# The Geologic Story of El Cerrito

*Congratulations on the 100th anniversary of El Cerrito!*

*Anyone know which anniversary it is for the rocks under our feet?*


G. L. Prost http://garyprostgeology.com/

How can we convey the concept of “Deep Time”?

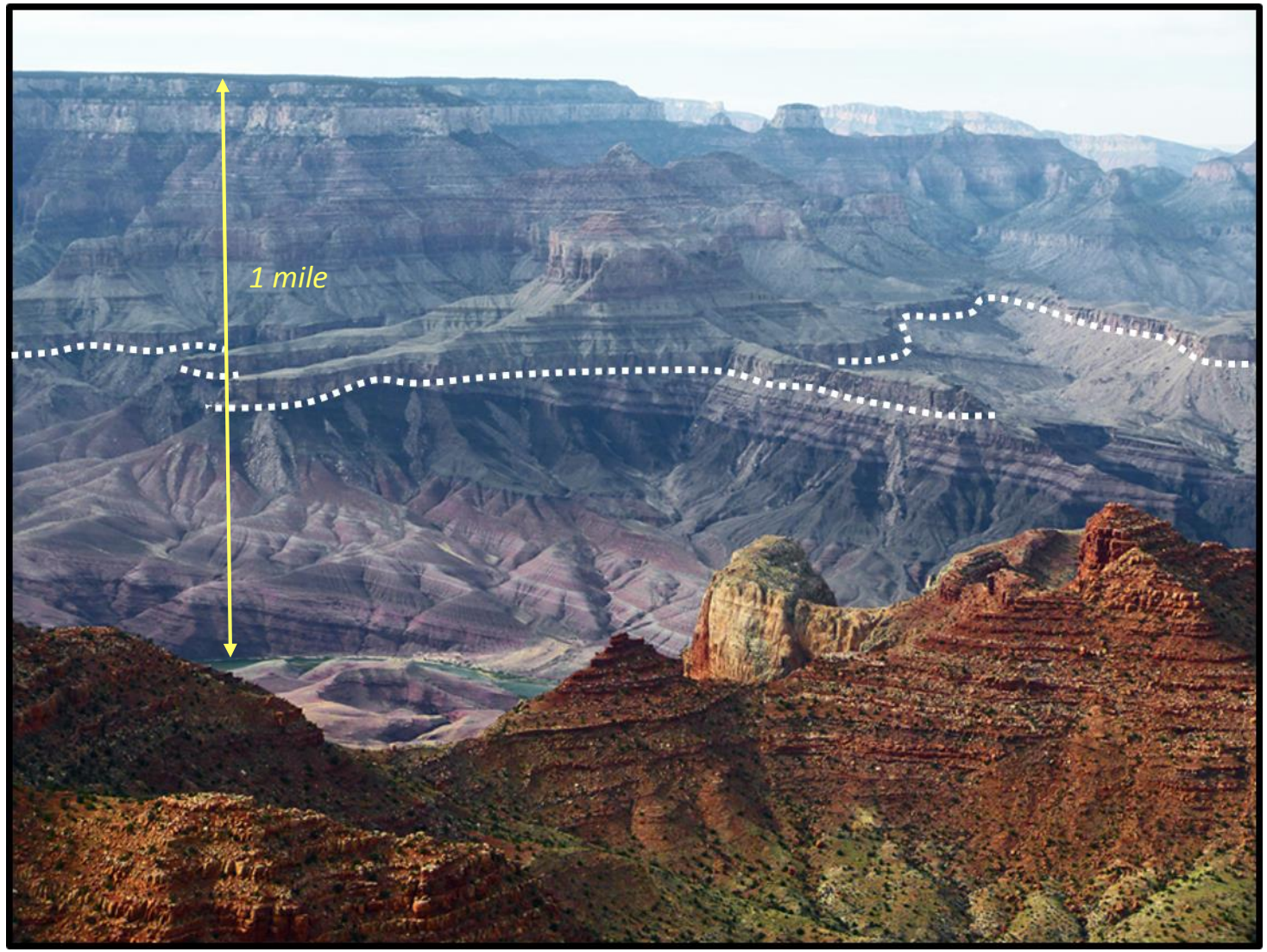
John McPhee, in Basin and Range (1981), wrote:

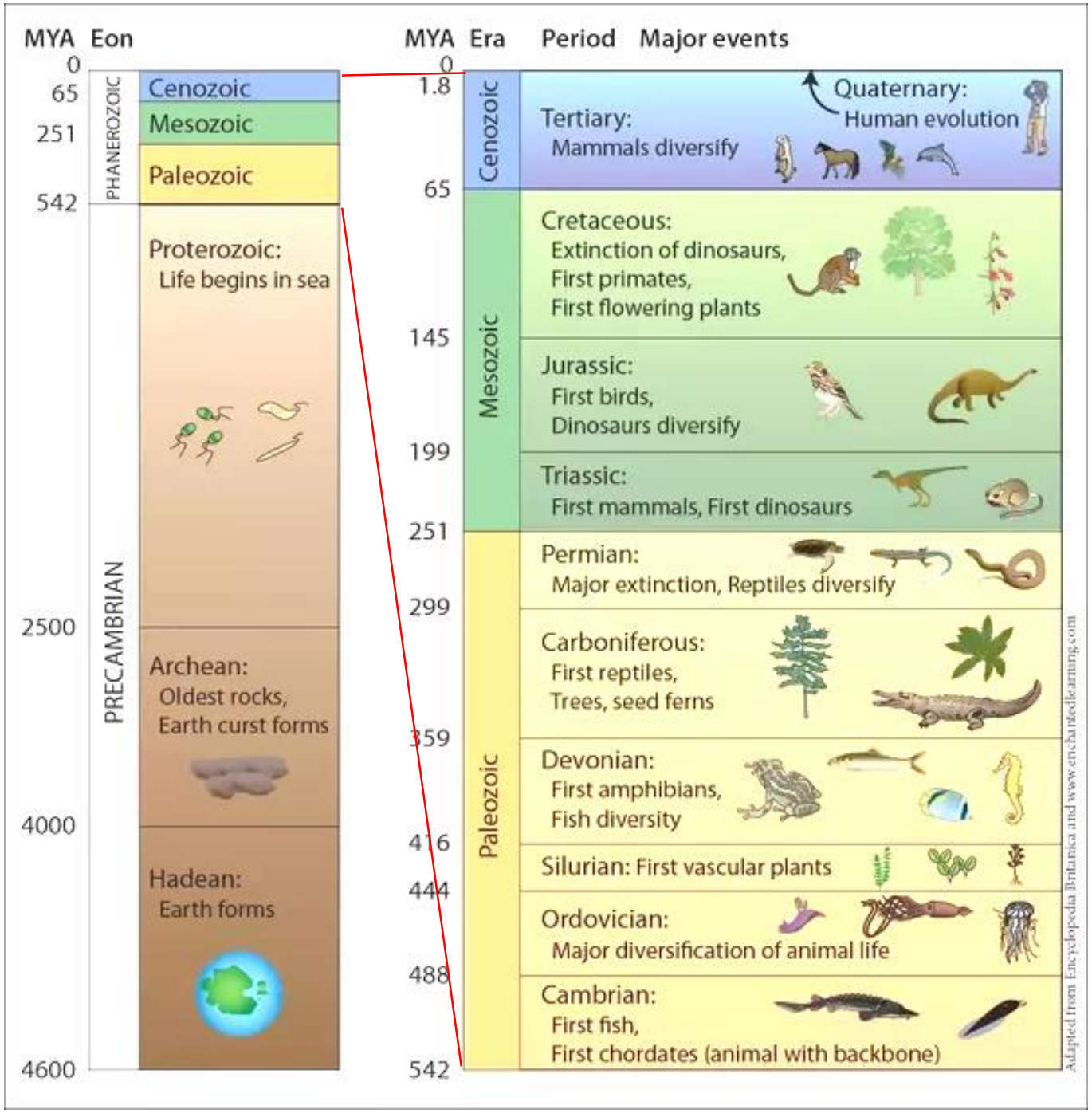
*“Consider the Earth’s history as the old measure of the English yard, the distance from the King’s nose to the tip of his outstretched hand. One stroke of a nail file on his middle finger erases human history.”*

Consider how long it must have taken to deposit layer upon layer of sand, one grain at a time, to get the mile thick sandstone cliffs seen in the Grand Canyon.

Well, we’ve dated the layers. We know it took about 550 million years*.

* About 12% of the age of the Earth






# *It's About Time*

← 11.5 Ma Northbrae Rhyolite

} 66 – 150 Ma 'Franciscan Complex'
(also called the Franciscan Terrane, Franciscan Assemblage, or Franciscan Mélange)

# The Geologic Time Scale

(and the rocks of El Cerrito)

http://www.aoml.noaa.gov/outreach/floridaseagrant/pdf_files/TropicalConnections_GeologicalTimeWithMajorEvolutionaryEventsInFossilRecord_KruczynskiFletcher.pdf

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# How did these rocks come to be here?

*Franciscan Assemblage (150 to 66 million years old)*

Meta-graywacke
Rust-colored metamorphosed dirty sandstone, probably deep-water landslide deposits (“turbidites”)

Blueschist
Blue-ish rock derived from marine sediments and seafloor basalt; has compositional banding and abundant mica, but little or no primary texture such as bedding

11.5 million years old

Northbrae Ryolite
Light-colored (quartz-rich) lava flow. The same rocks forms Indian Rock in Berkeley. The source may have been Round Top Volcano in the Sibley Volcanic Preserve (Oakland)

# First, Some Background: Geologic Setting of the East Bay

World's Tectonic Plates Today


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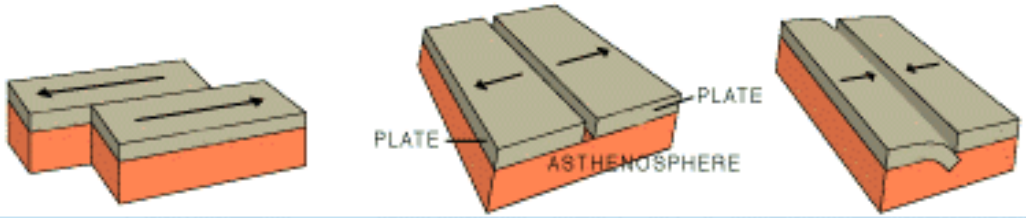
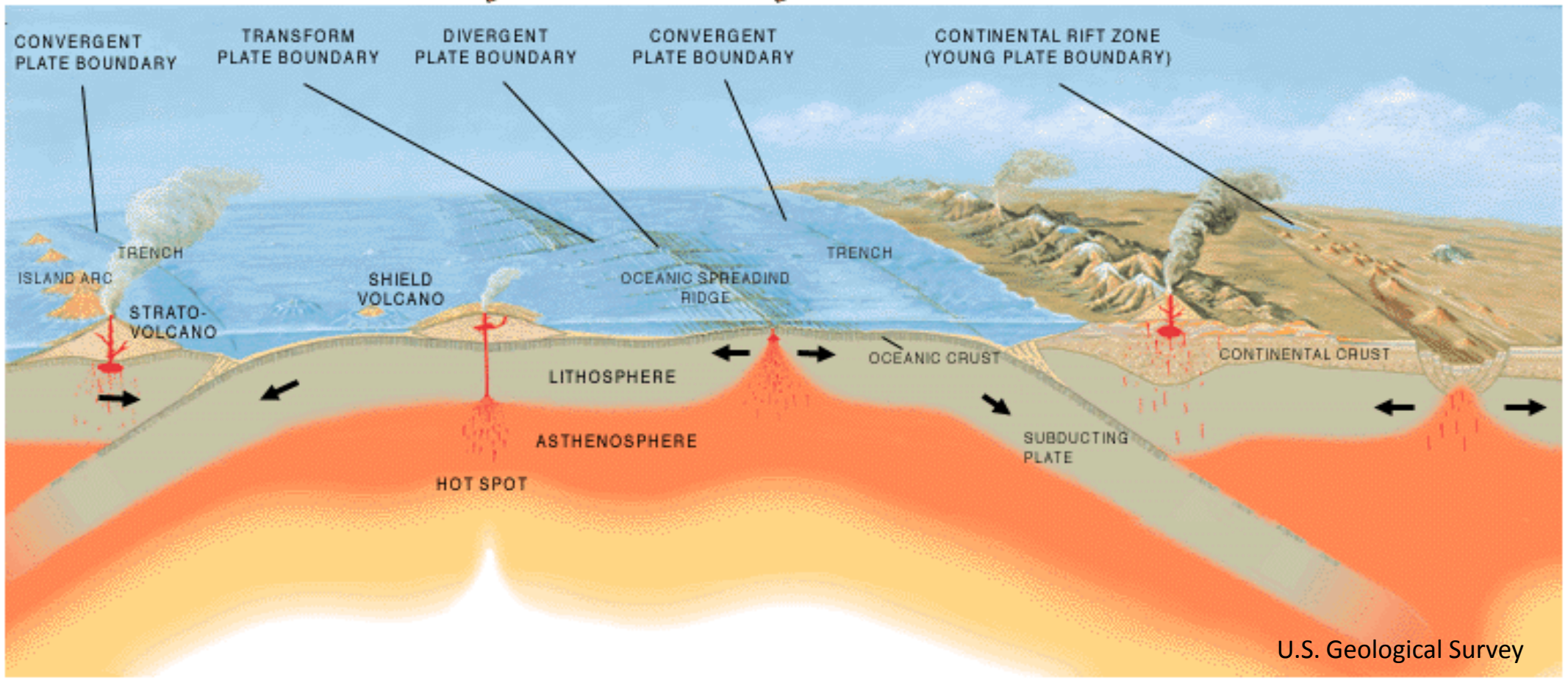
# 3 Types of Plate Boundary

Transform  Divergent (Spreading)  Convergent (Subduction)




U.S. Geological Survey

http://oceanexplorer.noaa.gov/facts/plate-boundaries.html

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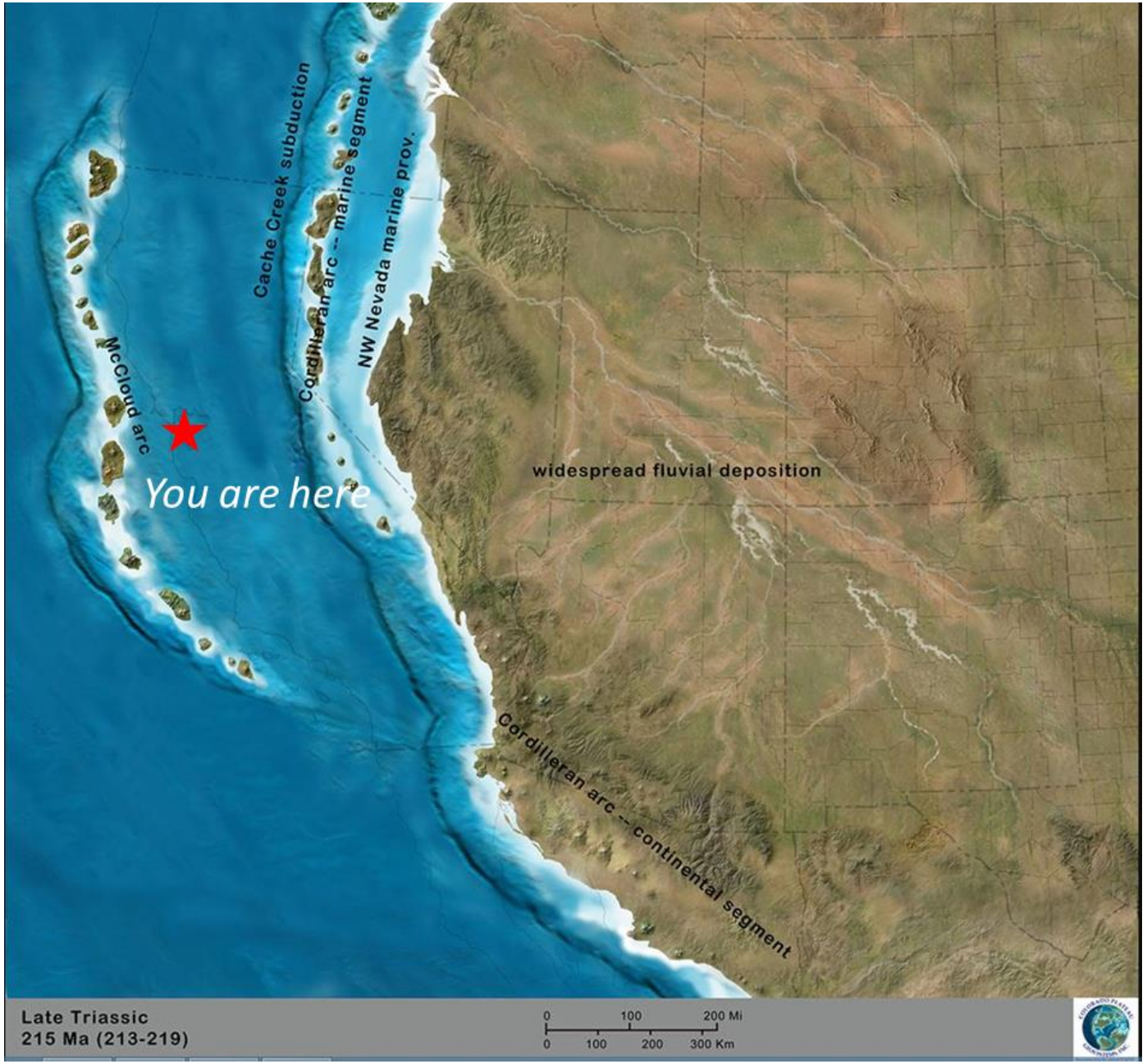
# El Cerrito Began Way Out in the Pacific




215 Million Years Ago

Paleo-geographic maps by Dr. Ron Blakey, Northern Arizona University

http://jan.ucc.nau.edu/rcb7/regionaltext.html

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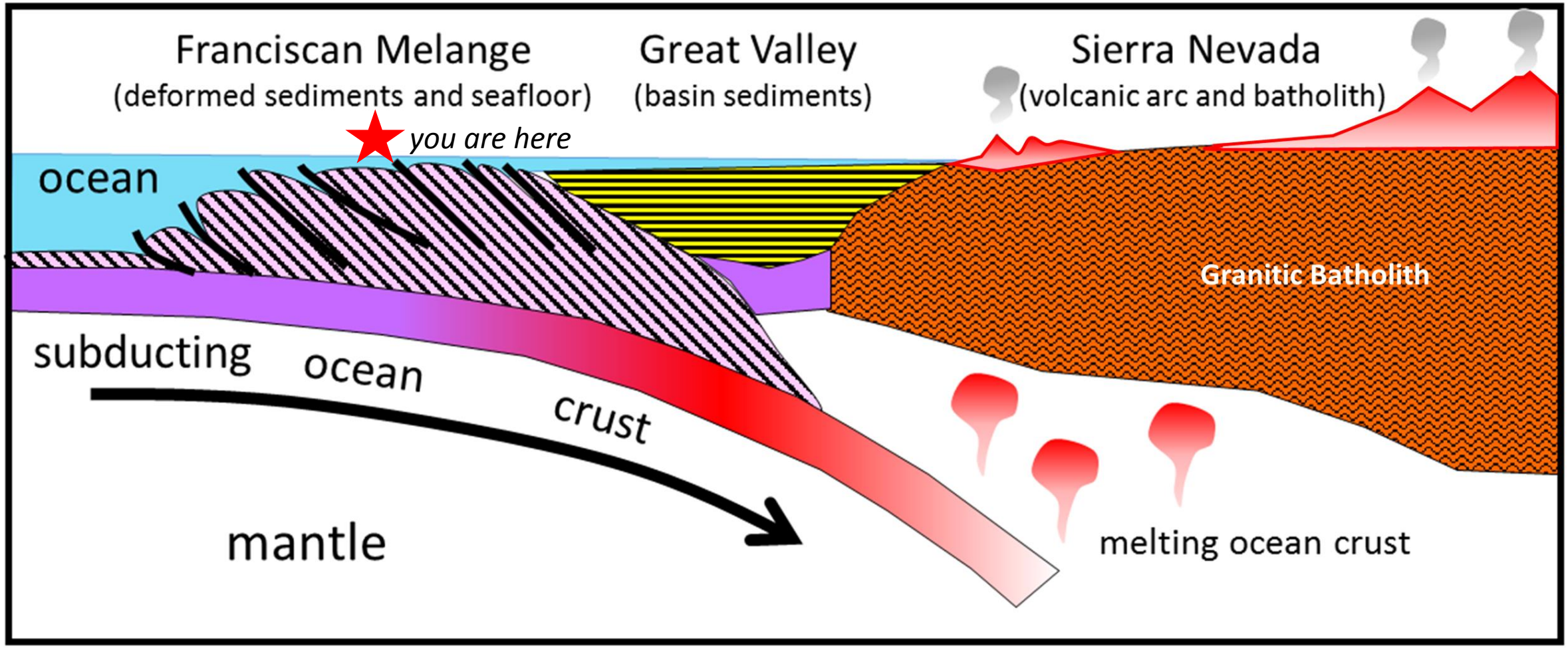
# Situation in the East Bay Hills until about 25 million years ago

(this is still going on offshore Oregon & Washington to the Cascades; Aleutians, Japan today)




Ocean crust and sediment is being subducted: dragged along with downgoing slab

# Metamorphic Rock Classification By Texture

- Metamorphic rocks are classified by texture (slate, schist, gneiss) or by composition (blueschist, greenschist, etc)
- Most of what you see in the Hillside Nature Area is a *Schist* by texture, meaning it has aligned minerals, mainly mica (looks like glitter)

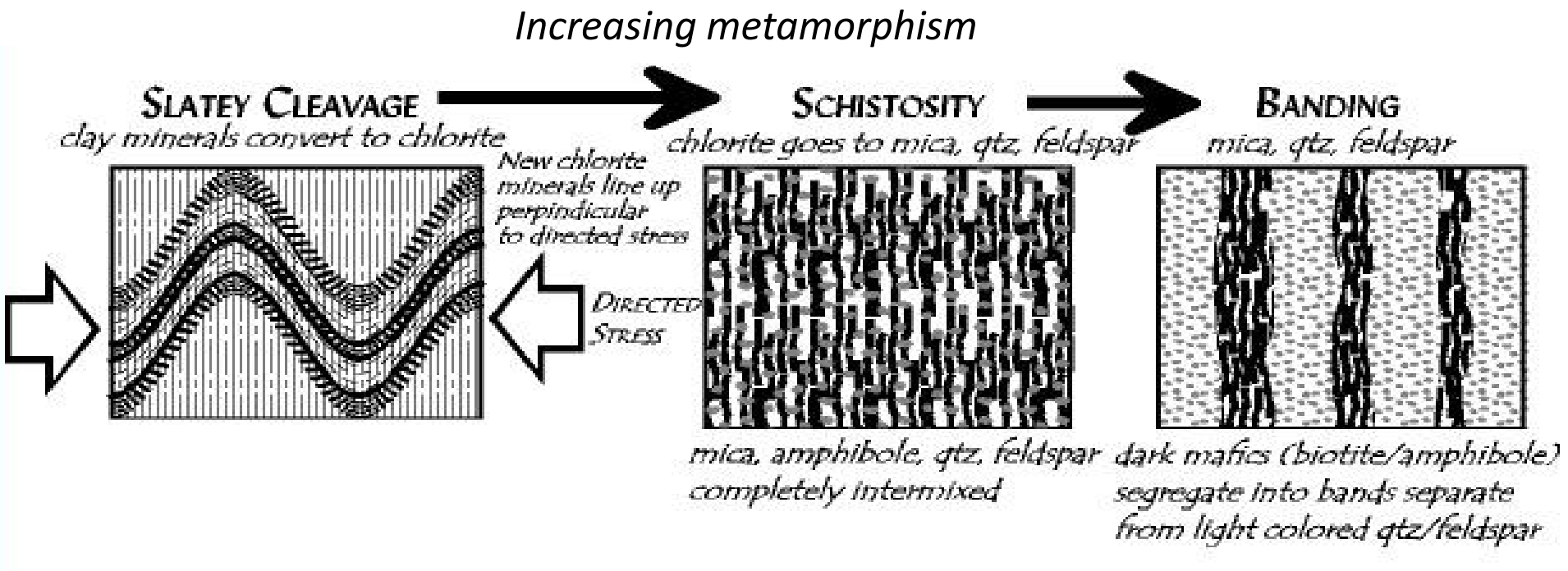
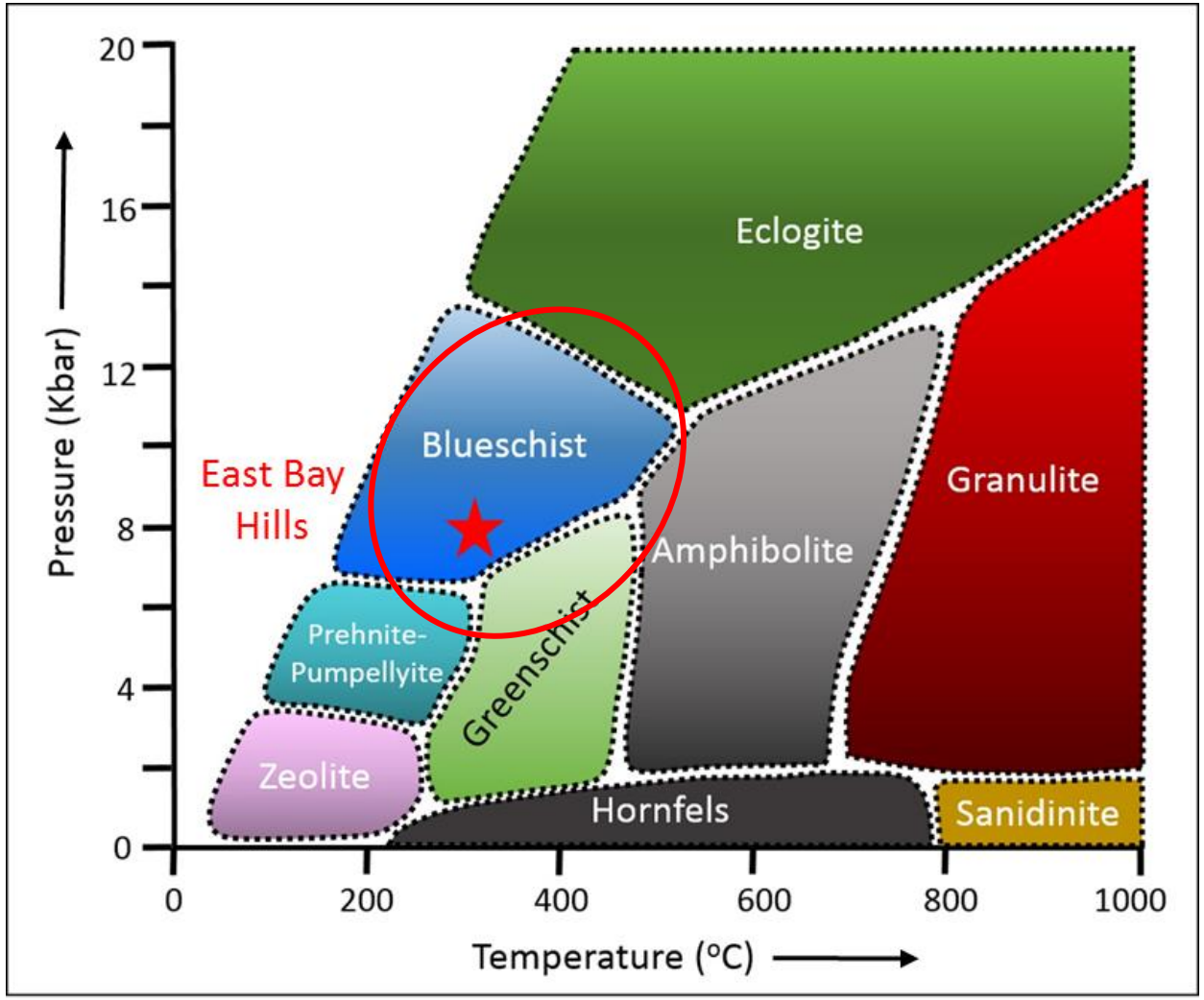



Diagram from Atlantis Online, http://atlantisonline.smfforfree2.com/index.php?topic=1379.15

# Metamorphic Rock Classification By Composition

- Compositionally these rocks are a *Blueschist* (the blue color comes from the mineral glaucophane)
- Blueschist is considered a “high pressure, low temperature” metamorphic rock that forms at 15-30 km (9-18 mi) depth and 200 to 500°C (392 – 932°F)
- Heat and pressure cause the original minerals in the rock to recrystallize and realign themselves




Composition Classification

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# Situation in the East Bay Hills until about 25 million years ago

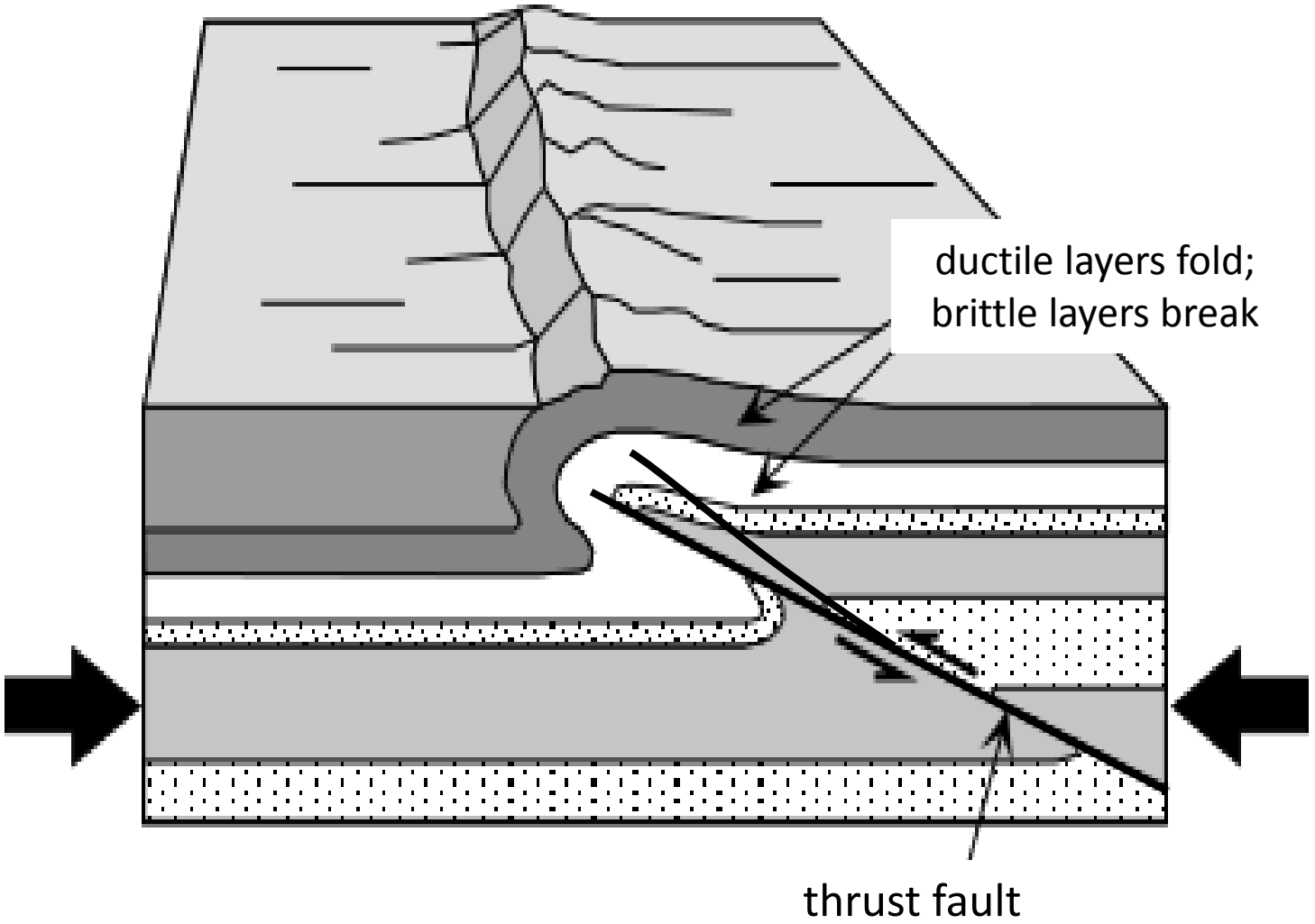


Diagram by US Geological Survey
https://earthquake.usgs.gov/learn/glossary/?term=blind%20thrust%20fault

First the rocks were buried deep in the Earth and metamorphosed

Then thrust faults in the East Bay Hills moved the metamorphosed ocean crust and sediments up and toward the west

# Franciscan Meta-Graywacke

## (metamorphosed dirty sandstone)

Outcrop just off Potrero


Detail

Outcrop just off Schmidt Lane

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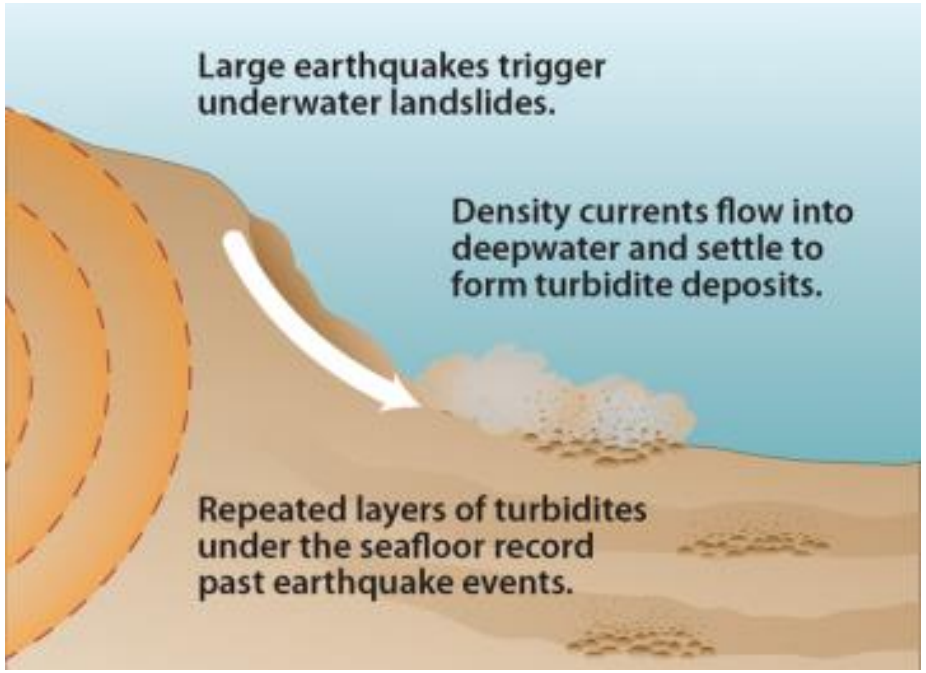
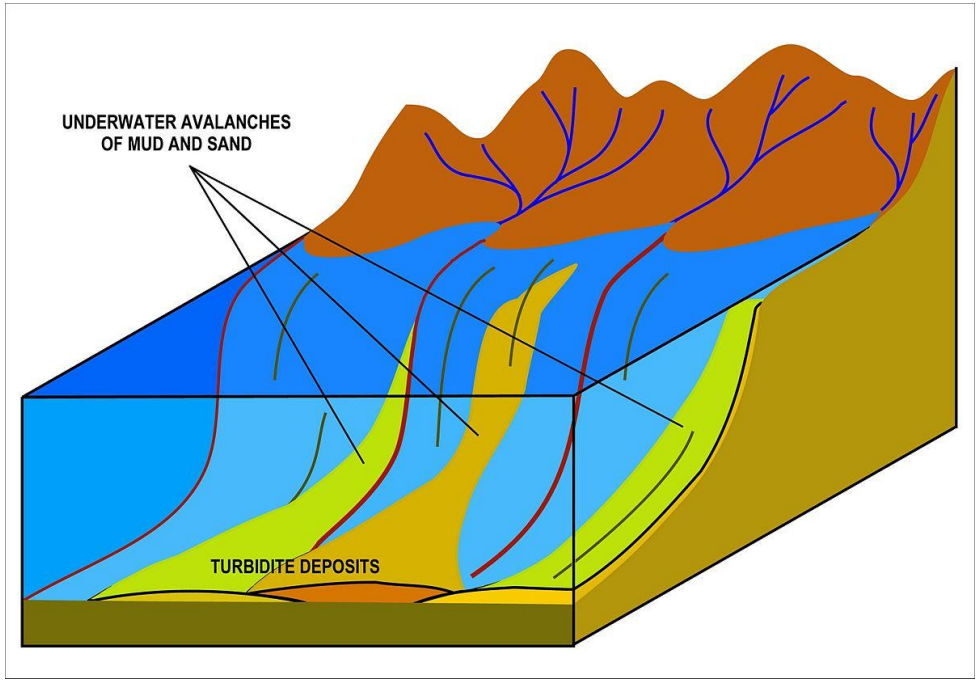
# Environment Where Turbidites & Graywackes Accumulate




Fairly young turbidite, Baja California
Recognize turbidites by multiple sand-to-shale layers

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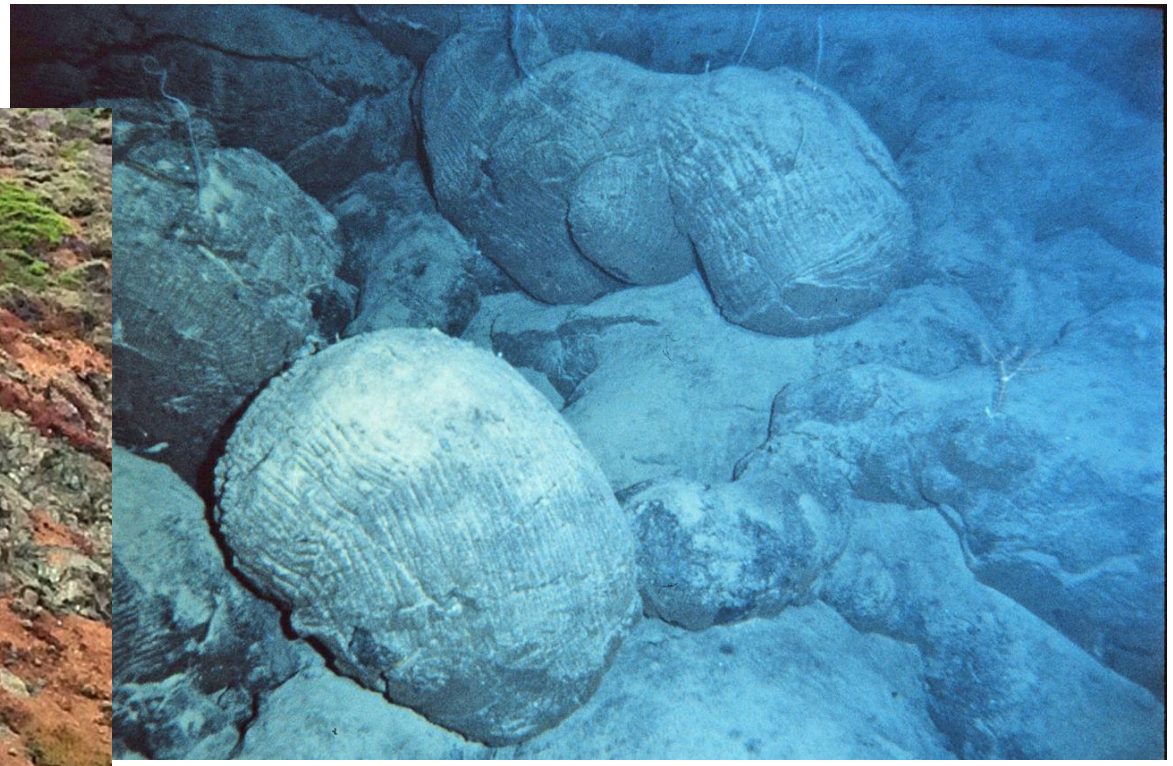
# Franciscan Blueschist

## (ancient ocean floor basalt)

Compositional banding in outcrop above Recycling Center

Real blue-green rock on Shevlin by Moeser (under powerline)

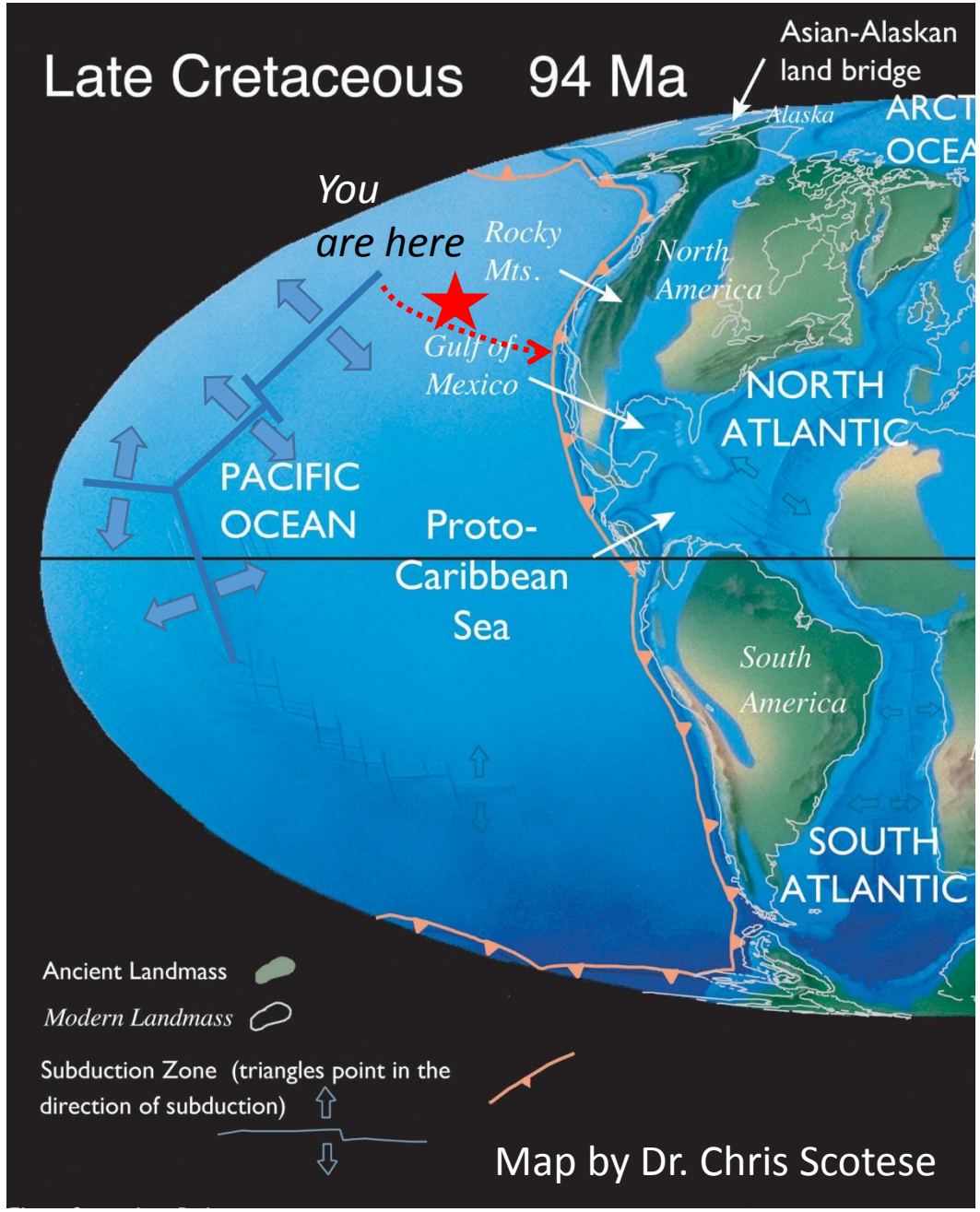
# The Blueschist was Originally Basalt Erupted on the Seafloor at the Pacific Spreading Center

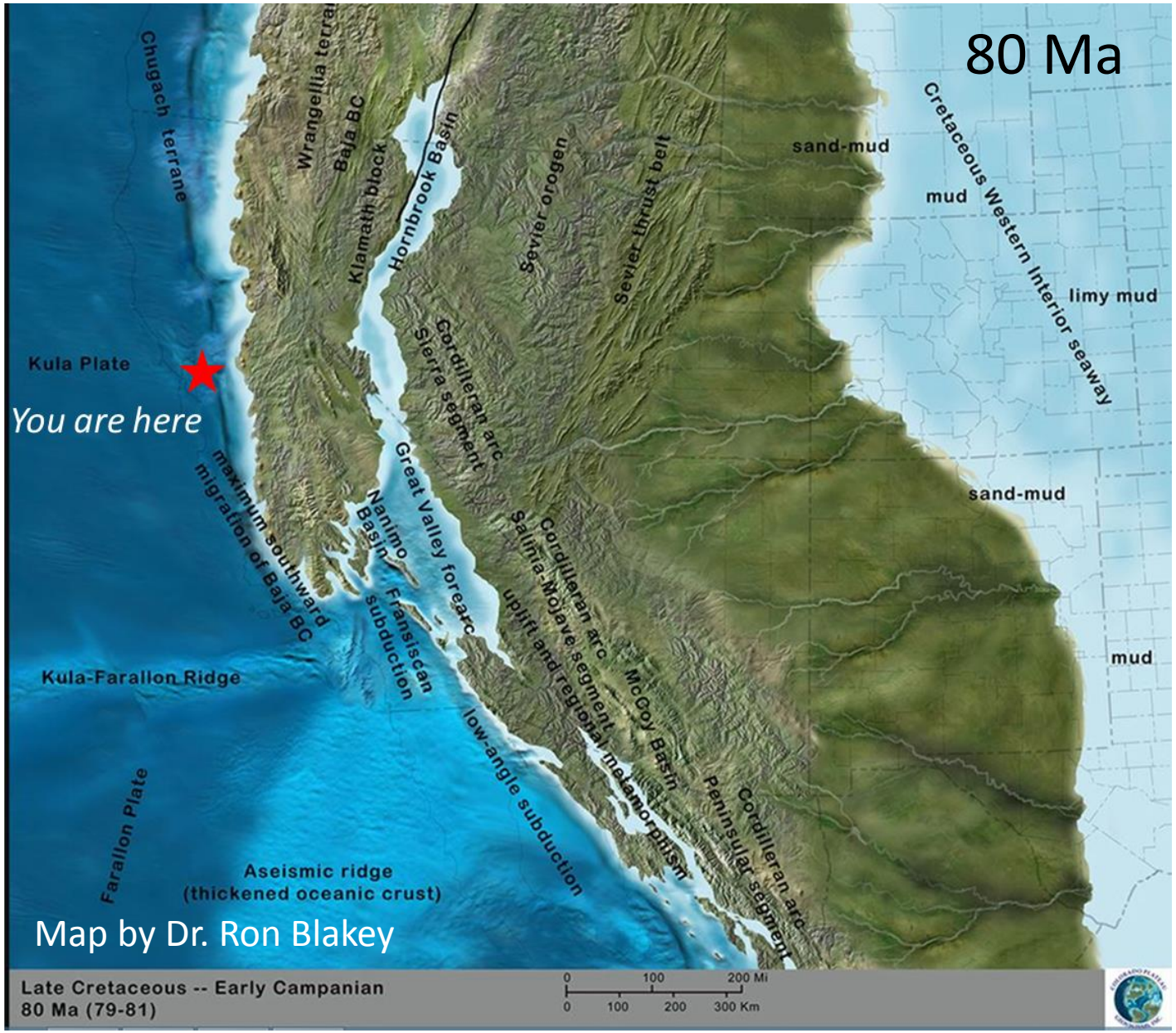


Pillow lava offshore Hawaii

The basalt became a blueschist during deep burial and metamorphism.
Pillow lava, Pt. Bonita Lighthouse

# What Did The Continent Look Like When The Pillow Basalt Was Erupting?

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# The Youngest Rock in the area is the 11.5 Ma Northbrae Rhyolite – a quartz-rich lava

The lava either flowed here, or was carried on the Hayward Fault

Julian Drive outcrops

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# Source of the Northbrae Rhyolite

***Stories in Stone at Sibley Preserve***
by Gordy Slack on April 01, 2005

Ten million years ago, when three-toed horses and long-necked camels roamed our region, volcanic eruptions tore through an alluvial fan, forming what would become Oakland's Round Top. This artist's conception shows what one of the Round Top eruptions might have looked like, with the still-volcanic Sierra in the distance.

https://baynature.org/article/voice-of-the-volcano/

# What Did This Part of the World Look Like 10 Million Years Ago?


Paleo-geographic maps by Dr. Ron Blakey
Northern Arizona University

http://jan.ucc.nau.edu/rcb7/regionaltext.html

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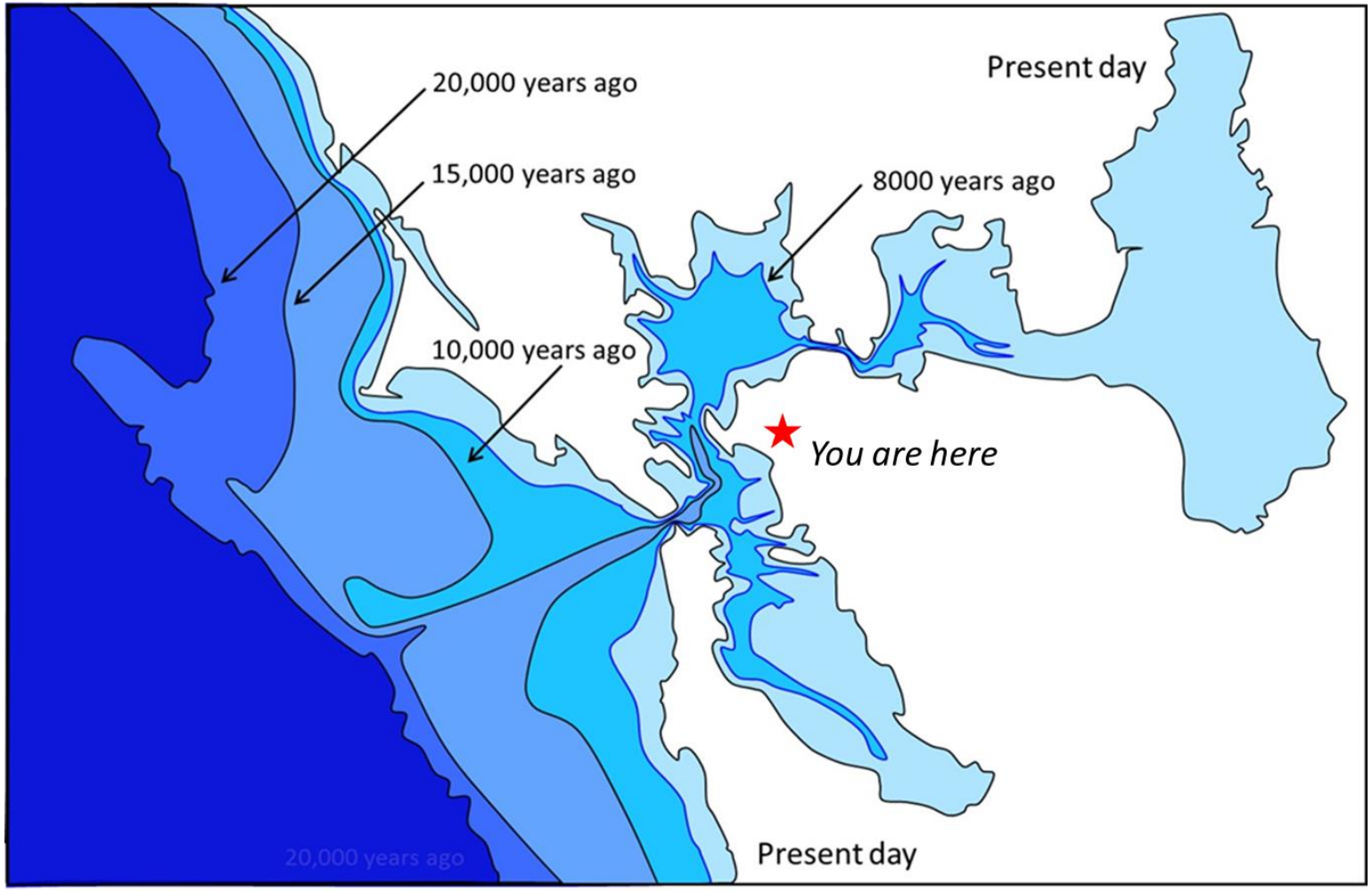
# Development of the Bay Area Over the Past Million Years (Ice Ages)




- A million years ago the area that is now San Francisco Bay was a flat plain between the Coast Range and the East Bay Hills.
- By half a million years ago there were rivers draining the Central Valley across the plain and through a gap in the Coast Ranges now called the Golden Gate.

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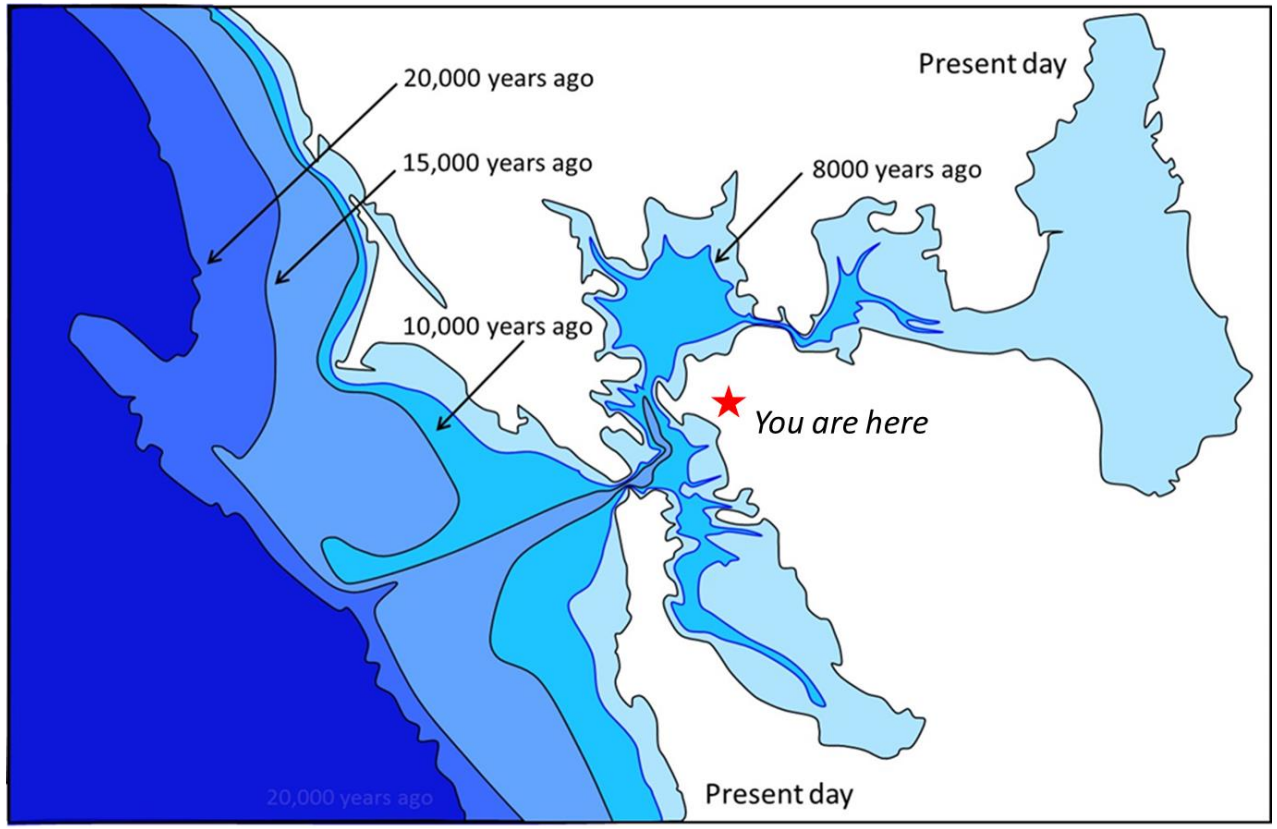
# Development of the Bay Area from the Last Ice Age to Present




- 20,000 years ago, at the height of the last ice age, sea level was 400 ft lower than today. The coast was 25 mi west of where it is now. The Farralon Islands were mountains, and the river that drained the Central Valley had cut a deep canyon from Carquinez Strait to the Golden Gate and beyond to the coast. Where the Bay is today was a broad valley.
- 12,000 to 15,000 years ago the glaciers began to melt and sea level began to rise. Sediment carried by the Sacramento River was deposited in the canyon, backfilling it. The Pacific spilled through the gap at the Golden Gate and began to fill the valley between the Coast Range and East Bay Hills.

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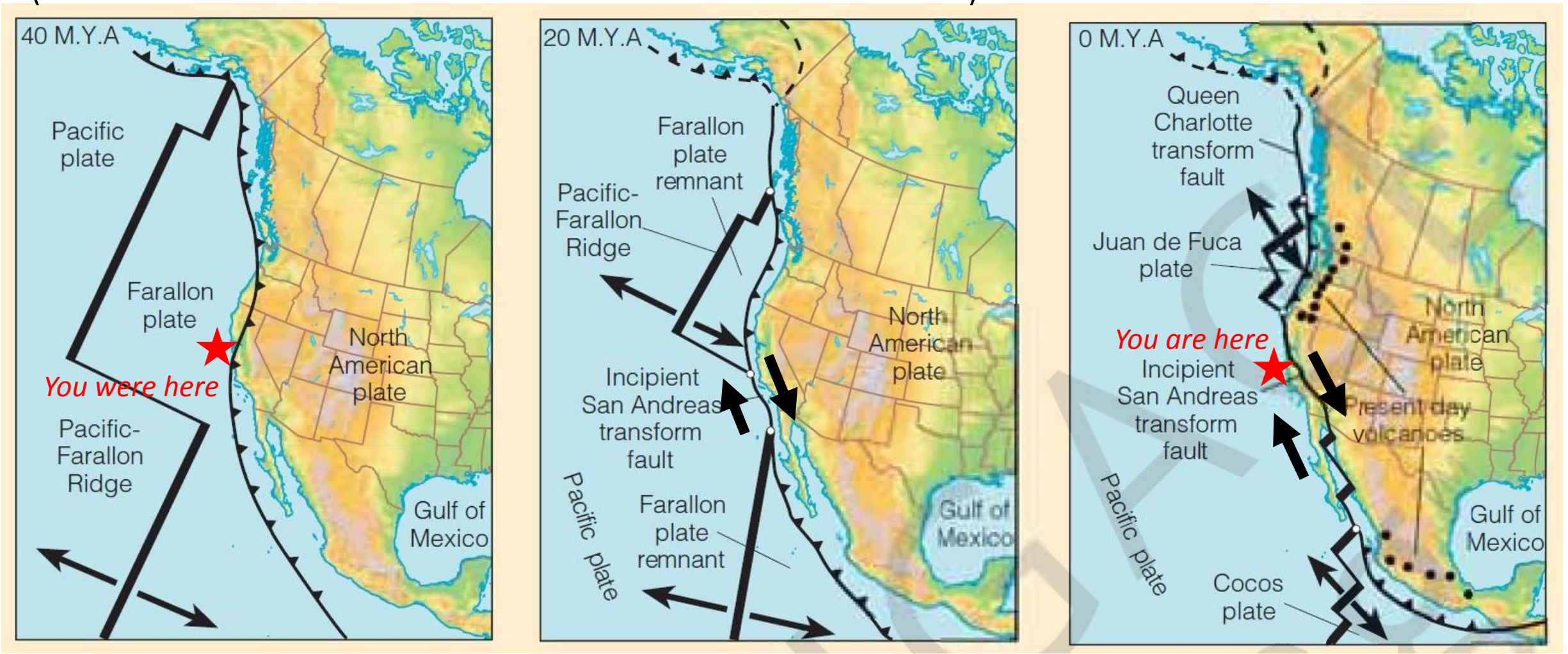
# Situation in the East Bay Hills since about 25 million years ago

About 25 million years ago subduction stopped in the Bay area. The Farallon Plate was now entirely under the continent; the Pacific Plate was moving NW relative to North America.

(The Juan de Fuca & Cocos Plates are remnants of the Farallon Plate)



# Present-Day Relative Movement Directions

## Pacific & North American Plates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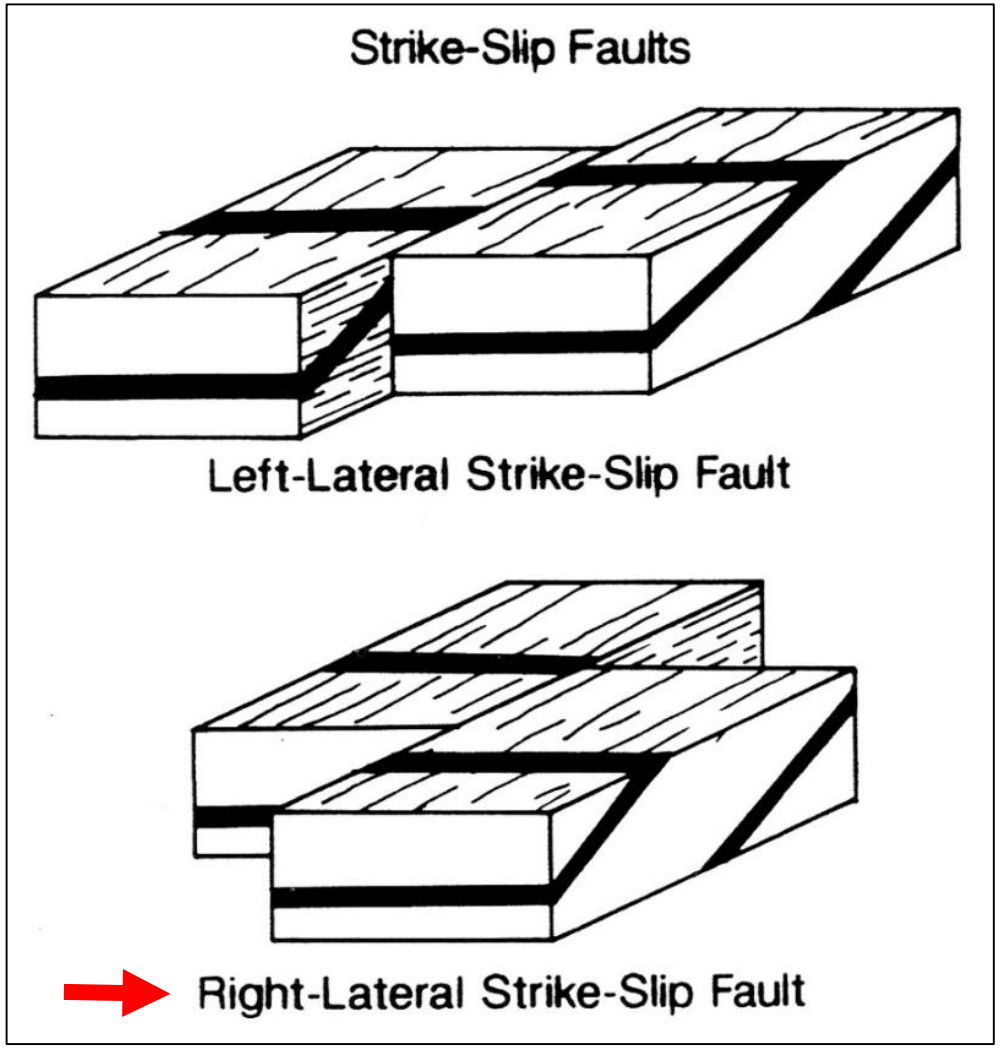
# What Causes Earthquakes….

# Situation in the East Bay Hills since about 25 million years ago

- The Hayward Fault is a right-lateral strike-slip fault*, part of the San Andreas System
- The El Cerrito strand is creeping (gradual slip; no big jumps) about 1.6” every ten years
- The last large rupture here was ~1705, so it *can* happen (Dave Schwartz, USGS)
- Total offset on the creeping section is about 3 miles in past 12 million years




* Means the side opposite you is moving to the right with respect to your side

# The Thrust Faults are Dead; *The Hayward Fault is Alive!*

The last major quake on the Hayward Fault in Hayward was a 6.8 to 7.0 in 1868. Maximum offset was 3 ft, up slightly to the east.

There were 3 quakes with magnitude 6-7 during the 1800s.


Google Earth, view north

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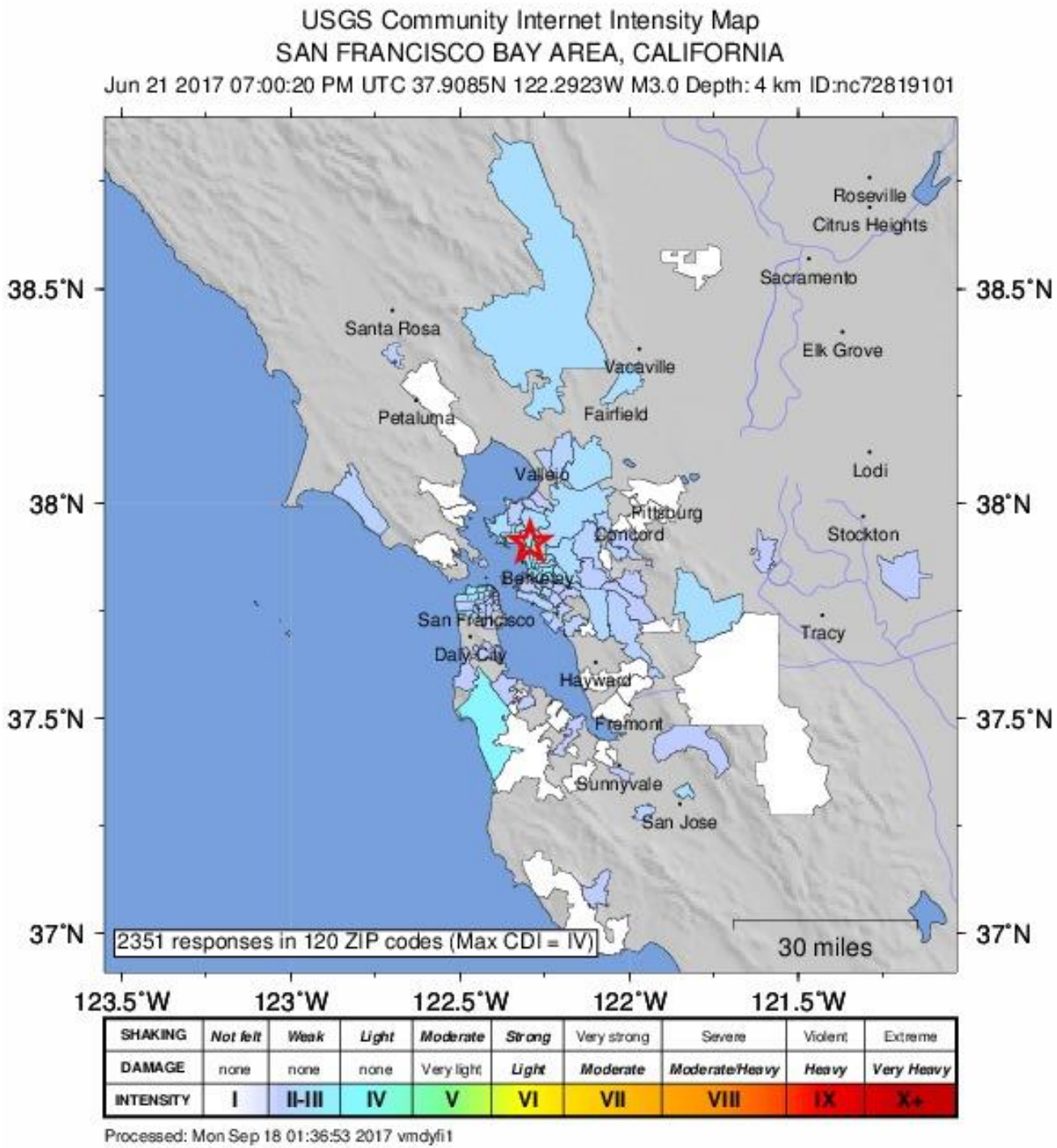


# USGS “Did You Feel It?” Map

El Cerrito Magnitude 3.0 Quake
June 21, 2017

Most responders felt a slight bump

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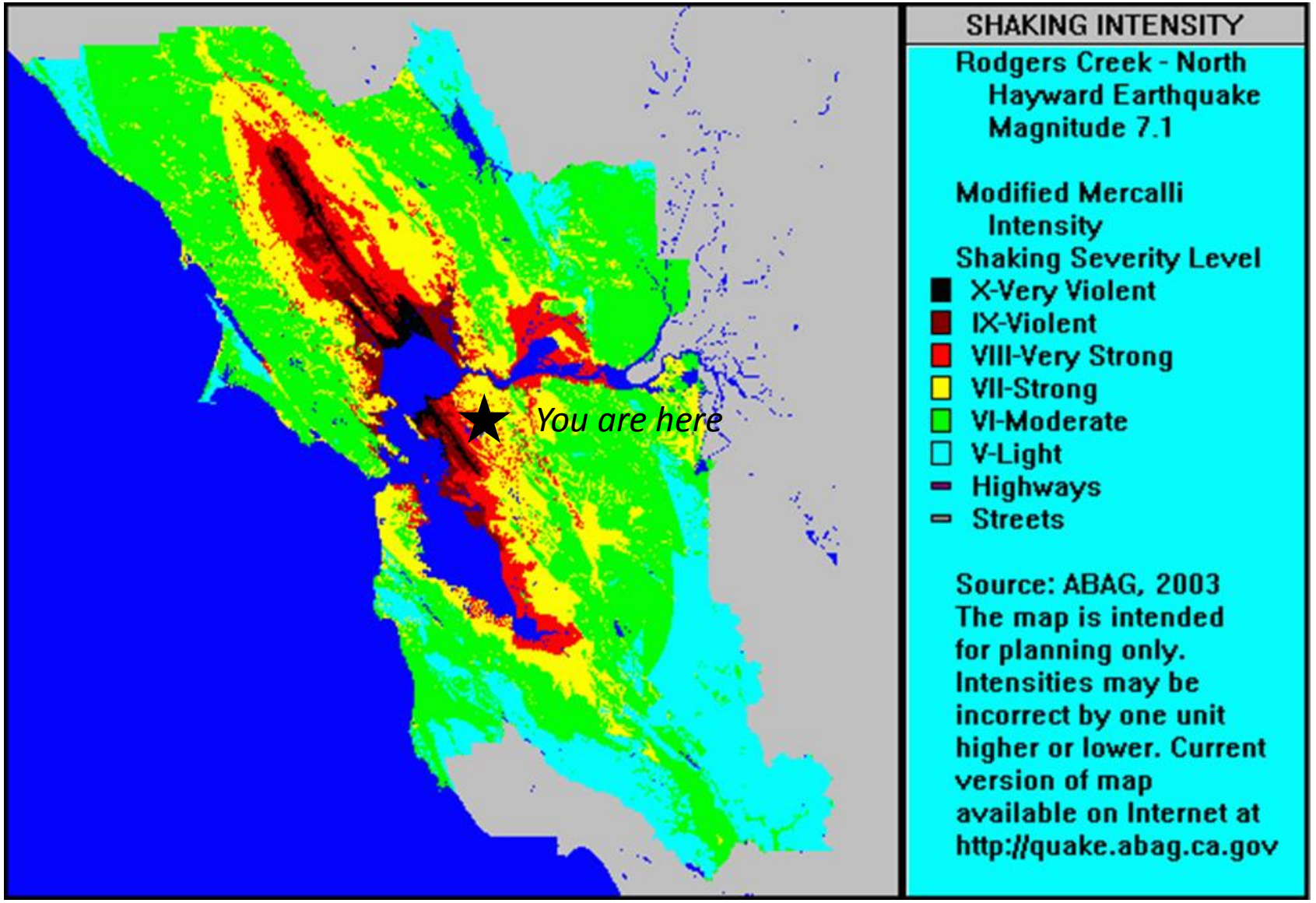
# *It's Alive!*

The USGS (2012) estimated there is a 30% chance of a 6.7 or greater earthquake on the Hayward Fault in the next 30 years

A magnitude 6 to 7 fault is easily felt; chimneys fall, furniture moves, there is substantial damage to buildings

For reference, the 1989 Loma Prieta quake was a 6.9

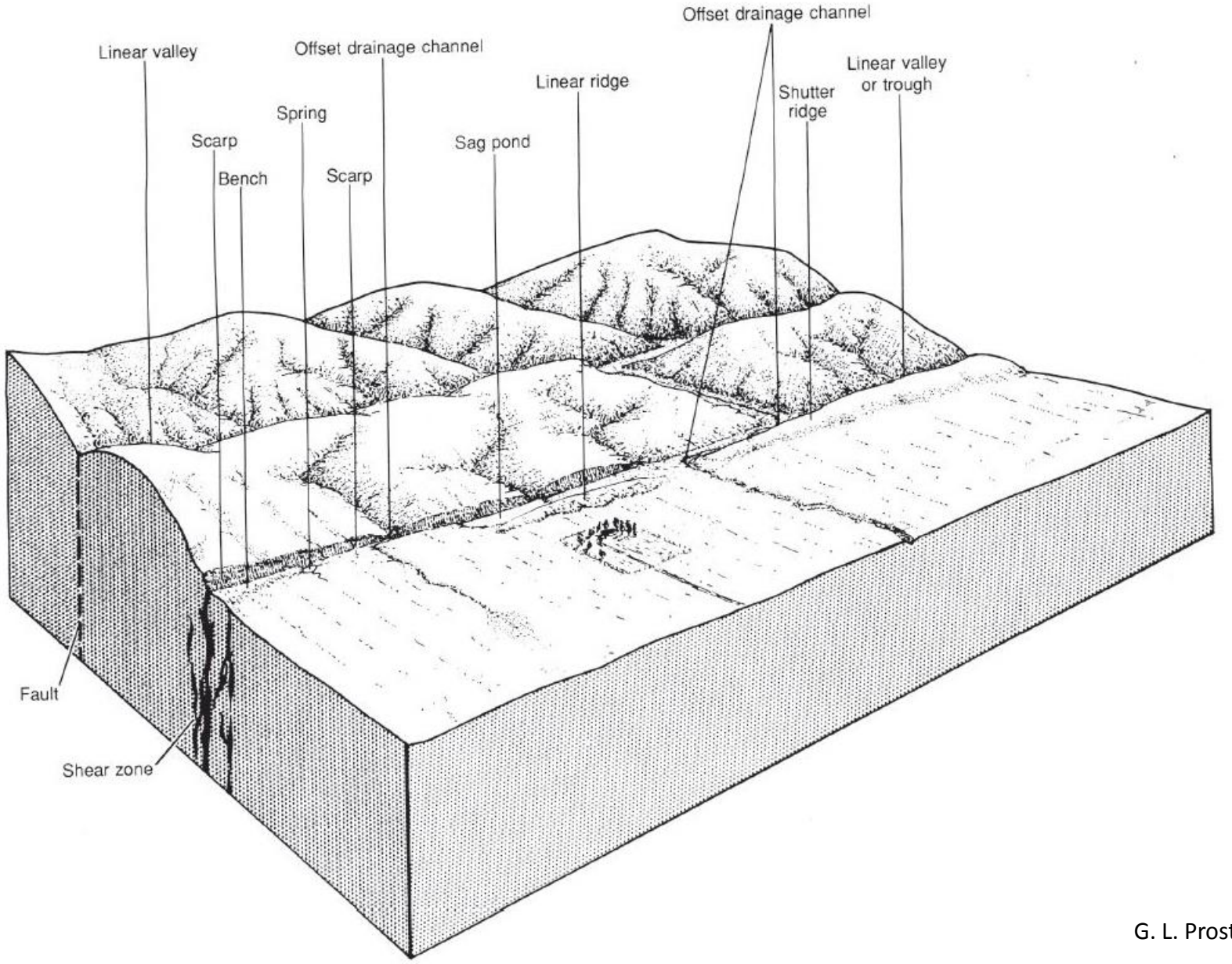



Surface motion map for a hypothetical earthquake on the northern portion of the Hayward Fault Zone and its northern extension, the Rodgers Creek Fault Zone.

Credit: Leonard G. https://en.wikipedia.org/wiki/Seismic_hazard

# How To Recognize a Fault

## (and what they look like below ground)

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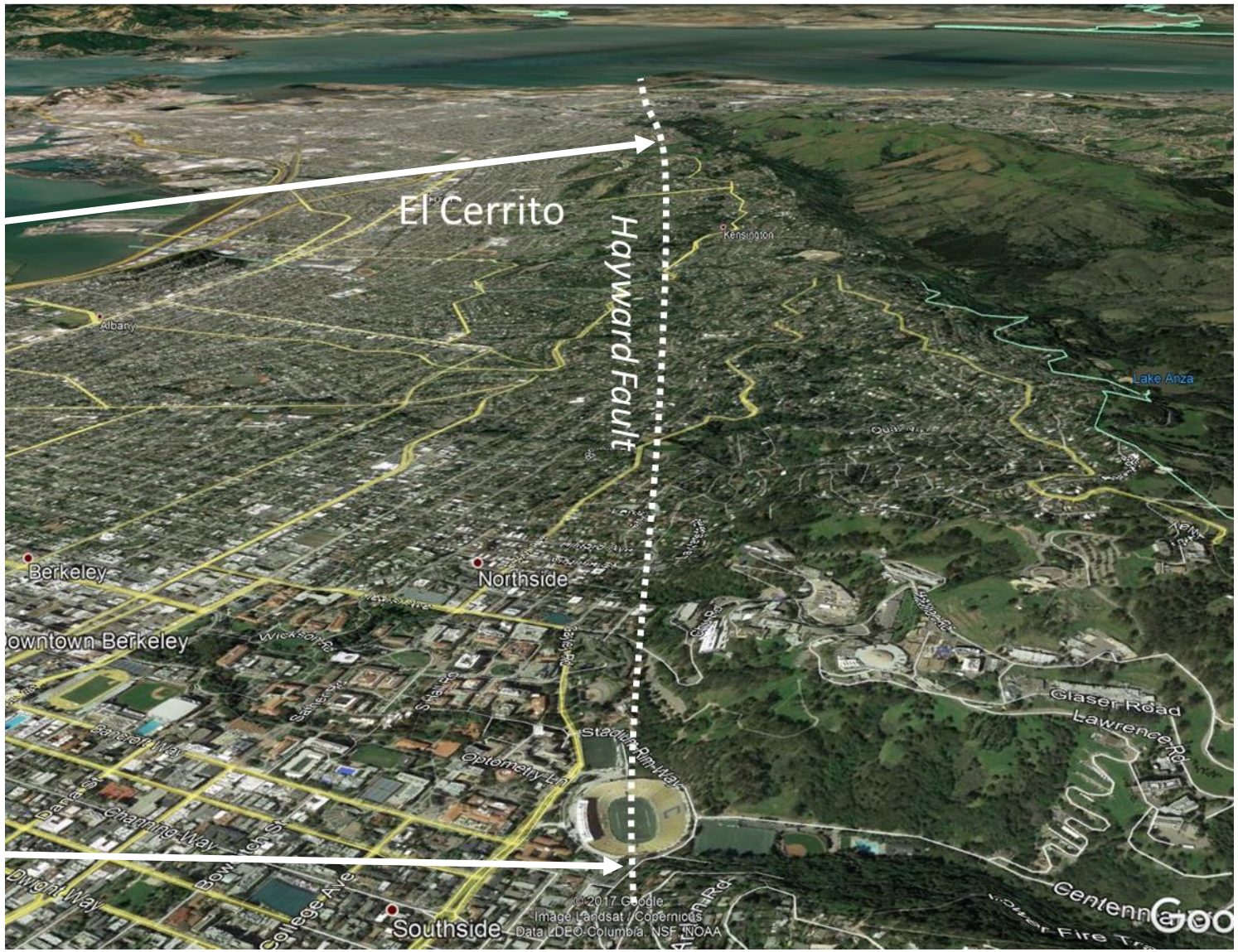
# The Hayward Fault is Creeping in El Cerrito (for now…..)



Google Earth, view north

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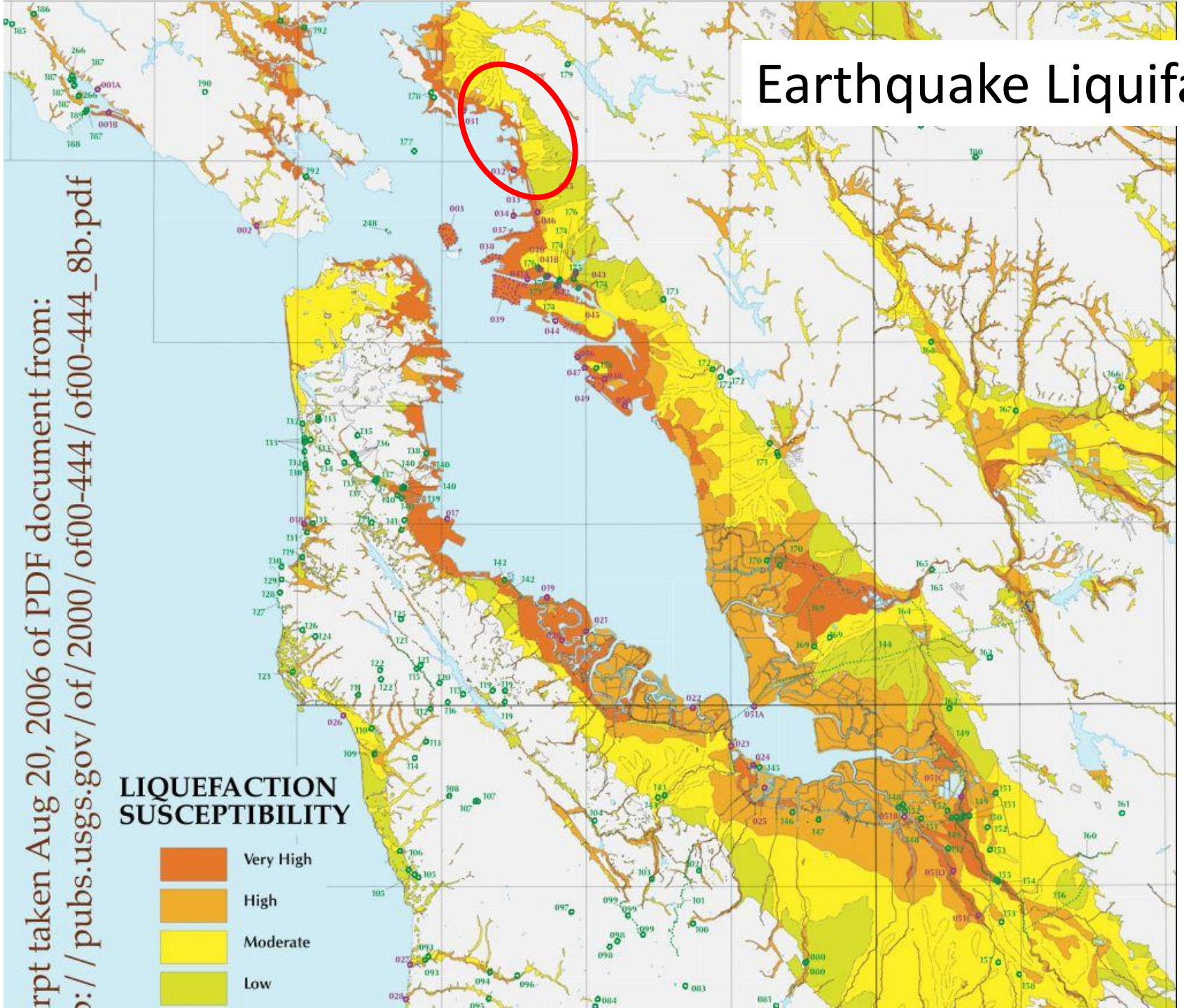
# Earthquake Liquifaction, El Cerrito

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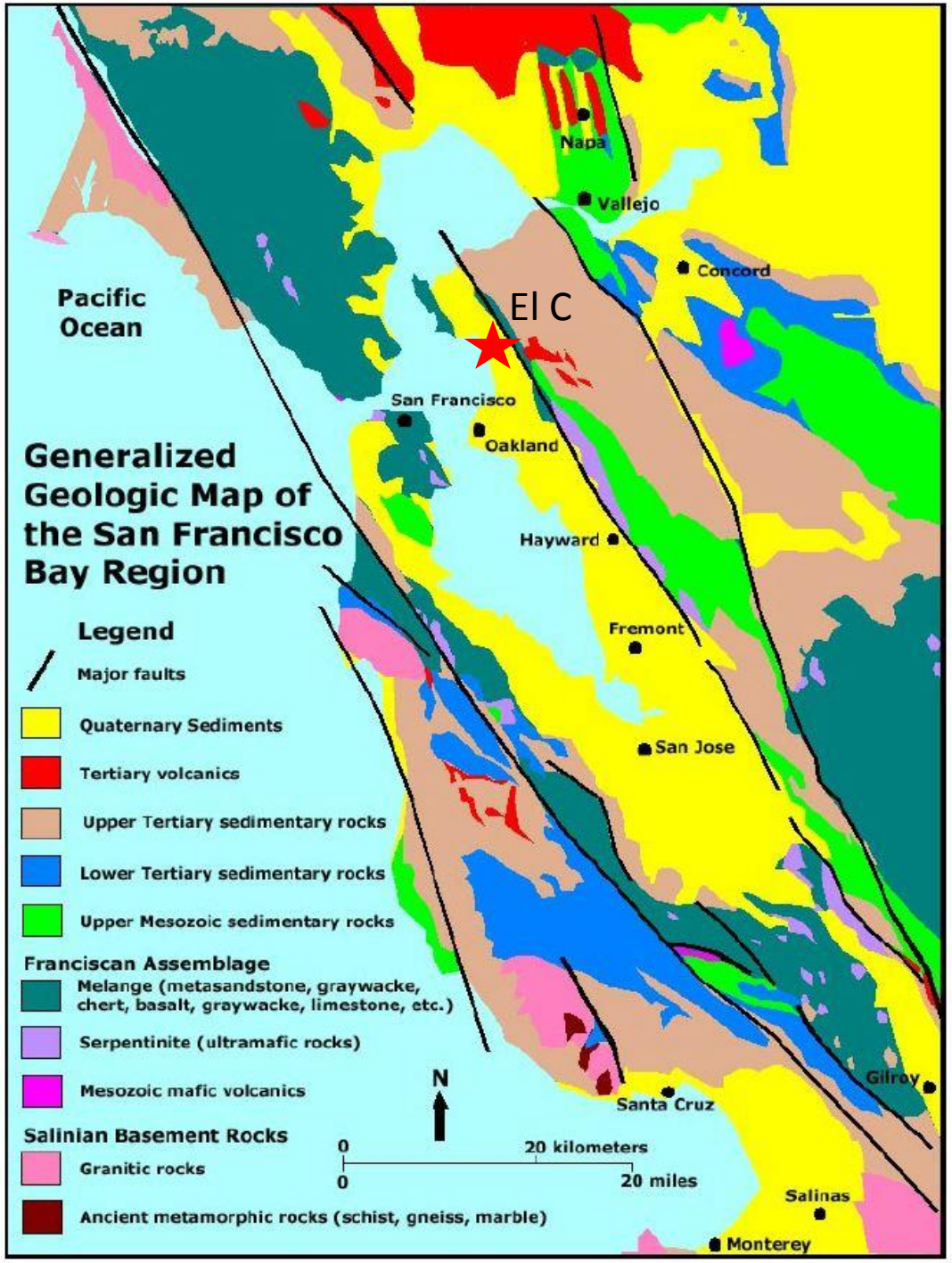
# Regional Geology, Bay Area

## Geologic Maps Show the Distribution of Rock Types and Faults



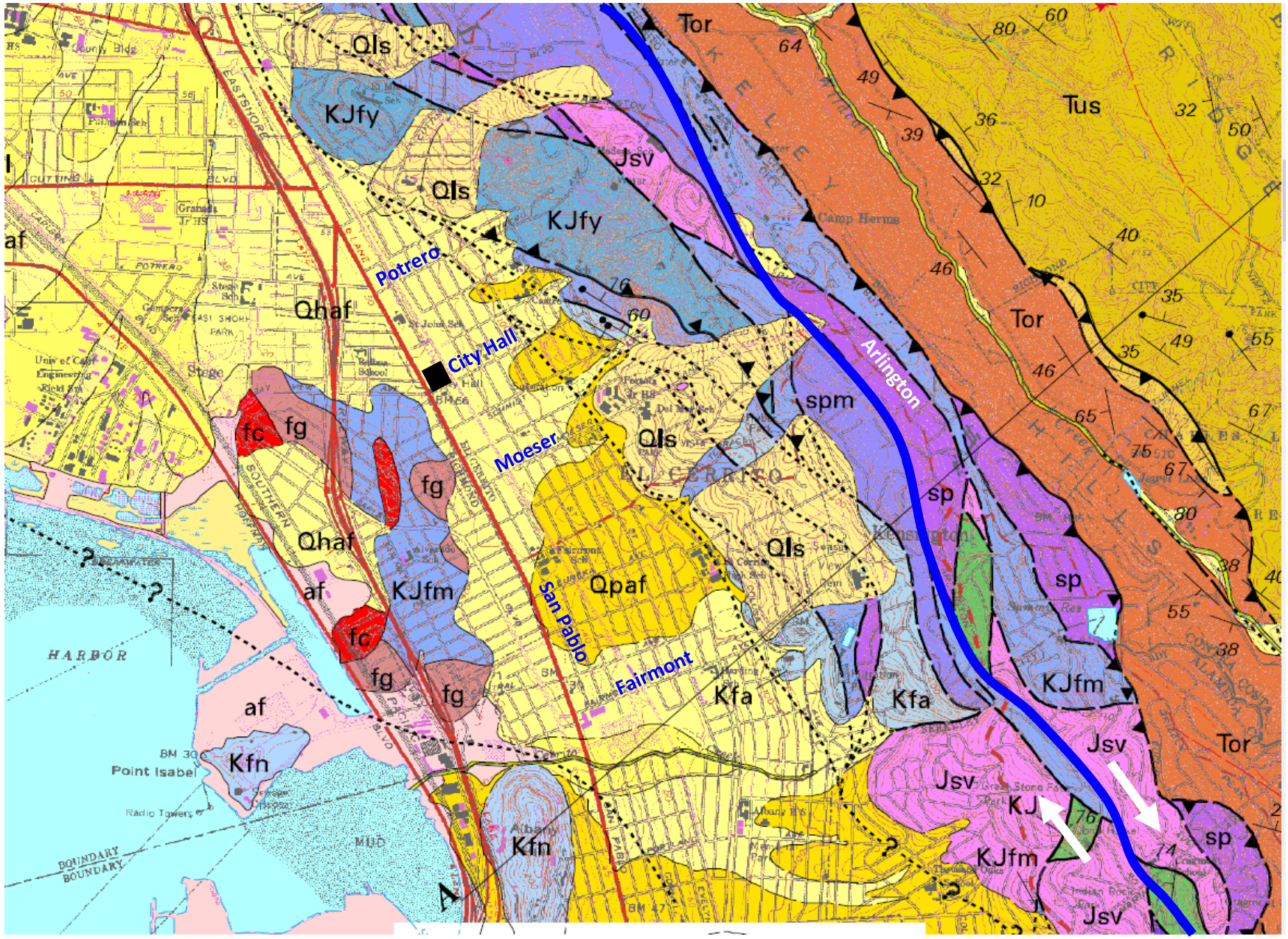

Rocks and Geology in the San Francisco Bay Region

By Philip Stoffer

Bulletin 2195

U.S. Geological Survey

# El Cerrito section of Geologic Map of Oakland Quadrangle, US Geological Survey




KJkv — Volcanoclastic breccia

Jsv — Keratophyre and quartz keratophyre (Late Jurassic)

Coast Range ophiolite (Jurassic)

Jpb — Pillow basalt, basalt breccia, and minor diabase

Jb — Massive basalt and diabase

Jgb — Gabbro

sp — Serpentinite

sc — Silica-carbonate rock

spm — Serpentinite matrix mélange

Franciscan Complex

KJf — Undivided Franciscan complex rocks (Cretaceous and Jurassic)

Kfn — Sandstone of the Novato Quarry terrane of Blake and others (1984) (Late Cretaceous)

Kfgm — Fine-grained quartz diorite (Late Cretaceous (?))

Kfa — Sandstone of the Alcatraz terrane of Blake and others (1984)(Cretaceous)

KJfy — Metasandstone of the Yolla Bolly terrane of Blake and others (1984) (Cretaceous(?) and Late Jurassic)

KJfs — Franciscan complex sandstone, undivided (Late Cretaceous to Late Jurassic)

KJfm — Franciscan complex, mélange (Cretaceous Late Jurassic), includes mapped locally: Graywacke and meta-graywacke blocks

fs

Hayward Fault (strike-slip)

Thrust Faults

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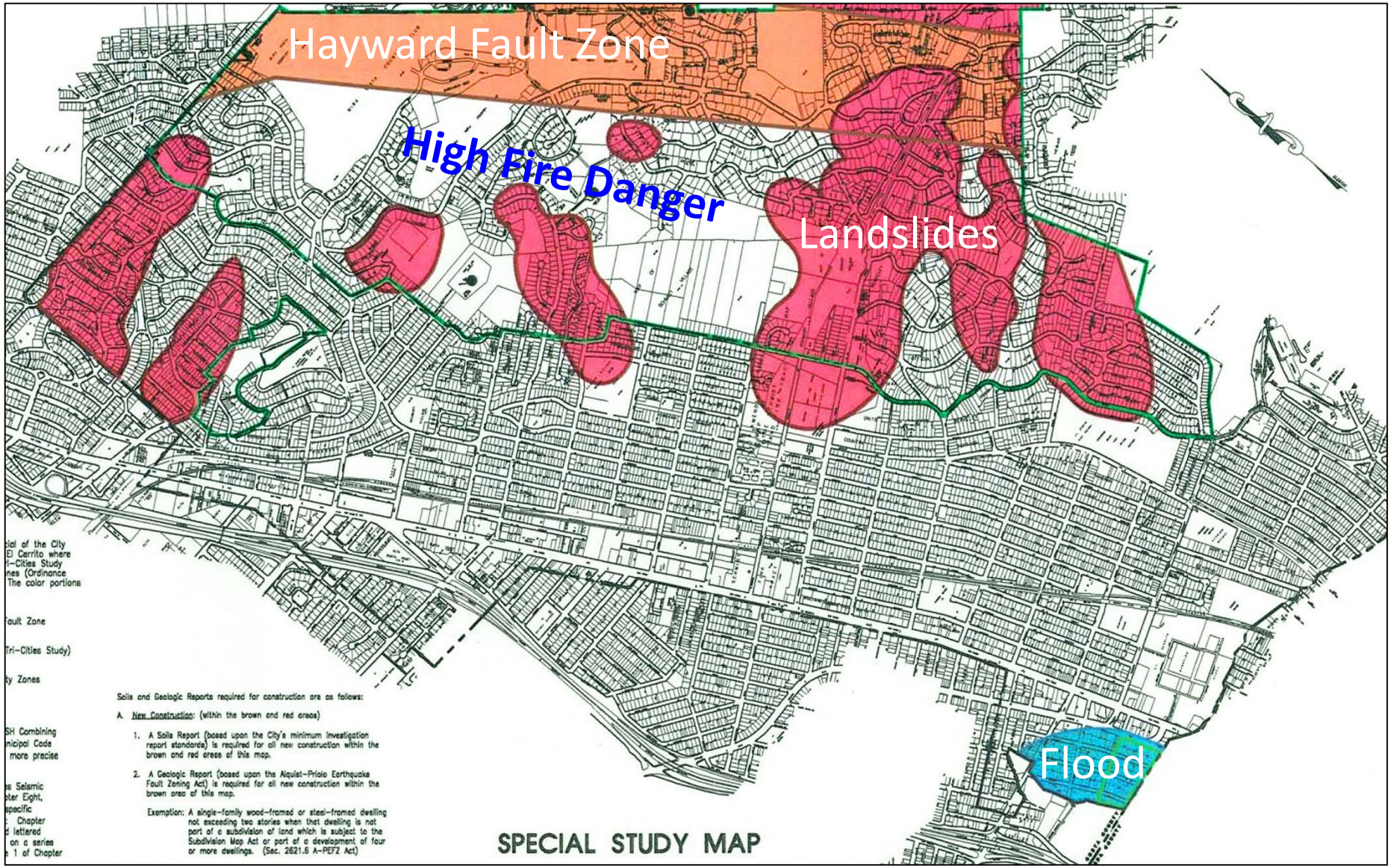
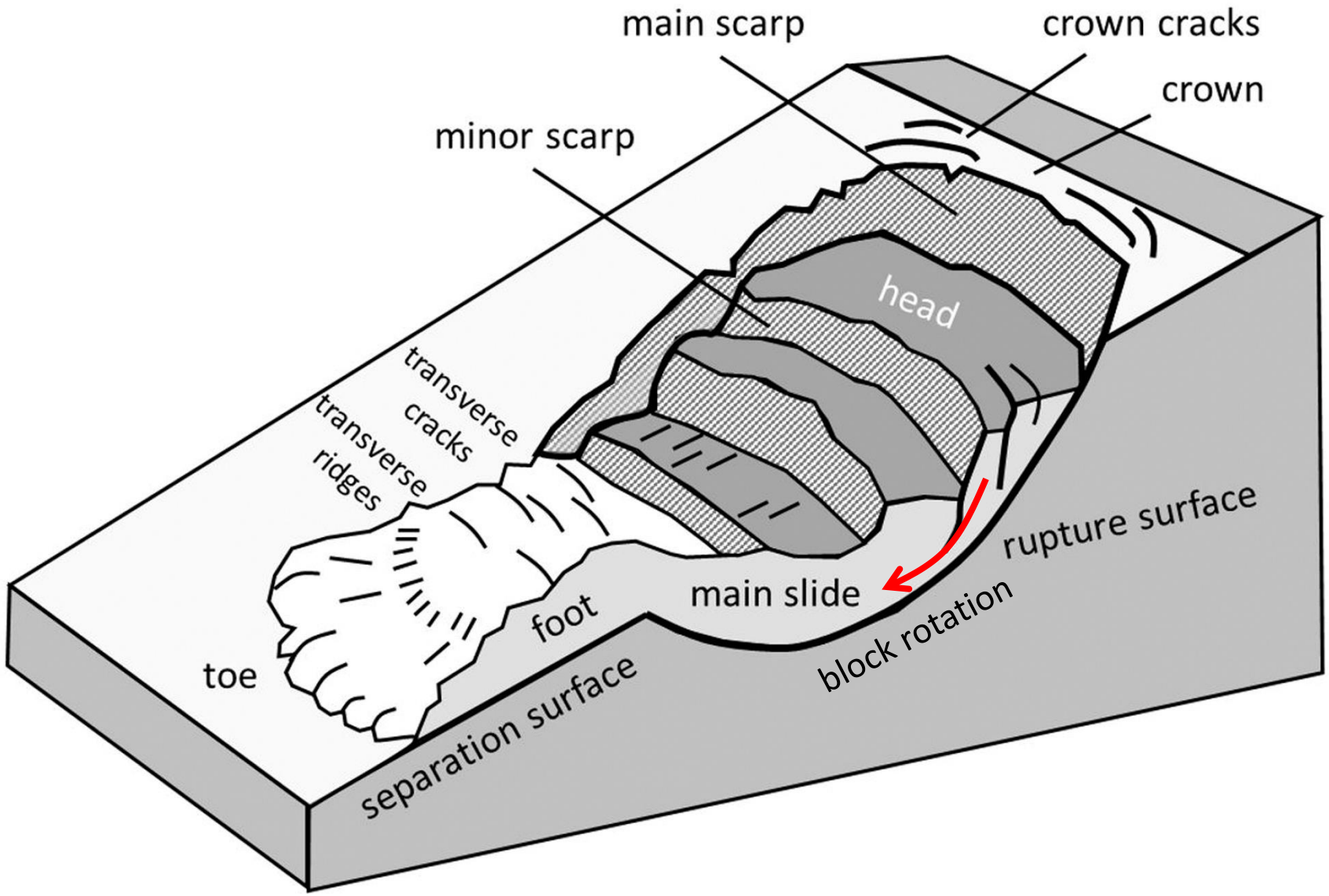



**Hazards map** of El Cerrito, California. Orange is the Hayward Fault zone; red is potential landslides; blue is potential flood zones; green outline is high fire danger.

Courtesy Harris & Associates Inc., and City of El Cerrito. http://www.el-cerrito.org/DocumentCenter/Home/View/463

# Recognizing Landslides

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# Recognizing Landslides

Havens Place

Detail

G. L. Prost http://garyprostgeology.com/

# Recognizing Land Movement

Downslope soil movement and bent trees

Cracked foundations

Offset pavement

The Mercury News **Oakland, Alameda most vulnerable to tsunami...**

# Tsunami threat

The areas shown in blue would be at risk of inundation in a large tsunami, studies show. The blue represents potential flooding under various models and not a single tsunami event.


https://ww2.kqed.org/news/2017/06/15/what-would-really-happen-if-a-tsunami-hit-san-francisco/

Since 1854, more than 71 tsunamis have been recorded in San Francisco Bay. Eric Geist, a geophysicist at the U.S. Geological Survey in Menlo Park, says that size is the most important factor in evaluating risk.

Steven Ward, a professor at UC Santa Cruz, has created a series of simulations. The initial wave stands just over 16 feet tall, much larger than historical tsunamis, but theoretically possible.

The original waves pile up as they squeeze through the 1-mile-wide Golden Gate. In Ward's simulations, the waves reach a maximum height of about 30 ft. Finally, the wave fans out into San Francisco Bay. By the time it reached the East Bay, the wave would be less than 3 ft high.

By Johanna Varner and Olivia Allen-Price
JUNE 15, 2017

# GEOLOGIST AT LUNCH




*The End*

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**Local geologic maps and rocks**


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**The Hayward Fault**


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**The Northbrae Rhyolite**


Cardwell, R. NCGS Field Trip - The Silica Rich Rocks in the Berkeley Hills. http://www.ncgeolsoc.org/FieldTripInfo/Northbrae%20Rhyolite%20FT.htm


**Geology for people in a hurry**


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*About the Author: Gary Prost has a PhD in Geology from Colorado School of Mines. He is a registered professional geologist who has spent the past 42 years working for the U.S. Geological Survey, mining companies, and oil companies. He is a member of the Northern California Geological Society.*


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