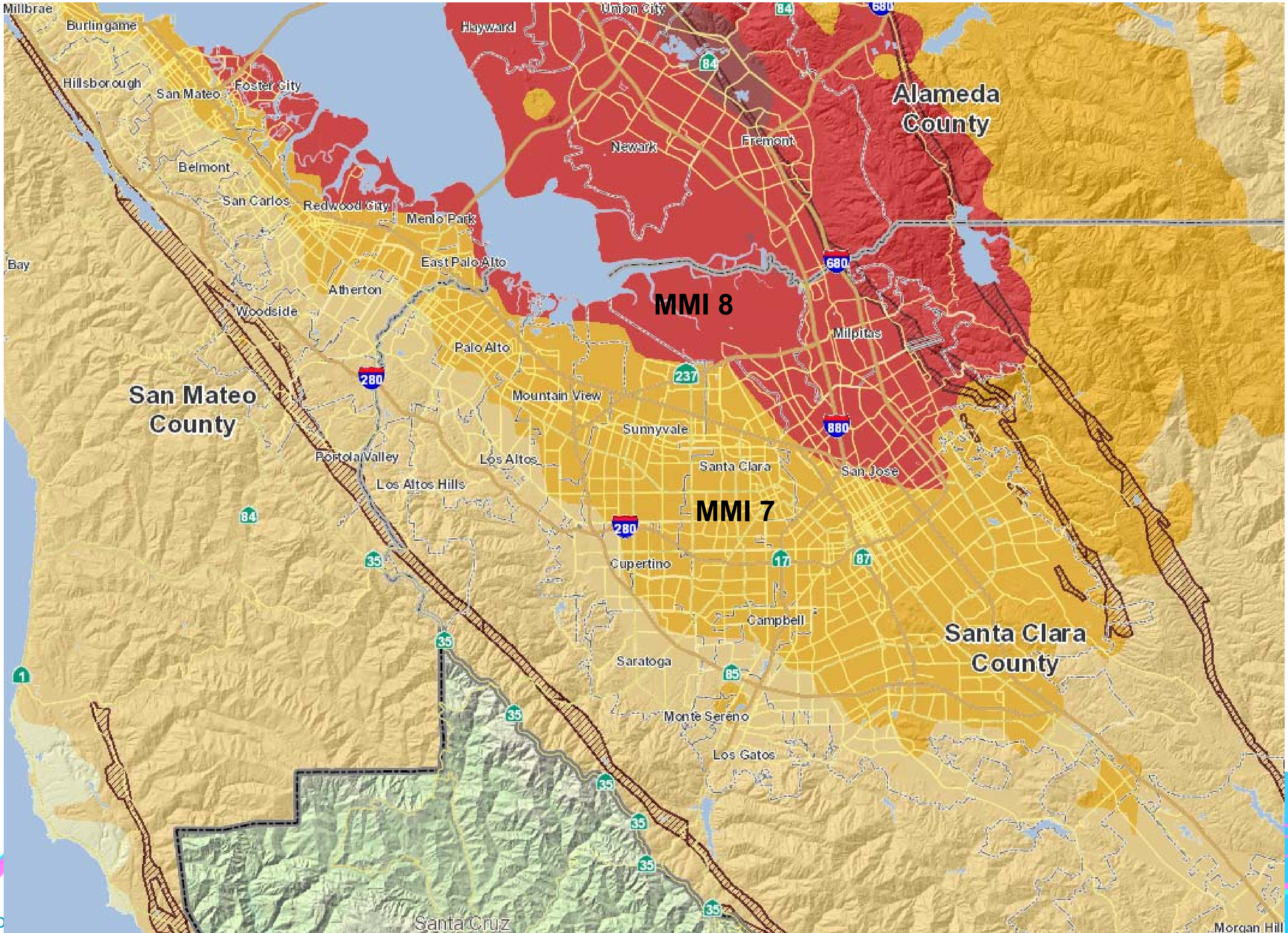
Hayward Fault

South (M6.8); ABAG Assessment



Hayward Fault

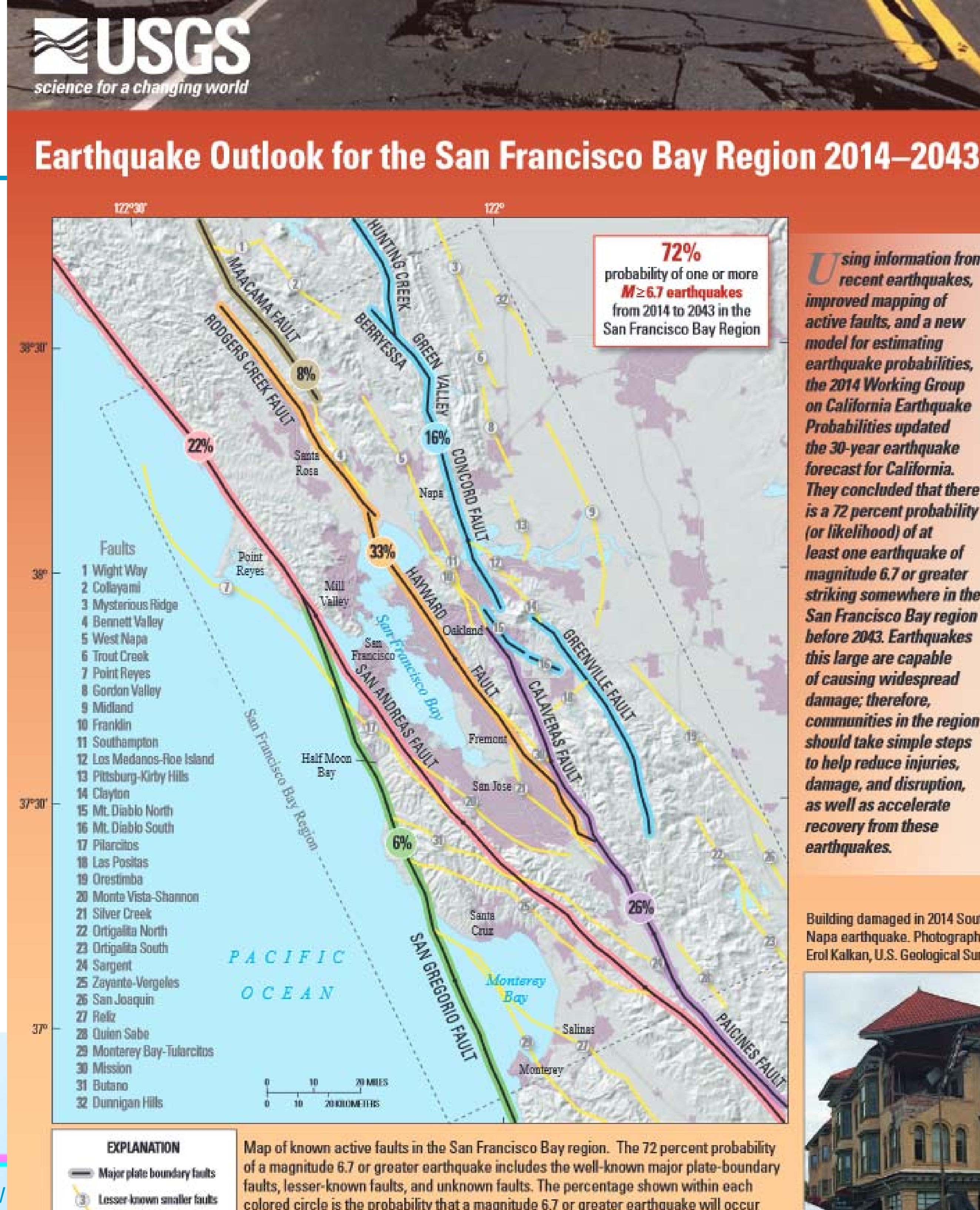
North and South (M7.0); ABAG Assessment



USGS Earthquake Outlook: 2014-2043

Take-away…

- 2014 Working Group on California Earthquake Probabilities updated the 30-year earthquake forecast for California.
- **72 percent probability** of at least one earthquake of **magnitude 6.7** or greater striking somewhere in the San Francisco Bay region **before 2043**.
- Get this report here… https://pubs.usgs.gov/fs/2016/3020/fs20163020.pdf


USGS science for a changing world

Earthquake Outlook for the San Francisco Bay Region 2014–2043

72% probability of one or more M≥6.7 earthquakes from 2014 to 2043 in the San Francisco Bay Region

Using information fron recent earthquakes, improved mapping of active faults, and a new model for estimating earthquake probabilities, the 2014 Working Group on California Earthquake Probabilities updated the 30-year earthquake forecast for California. They concluded that there is a 72 percent probability (or likelihood) of at least one earthquake of magnitude 6.7 or greater striking somewhere in the San Francisco Bay region before 2043. Earthquakes this large are capable of causing widespread damage; therefore, communities in the region should take simple steps to help reduce injuries, damage, and disruption, as well as accelerate recovery from these earthquakes.

Map of known active faults in the San Francisco Bay region. The 72 percent probability of a magnitude 6.7 or greater earthquake includes the well-known major plate-boundary faults, lesser-known faults, and unknown faults. The percentage shown within each colored circle is the probability that a magnitude 6.7 or greater earthquake will occur

Building damaged in 2014 Sou Napa earthquake. Photograph Erol Kalkan, U.S. Geological Su

Where are we going with this?
Cupertino DPW, Service Center

- The Service Center is staffed by about 70 employees.

Streets Division
- 142 Center Lane Miles of Streets
- 9645 Traffic Related Signs
- 2200 Storm Drain Inlets
- 3200 Streetlights
- 480 Park/Parking Lot Lights
- Sidewalks, Curbs & Gutters

Grounds Division
- 19 Parks and Open Space Areas
- 9 Cupertino Union School District Athletic Fields for Youth Sports Programs
- Maintain All Playgrounds in Accordance with California Playground Safety Requirements
- Water Fowl Management
- Provide Support to Park and Community Services Programs

Trees and Right of way Division
- Maintain 22117 Tree Assets
- 53.5 Acres of medians and ROW areas
- Coordinates with Streets Maintenance division on root inspections of effected trees
- Community outreach
- Tree planting events
- Median renovations

Facilities and Fleet Division
- 45 Buildings, 205,000 sq. ft.
- 102 vehicles, 600 pieces of equipment
- Blackberry Farms pool
- Civic Center fountains
- Small tenant improvement projects
- Fleet –maintenance operations, and Recreation and Community Services
- Facilities –Civic Center, Recreation & Community Services, and corporation yard.

The situation
Cupertino DPW, Service Center

- The Service Center is staffed by about 70 employees.
- *The best time for an earthquake* would be during the normal Service Center day shift when staffing is at its fullest.
- Staff commute times
  - 10-15 minutes for 26% of the close-in staff
  - ~20 minutes for 18%, and
  - ~30 minutes for 56%.
- For an *earthquake* after hours and weekends, the expectation is that Service Center employees will make every effort to report to work to help the city with its response, once their own situation at home is stable.
- Given that 74% of the staff resides at least 20 minutes away on a good traffic day and the extent of damage that city residents and staff may experience at home, it is possible that Service Center resources will not be immediately available to respond to the City.

After an earthquake…

The Goal

Ensure city-managed roads are open and accessible for Sheriff, Fire, and EMS responders.

Approach

Cupertino Citizen Corps performs an initial city-wide *windshield* ***access*** *survey* during the period immediately after an earthquake.

Objectives

- All 142 miles of City streets are visually inspected for access.
- Problem reports are submitted to jump-start the City's response and repair process as staff becomes available.

Areas of Interest

- Access to and from Fire Stations (SCCFD #71, #72, #77, SJC #15)
- Access to and from Hospitals (Kaiser on Homestead)
- Access on all major roads throughout the City
- Access over all I-280 and Rt 85 overpasses
- Access on all residential streets

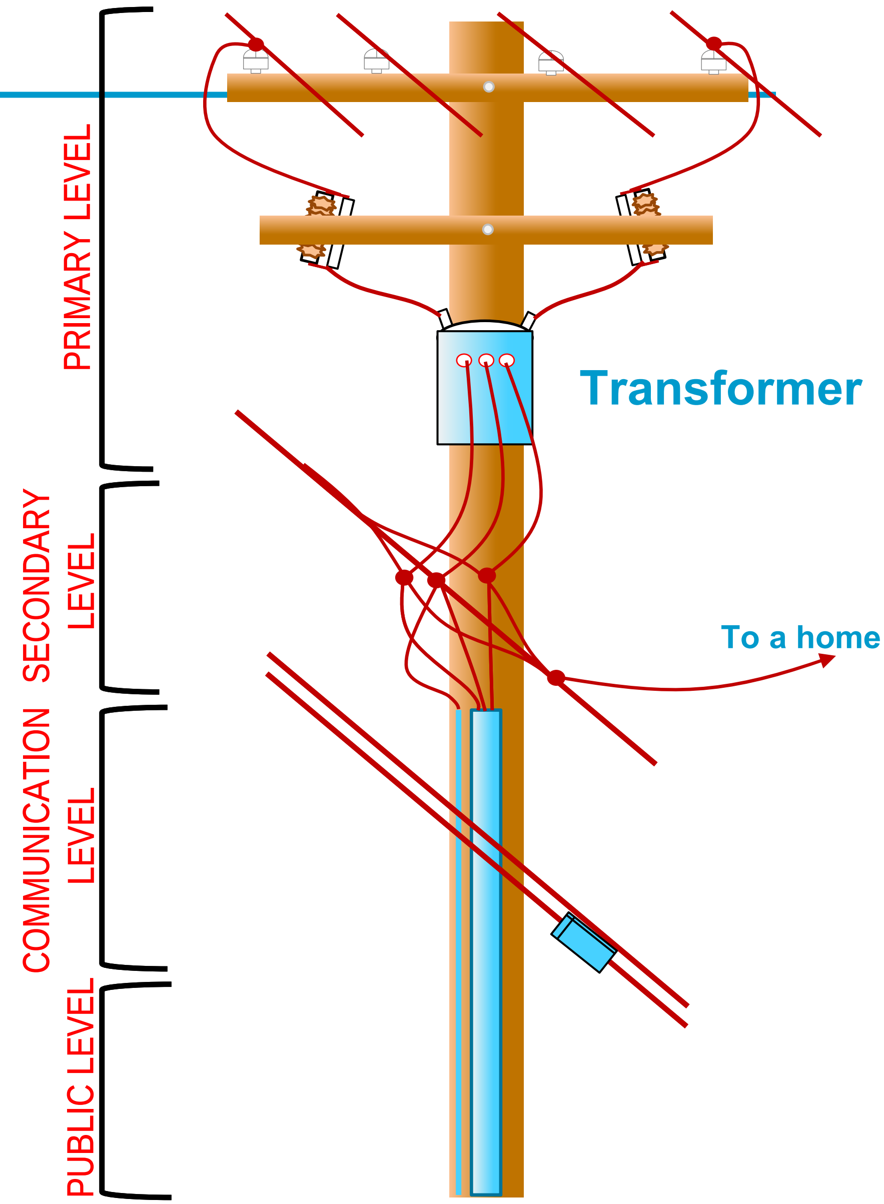
Areas of Interest

Things that will inhibit access…

1. Utility pole/Street light problems
2. Road problems
3. Bridge problems

Utility Poles 101

The utility poles in our neighborhoods can range in height from 30- to 60-feet tall.



Primary Level

Local distribution; carries high voltage, over 600VAC, step-down transformers

Secondary Level

Service connections; Supplying 120-240VAC

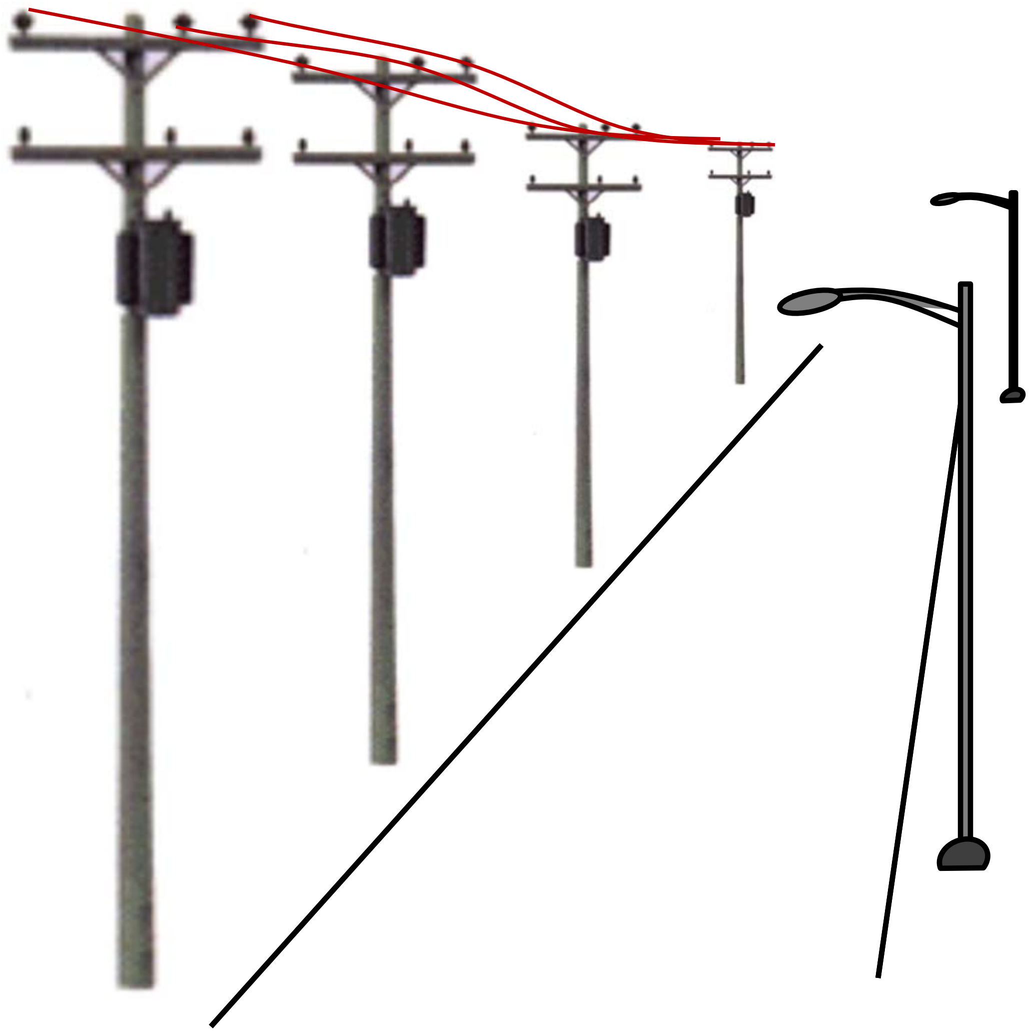
Communications Level

Telephone, Cable, Fiber

Utility Poles
Things to look for

Life is good!

- All power poles are upright.
- No wires on the ground.

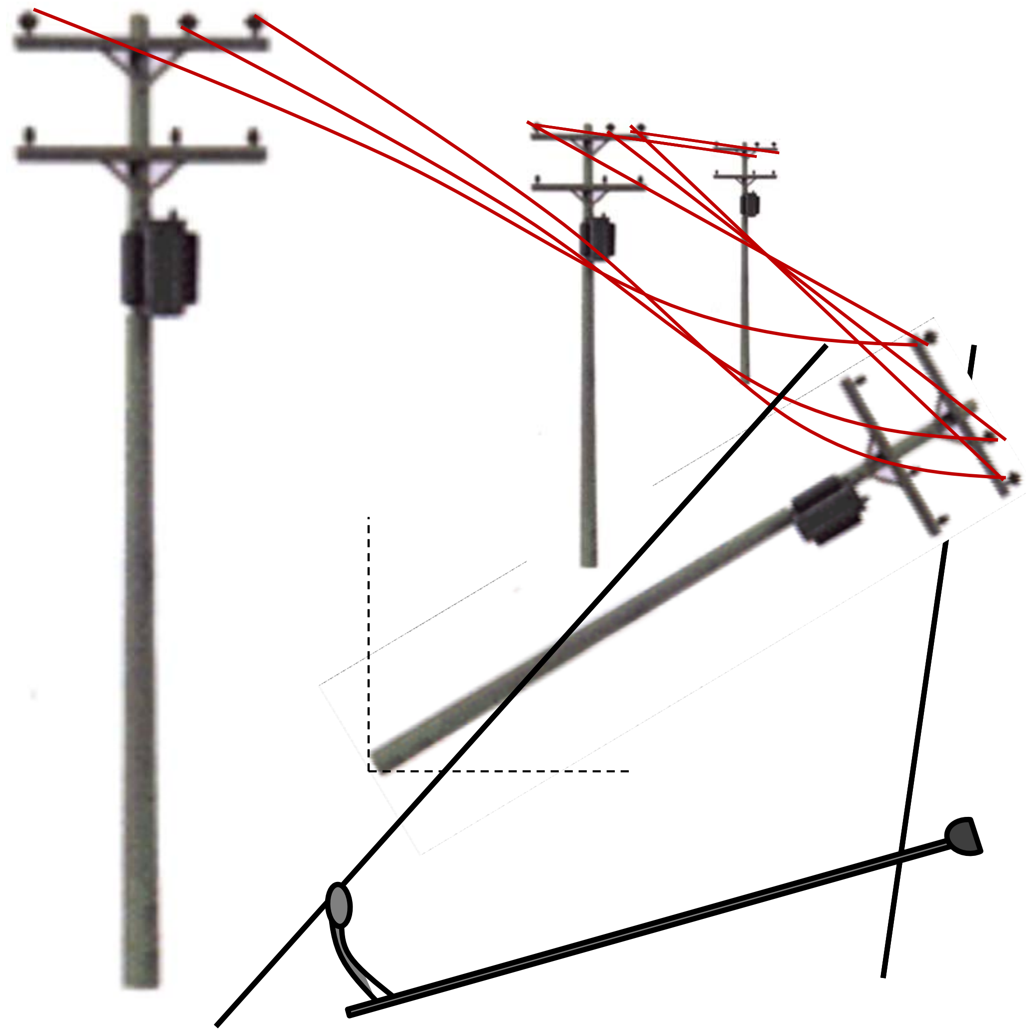


Utility Poles

Things to look for

Problems

- Utility poles are…
  - On the ground, or
  - at an angle off of the normal vertical alignment.
- Wires holding the pole from falling
- Wires in the streets
- Street lighting poles bent or on the ground



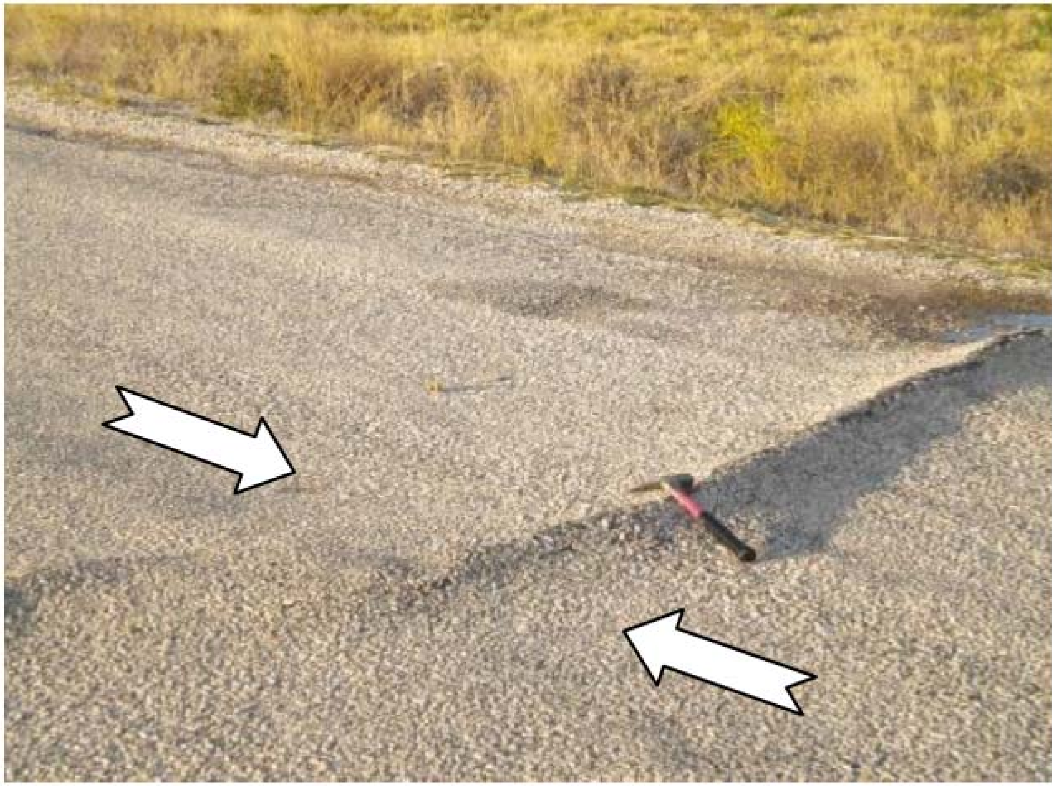
Road deformations

Three kinds of stress to roads

- Tensional stress… stretches rock
- Compressional stress… squeezes rock
- Shear stress… slippage and translation

Road deformations

Compressional stress; squeezes rock and roads



Road deformations

Loma Prieta Earthquake of 1989

Compressional stress; thrust in sidewalk in Los Gatos, on University Avenue near Royce Street.

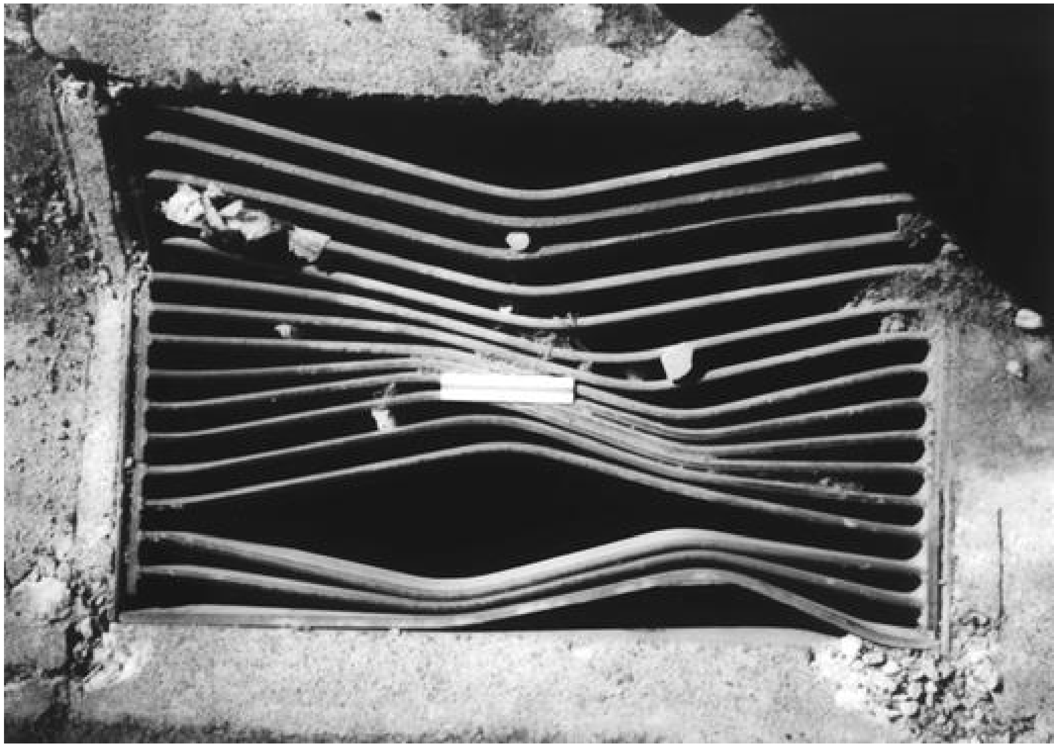
There was plenty of visible damage like this; the concrete displayed a regular pattern of deformation consisting of buckling and thrusting in a north-south to northeast-southwest direction.

Road deformations

Loma Prieta Earthquake of 1989

Compressional stress; Onramp to southbound State Highway 17 at State Route 9 in Los Gatos.

Evidence of permanent contractional strain included utility-box lids that no longer fit into their casings and distorted storm-drain gratings.



Road deformations

6.0 West Napa Earthquake, August 24, 2014

Shear stress; causes slippage.

“Afterslip” is the movement or "creeping" that takes place along a fault, including the trace of its surface rupture, after an earthquake.

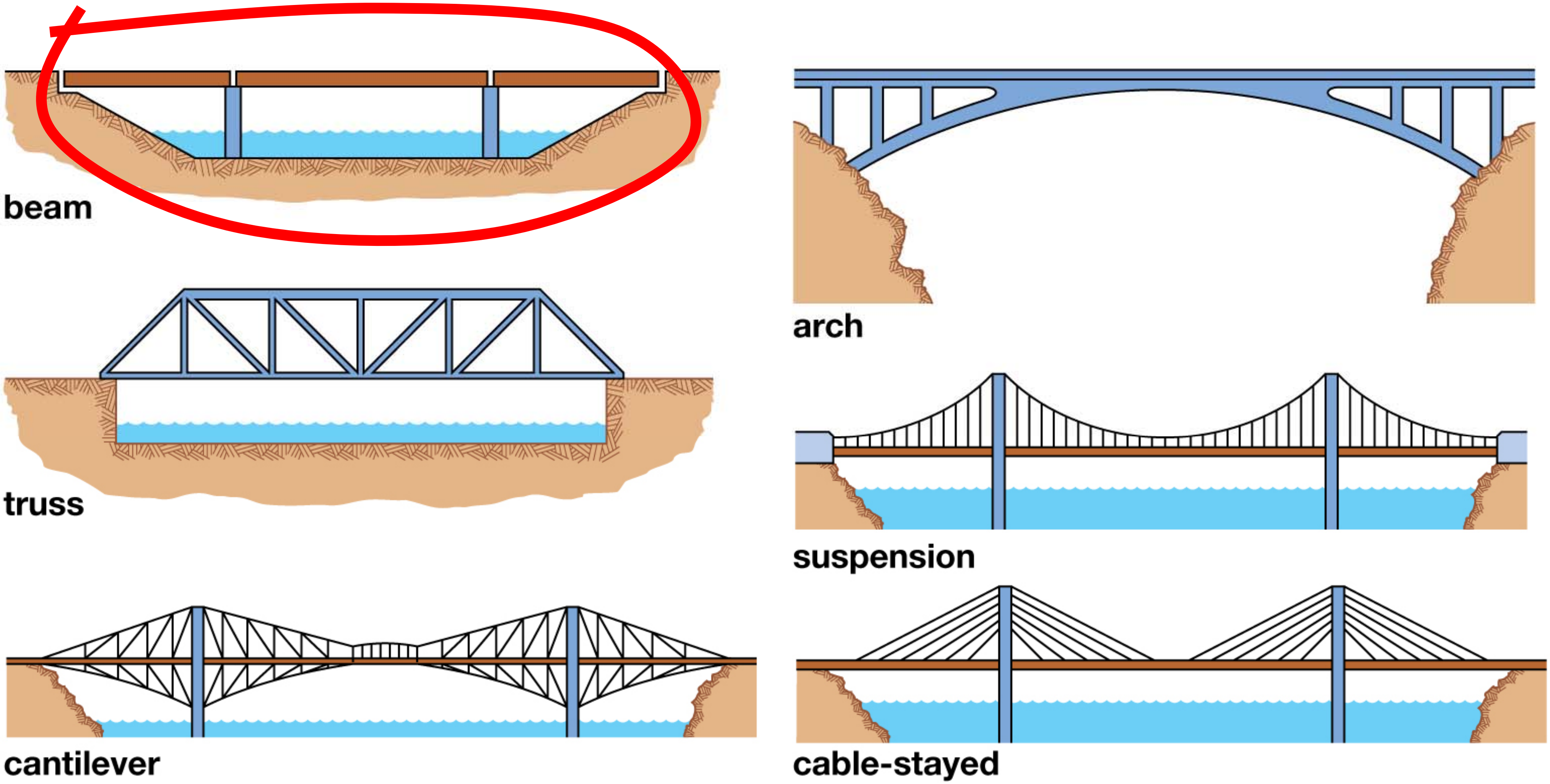
Road deformations

7.1 Ridgecrest Earthquake, July 5, 2019

Anticipated local road damage

1. Extreme deformation of pavement
2. Sink holes (underground utility damage)
3. Damaged transitions to bridge abutments

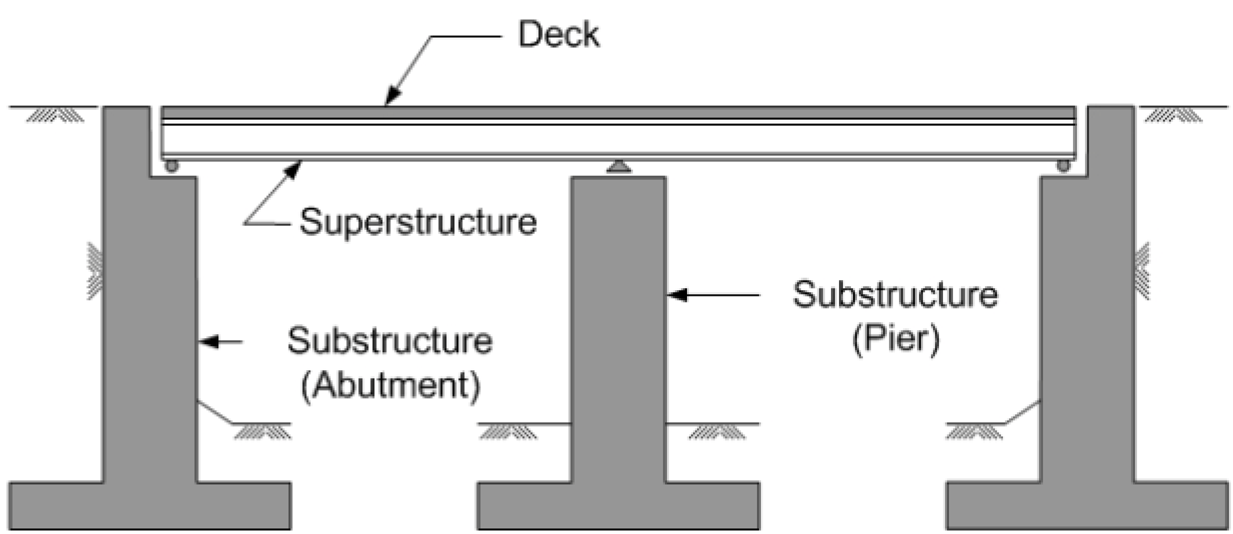
Bridges



Structural Elements of Bridges

MAY SKIP

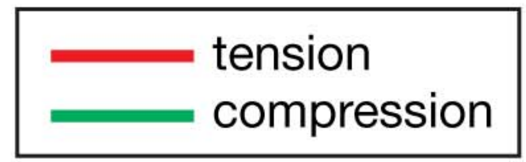
- Abutment: Abutments are the elements at the ends of a bridge, which provide support for it. They absorb many of the forces placed on the bridge and act as retaining walls that prevent the earth under the approach to the bridge from moving.

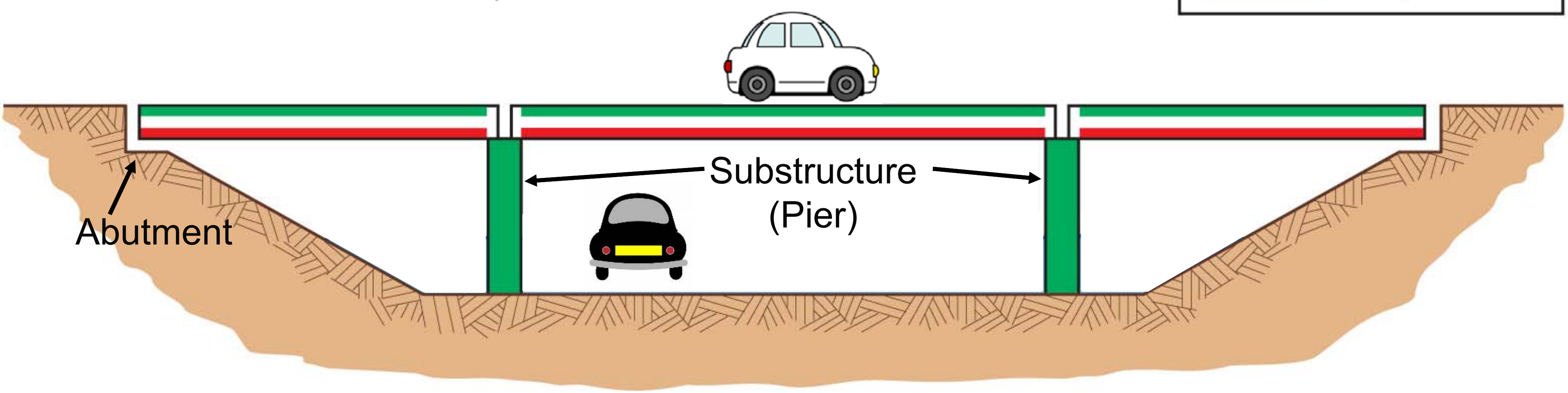


Beam Bridges

All I-280 and Rt 85 overpasses are beam bridges.

- A beam carries vertical loads by bending.
- As the beam bridge bends, it undergoes horizontal compression on the top.
- At the same time, the bottom of the beam is subjected to horizontal tension.
- The supports carry the loads from the beam by compression vertically to the foundations.





Bridge Damage - Road / bridge deck misalignment
Chilean 2010 earthquake

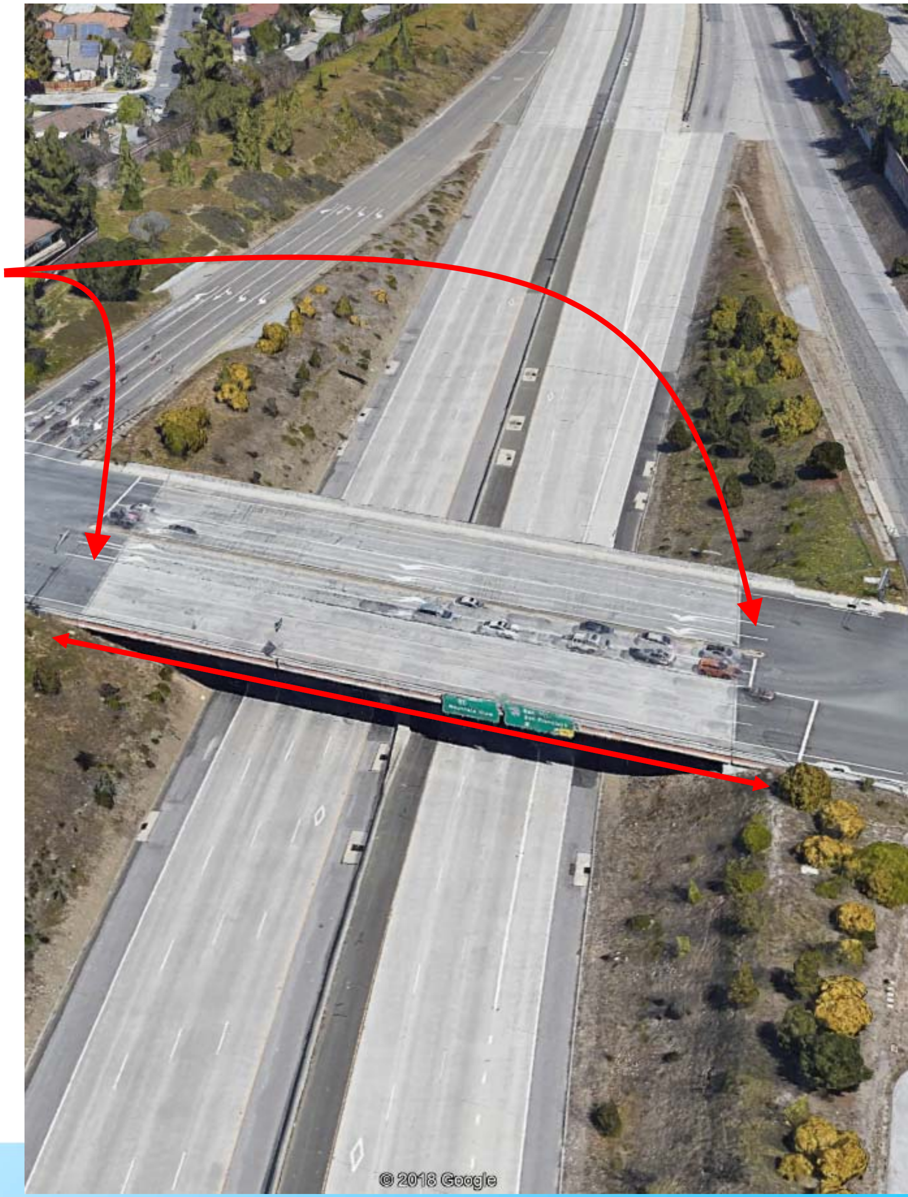
Bridge Damage - Road / bridge deck misalignment
Chilean 2010 earthquake

Bridge Damage - Road / bridge deck misalignment

Chilean 2010 earthquake

What to look for

1. Bridge is still standing
2. Subsidence where the road meets the bridge deck (abutment)
3. Road / bridge deck misalignment
4. Obvious cracks on the bridge deck



Areas of Interest

Summary

1. Traffic control: lights flashing or totally out
2. Streets blocked or obstructed by fallen utility poles, street lights, trees
3. Utility poles leaning off of vertical (risk of falling)
4. Road deformations – bulges, cracks, sink holes
5. Bridges – visible damage
6. Unusual pot holes
7. Vertical or Horizontal land displacements
8. Water main, sewage main, storm drain breaks
9. Observed smoke, fires
10. Observed strong smell of gas

What’s next?

7–Nov: CARES General Meeting, Drill Prep; process, tools, plan

16-Nov: Cupertino *Streets First Look* evaluation test

Thank you

Any Questions?

References

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