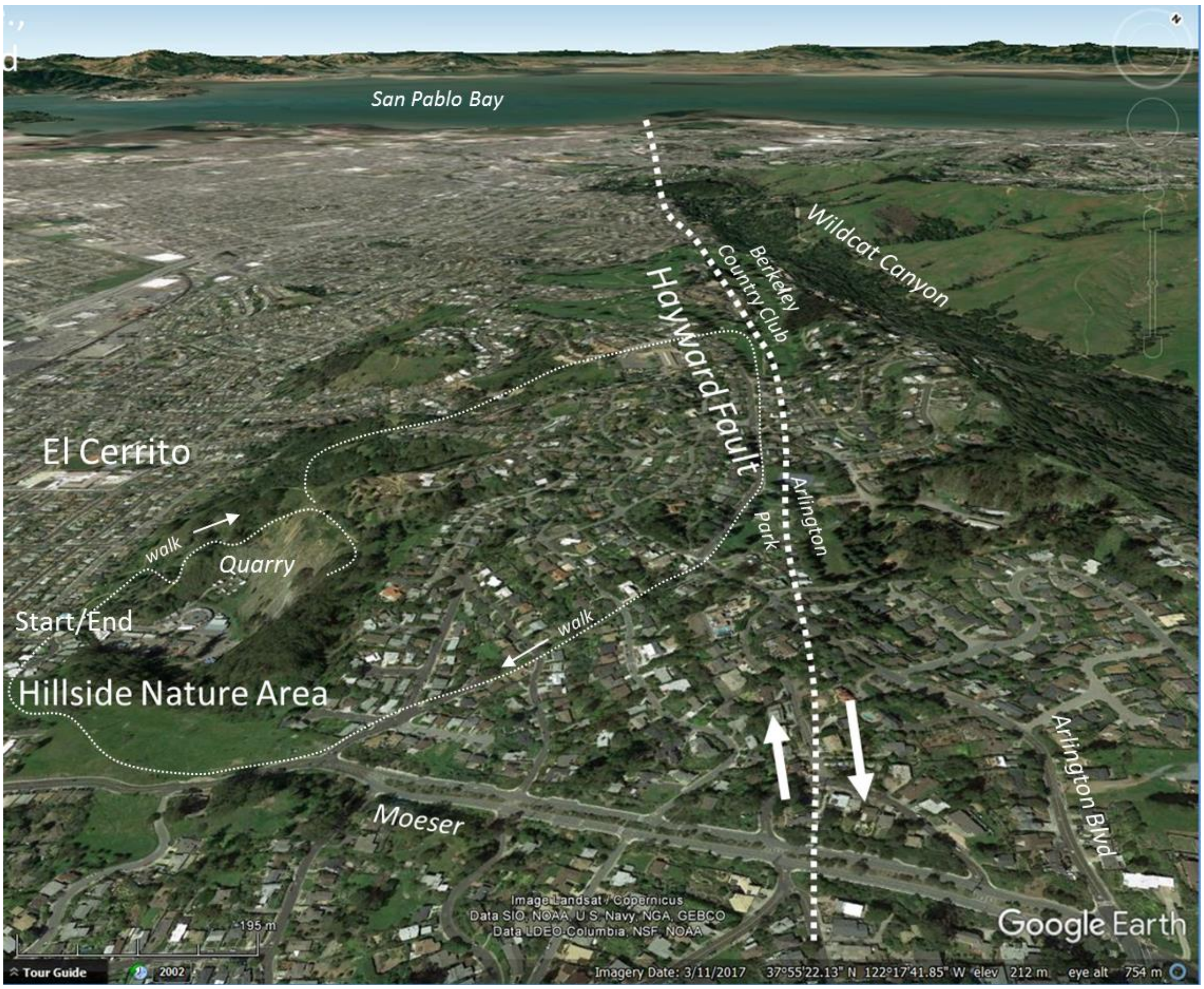
Northern California Geological Society

Walking Guide to the Geology of the Hillside Natural Area and Hayward Fault,

East Bay Hills, El Cerrito, CA

October 23, 2021



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G. Prost

Contents

Abstract

The Hillside Natural Area (Fig. 1) lies in the East Bay Hills, a part of the Coast Ranges that are dominated by Mesozoic-age Franciscan terrane. The Franciscan Complex or Franciscan Assemblage is a generally late Mesozoic terrane of heterogeneous rocks found throughout the California Coast Ranges. Typical Franciscan Complex rocks consist of metagreywackes, thin-bedded radiolarian chert, altered pillow basalts (greenstone), and blueschists. The Franciscan has been divided into 1) *Coherent terranes* that are internally consistent in metamorphic grade and include sediments, cherts and basalts ranging from zeolite to prehnite-pumpellyite to blueschist-grade metamorphism, and 2) *Mélange terranes* that are smaller, are characterized by discontinuous units, and may contain blocks of varied lithology and much higher grade metamorphism (amphibolite, eclogite, and garnet-blueschist) embedded within a mudstone or serpentinite matrix. The Franciscan Complex accumulated in the Farallon subduction zone (Figs. 2, 3). Seafloor and overlying sediments in this assemblage were first dragged down into the subduction zone, metamorphosed to varying extents, then thrust back to the surface. The western Franciscan Complex can be as old as Jurassic or as young as Eocene in this area.

The Hayward fault cuts through the East Bay Hills and is part of the modern transform boundary (San Andreas Fault system) between the Pacific and North American plates. This boundary evolved when North America collided with and overran the Farallon-Pacific spreading center, beginning between 30 and 20 million years ago. Right-lateral strike slip motion on the Hayward Fault helps accommodate the northwest motion of the Pacific plate relative to North America.

The Coast Ranges are relatively young, with uplift beginning around 3 to 4 million years ago. The rise of the Coast Ranges is documented by the shift from marine to terrestrial sediments in Late Pliocene time. The forces that lifted the Coast Ranges appear to be related to the interaction of blocks separated by various faults within the San Andreas Fault system and to the northward migration of the Mendocino triple junction (DeCourten, online).

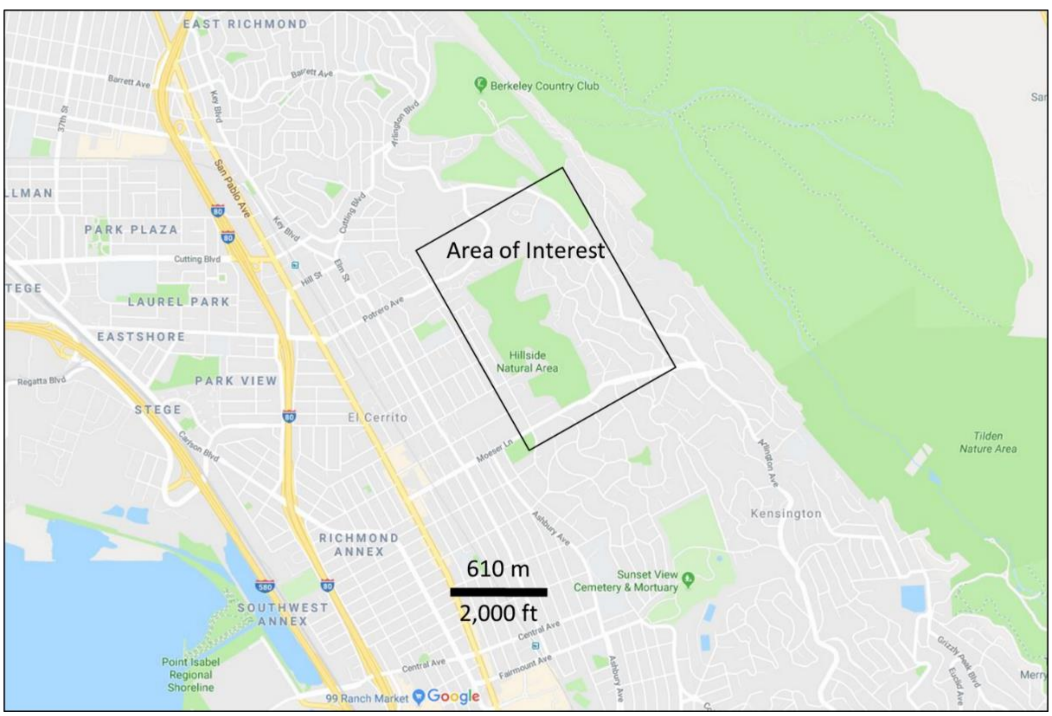

Figure 1. Google map showing the location of the Hillside Natural Area, El Cerrito.

Figure 2. Plate tectonic map of the world, showing location of the Hillside Natural Area (red star) near the boundary of Pacific and North American tectonic plates. USGS map, https://earthquake.usgs.gov/learn/glossary/?term=plate%20tectonics

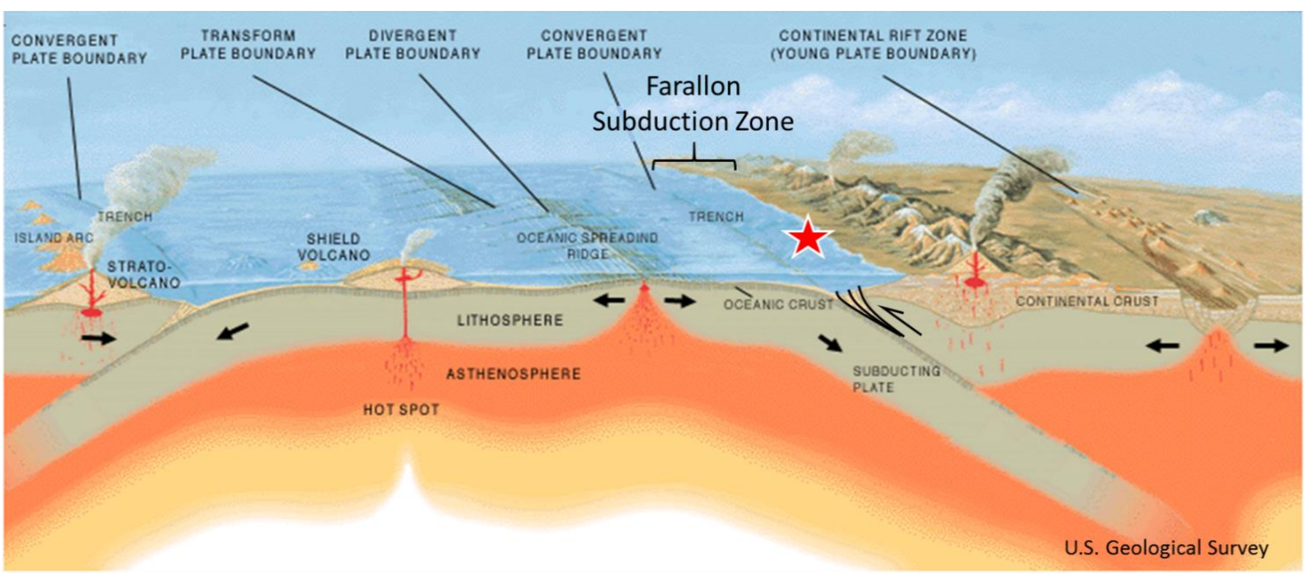

Figure 3. Plate tectonic processes. The Farallon subduction zone and location of the East Bay Hills (red star) prior to initiation of the San Andreas Fault system roughly 25 million years ago. Modified after USGS, https://pubs.usgs.gov/gip/dynamic/Vigil.html

A Brief History of the Hillside Natural Area

Native Americans

Native Americans are thought to have inhabited the Bay Area for at least 8,000 years prior to the arrival of Europeans. The region probably was one of the most densely populated north of Mexico. When Spanish explorers and missionaries arrived in 1769, the Ohlone (part of the Miwok language family) inhabited many small villages near the coast from San Francisco Bay through Monterey Bay to the lower Salinas Valley. They lived by hunting, fishing, and gathering, encouraging yield and forage by burning. The arrival of the Spanish in 1769 dramatically changed this way of life.

The Spanish built missions with the objective of converting the native people to Christianity and a European way of life. Conversion was voluntary at first, but converts could not leave. Roundups and forced labor soon became the norm. The great majority of Native Americans that moved to missions soon died of European diseases, poor nutrition, ill-treatment, and other causes.

The missionary Franciscans claimed that lands, crops, and cattle nominally belonged to the Indians and would eventually be returned to them. But when an independent Mexico secularized the missions and exiled the friars in the mid-1830s, the vast holdings were instead distributed mostly to military men. Without their original food supplies or way of life, the remaining Native Americans were forced into peonage. After the Gold Rush and California's entry into the Union in 1850, a combination of killings, forced removal of children, and mistreatment that amounted to slavery became routine. Usually with the aid of liquor, natives were declared "vagabonds" and forced to bring in the harvest, after which they were cast adrift to starve. Their own harvest season was by this time lost to them (Madley, 2016). The already decimated Native Americans declined even more.

The Ohlone that survive today belong to a number of distinct groups, most in their original territory. The Muwekma Ohlone Tribe has members from around the San Francisco Bay Area, and is composed of descendants of the Ohlones/Costanoans from the San Jose, Santa Clara, and San Francisco missions.

Settlers

A Spanish exploration party, led by Don Gaspar de Portolà, marched overland from Mexico, arriving on November 2, 1769, was the first documented European visit to San Francisco Bay area. Seven years later a Spanish mission, Mission San Francisco de Asís (Mission Dolores), was established with a small settlement, and a military fort (the Presidio) was built.

The Spanish recognized San Francisco's large natural harbor to be of strategic value. Mission San Francisco de Asís, established by Fra. Junípero Serra, began the cultural and religious conversion of the 10,000 or so Ohlone who lived in the area. The mission became known as Mission Dolores, after a creek named for Our Lady of Sorrows.

The first anchorage was established at a small inlet on the north-east end of the peninsula (now lower Market Street), and the small settlement that grew up nearby was named Yerba Buena, after a fragrant herb that grew there.

The area became part of Mexico upon independence from Spain in 1821. In 1835, William Richardson, an Englishman, established the first significant homestead near what is now Portsmouth Square in Chinatown. The town began to attract American settlers. In 1846, Yerba Buena doubled in population when about 240 Mormon pioneers from the east coast arrived by ship led by Sam Brannan. Brannan would later become well known for being the first publicist of the California Gold Rush of 1849 and the first millionaire resulting from it.

After outbreak of the Mexican American War US Navy Commodore John Sloat claimed California for the United States on July 7, 1846. Two days later US Navy Captain John Montgomery and US Marine Second Lieutenant Henry Watson of the USS Portsmouth arrived to claim Yerba Buena. On January 30, 1847, Lt. Bartlett's ordered that the name Yerba Buena be changed to San Francisco. The city and the rest of California officially became American in 1848 by the Treaty of Guadalupe Hidalgo, which ended the Mexican-American War.

The California gold rush, starting in 1848, led to a population boom, including considerable immigration. Between January 1848 and December 1849, the population of San Francisco increased from 1,000 to 25,000. California was admitted to the U.S. as a state on September 9, 1850. The rapid growth of Bay Area communities continued through the 1850s and due to California mining as well as the 1859 Comstock Lode silver discovery in Nevada. Agriculture and the railroads also played a role in bringing settlers to California (SF-Info.org and Wikipedia).

El Cerrito grew from a blacksmith shop built by William Rust in the 1880s near Cerrito Creek. The town was initially settled by refugees from the 1906 San Francisco earthquake. They built in Don Víctor Castro's Rancho San Pablo land grant. Rancho San Pablo was 18,000 acres of former Mission Dolores grazing lands granted after Mexican independence to Francisco Castro, former alcalde (mayor) of San Jose. A post office opened in 1909 and the refugee camp became known as Rust, after the first postmaster. The residents changed the name to El Cerrito ("little hill") in 1916, in reference to Albany Hill just to the south. In 1910 El Cerrito was incorporated as a village with 1,500 residents.

Hillside Natural Area

In the first half of the 20th Century, today's Hillside Natural Area was used for grazing (you can still find old fence posts and barbed wire) and quarrying. The Hutchinson Quarry (later the Brown and Hutchinson Quarry), lies at the east end of Schmidt Lane. The quarry started around 1900. A rail line ran up Schmidt from the Santa Fe line along today's BART tracks. The quarry closed in the late 1940s as homes encroached and folks complained about blasting. In 1972 it became the Recycling Center.

The Hillside Natural Area was largely assembled in the 1950s. Forest Brown was the last operator of the old Hutchinson quarry, and donated much of the land that became the southern portion of the Hillside Natural Area. The remaining land came to the city from developers who deemed it too steep and/or slide-prone for housing. Today it contains 102 acres, according the city web site. The park is bordered by the City of El Cerrito and open space owned by EBMUD, PG&E, and Stege.

The quarry is just below the Kerr property. Clark Kerr, Chancellor of U.C. Berkeley from 1952-1958, was president of the University of California system from 1958-1967. It was also the home of Kay Kerr, one of the founders of Save the Bay. She was inspired to help start that group while watching the filling of Point Isabel from her window (David Weinstein, El Cerrito Historical Society).

Geologic History

Convergent Margin

The oldest rocks in the Hillside Natural Area are 150-200 million-year-old meta-greywacke and blueschist of the Franciscan assemblage. Blueschist the rock is a product of blueschist grade metamorphism of ocean floor basalt. The basalt formed at the Pacific spreading center and moved ever-so-slowly eastward toward North America as part of the Farallon tectonic plate (Figs. 4, 5).

As the Farallon Plate moved west it slowly accumulated sediment. Some was contributed by siliceous plankton (radiolarians) floating of the sea surface. As these single celled creatures died their shells fell to the bottom. The radiolaria found in the chert lived between 100 and 200 million years ago in a tropical to subtropical marine environment. The metamorphosed siliceous sediment is what forms the deformed "ribbon cherts" seen, for example, on the Marin Headlands and in Golden Gate Park. Siliceous turbidites, represented by bedded cherts, can be deposited in the vicinity of ocean ridges (SEPM, 2013).

Most of the Franciscan consists of turbidite sandstone and shale. Sediments are constantly being deposited on continental shelves. At some point they accumulate to the point where they become gravitationally unstable, at which point an earthquake or other disturbance triggers a submarine landslide. The watery sediment becomes a slurry that runs downslope as a turbidity current, and the deposits they form in the deep ocean are turbidites. Turbidites may be thin to very thick bedded, with individual beds often characterized by fining-upward graded bedding. The dirty sandstones found in turbidites are typically called "greywacke," from the German *grauwacke*, signifying a grey, earthy rock.

As the Farallon plate plunged beneath North America the sediments it carried and parts of the upper ocean floor were scraped off and accreted to the continent along with island arcs and continental fragments carried on the seafloor (Fig. 4). Based on the blueschist-grade metamorphism, we know that this process involved dragging the rocks down to depths around 15-30 km (9-18 mi) and temperatures between 200 and 500^{o} C (392 – 932^{o} F). At the same time the rocks were being thrust back up and toward the west (Fig. 6). This may be the source of the thrust fault in the old Brown and Hutchinson quarry; alternatively it has been described as a "megathrust"representing the top of the downgoing oceanic plate, that is, an actual plate boundary (Wakabayashi, 2013; 2015). As is the nature of thrust faults, the older and deeper rocks (blueschist-grade metamorphism) were thrust above younger and shallower units (prehnite-pumpellyite-grade).

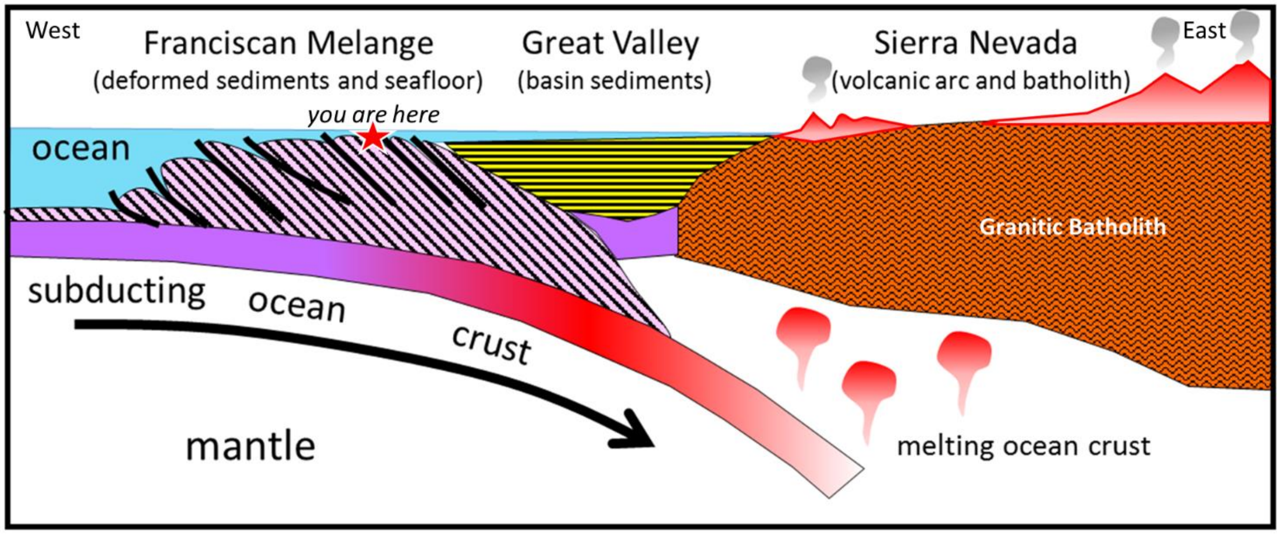

Figure 4. Ocean crust and sediment was subducted, that is, dragged along with downgoing slab, and became the Franciscan Complex. Red star indicates the East Bay Hills.

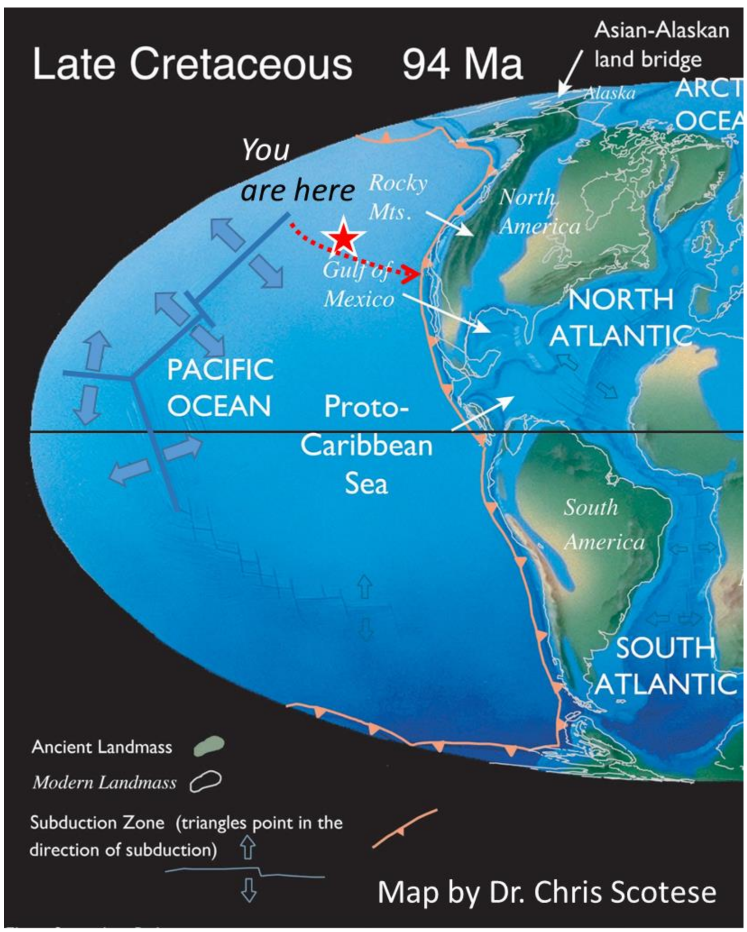

Figure 5. Plate tectonics in the East Bay area (star) at 94 Ma (Cretaceous). From Scotese, 2001, online.

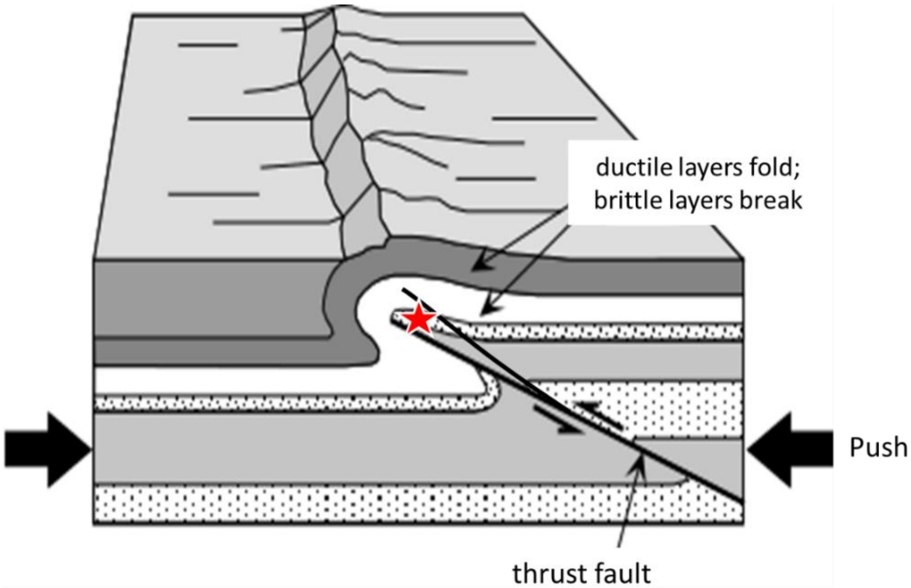

Figure 6. Rocks in the East Bay Hills were buried deep in the Earth and metamorphosed. Thrust faults later moved the metamorphosed ocean crust and sediments up and toward the west. The red star indicates the location of the quarry in this schematic diagram. Modified after USGS, https://earthquake.usgs.gov/learn/glossary/?term=blind%20thrust%20fault.

Transform Margin

About 25 million years ago subduction stopped in the Bay area. The Farallon Plate was now almost entirely under the continent; the Pacific Plate was moving northwest relative to North America (Figs. 7, 8). The Juan de Fuca & Cocos Plates are remnants of the Farallon Plate.

Between 30 and 20 Ma the Farallon Plate was largely subducted beneath the North American tectonic plate. This led to initiation of the San Andreas transform fault system, a series of faults that included the Hayward Fault, Rogers Creek Fault, and Calaveras Fault in the East Bay, North Bay, and South Bay, respectively. These are all right-lateral strike-slip faults (Fig. 9).

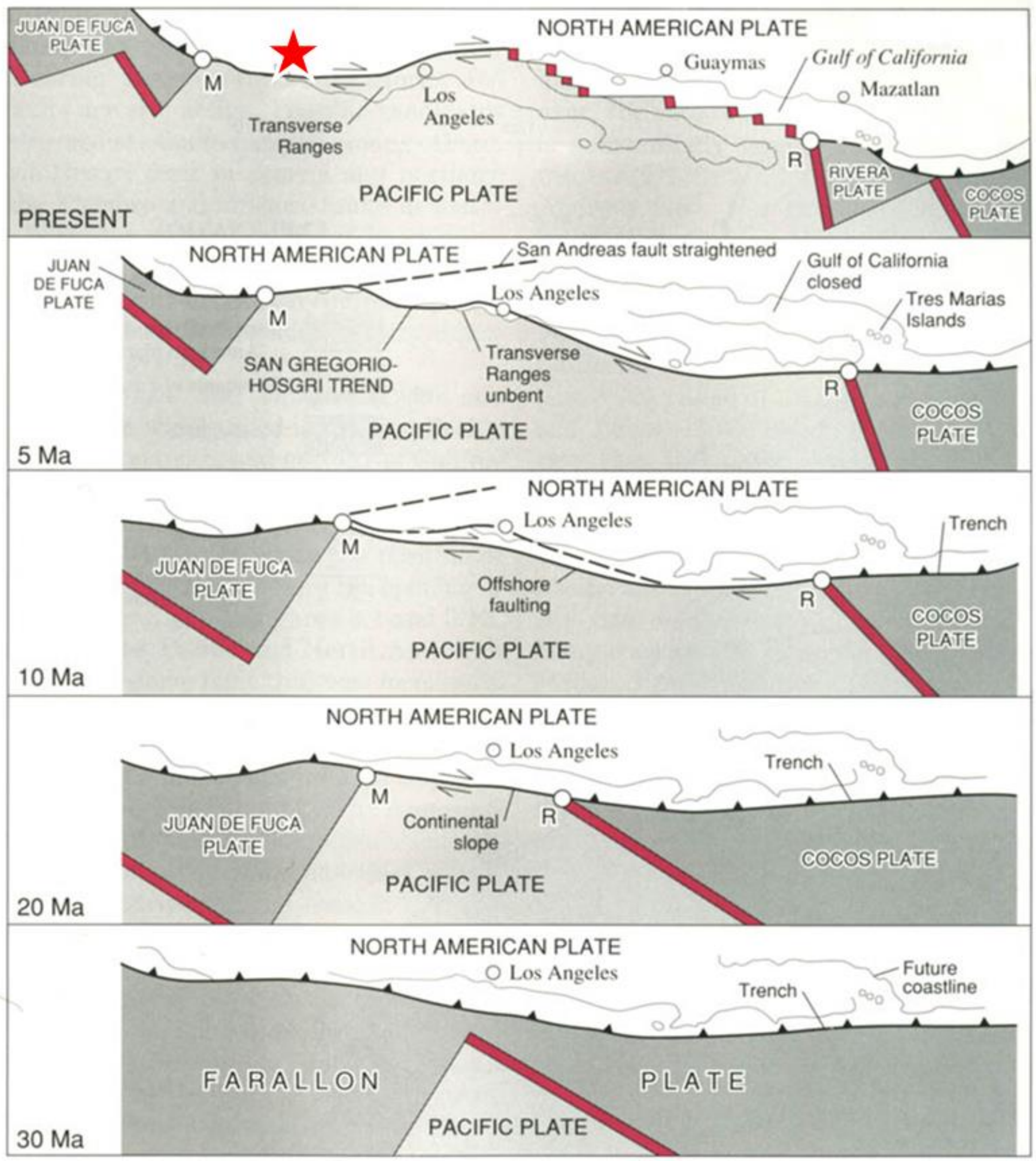

Figure 7. Diagrams showing plate-tectonic evolution of the San Andreas transform fault system. The East Bay area is indicated by the red star. M is the Mendocino triple junction; R is the Rivera triple junction. From Irwin, 1990.

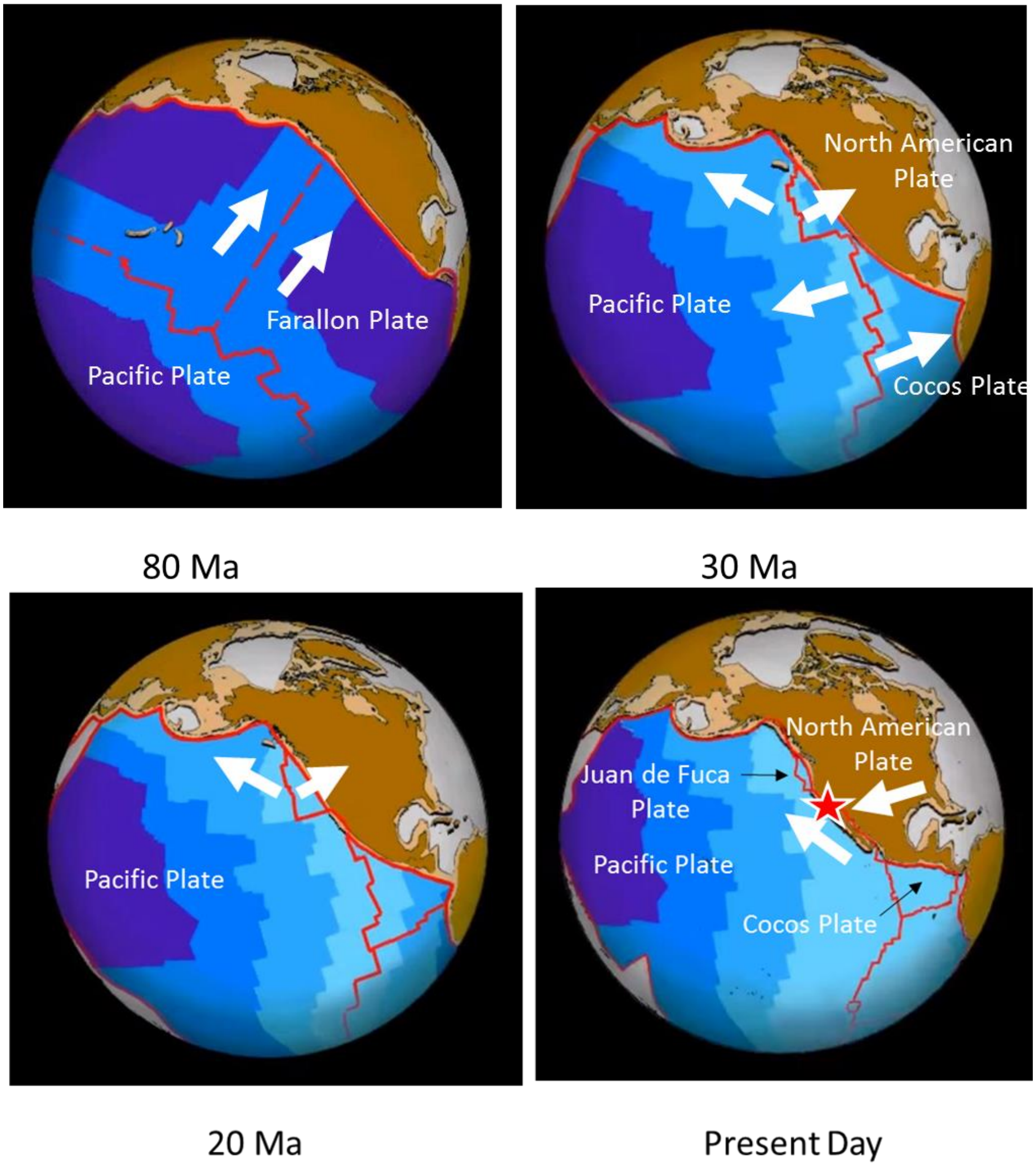

Figure 8. Plate motions (arrows) over the past 80 million years in the Bay Area (red star). Modified from "An Animated Tectonic History of Western North America and Southern California" by Tanya Atwater, Dept. Geological Sciences, University of California, Santa Barbara
https://www.youtube.com/watch?v=VTSVktP53jM

Miocene Volcanism

Volcanism related to the transform margin has been spotty throughout the Coast Ranges. About 10 million years ago a rhyolitic volcano erupted, probably in the Sibley Volcanic Preserve, Oakland (Slack, 2005), although there may be an undiscovered closer source. The Northbrae Rhyolite in El Cerrito is either a welded tuff, or parts of a rhyolite flow that was carried to El Cerrito on the north-moving west side of the Hayward Fault.

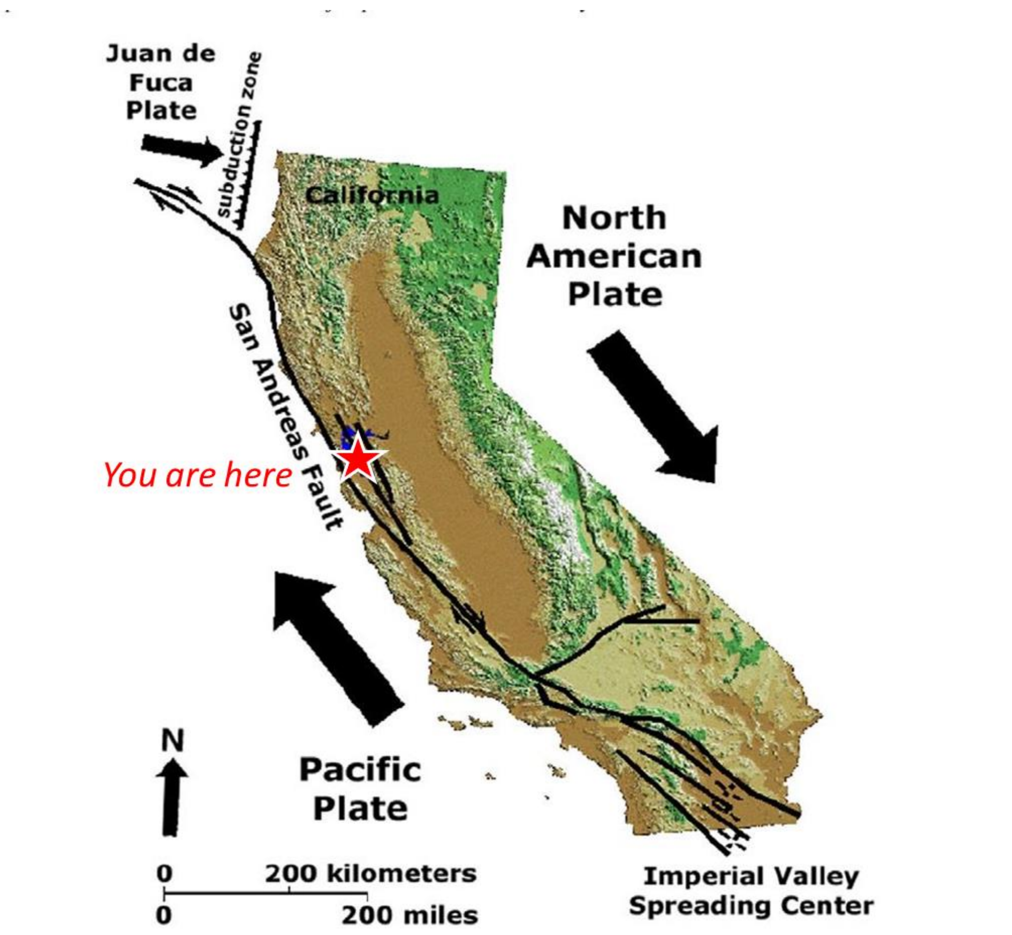

Figure 9. San Andreas Fault transform system and relative motions along the plate boundary. This transform plate boundary has been active for the past 25 to 30 Ma. The red star indicates the East Bay Hills. From Stoffer, 2002.

Ice Age Bay Area

The most recent Ice Age began around 2.6 million years ago. A million years ago San Francisco Bay was a flat plain between the Peninsular 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 near Colma, the Colma Gap. About 125,000 years ago the San Andreas Fault closed this gap and the rivers began to drain through a new gap at the Golden Gate. Twenty thousand years ago, at the height of the last glaciation, sea level was about 122 m (400 ft) lower than today. The coast was 40 km (25 mi) west of where it is now (Fig. 10). The Farallon Islands were onshore mountains, and the river that drained the Central Valley had cut a deep canyon from Carquinez Strait to the Golden Gate. Where the Bay is today was a broad valley. Between 15,000 and 12,000 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.

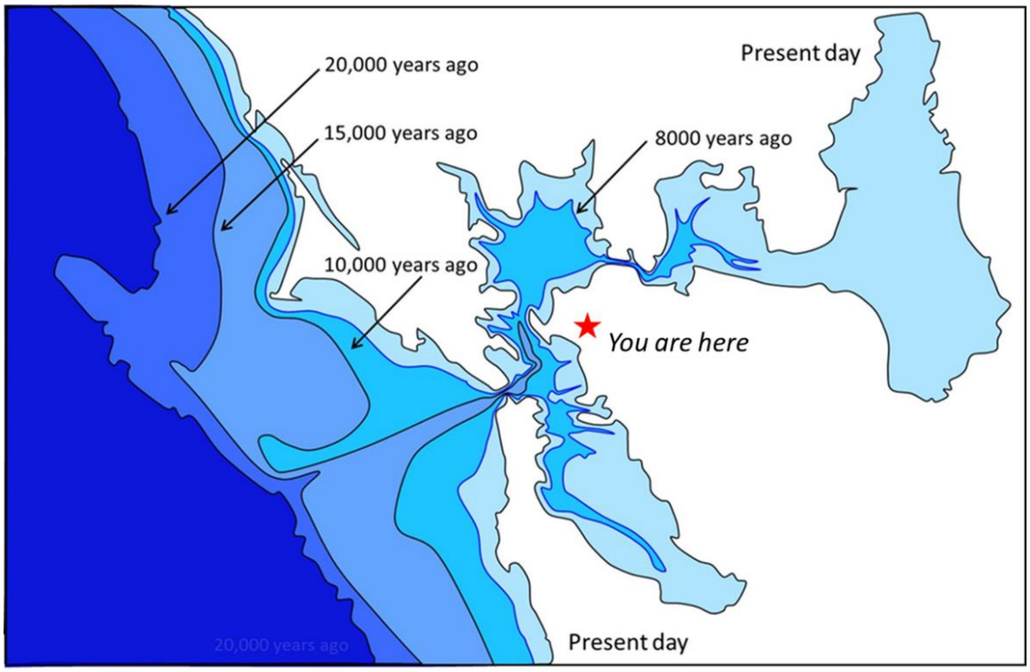

Figure 10. Changing Bay area coastlines over the past 20,000 years.

Local Rocks

Franciscan Terrane

The Franciscan Terrane is one of several terranes along the west coast of North America (Fig. 11). Rocks known as the Franciscan Complex include the seafloor and overlying sediments that were transported to and accreted onto the North American continent. Rocks found in the Franciscan Complex include greywacke sandstone and mudstone with lesser amounts of volcanics, chert, and limestone. Of these, greywacke, mudstone, and blueschist (glaucophane schist, essentially a metamorphosed basalt) are found in the Hillside Natural Area and surrounding neighborhoods. A small turbidite outcrop in the Hillside Natural Area has been described as both chert ("ribbon chert") and siliceous greywacke. Small pods of serpentinite are also known (eg, Berkeley Country Club, Madera Elementary School).

Blue Schist

Ocean floor basalts are part of the Franciscan Complex. These volcanics include flows, pillow basalts, and metamorphic rocks derived from them, including greenstone and blueschist. Blueschist tends to be massive. It may have compositional banding, but generally does not show bedding (Fig. 12). In some cases it displays crenulation cleavage.

Franciscan rocks in the East Bay Hills were metamorphosed when they were dragged into the subduction zone that existed along the west side of North America prior to around 25 million years ago. The schistose texture (aligned micas) indicates the rocks have been under significant compression. We can get an idea of the depth of burial from the minerals in the rocks. Blueschist facies, a product of blueschist-grade metamorphism, is considered a "high pressure, low temperature" metamorphic rock (Fig. 13).

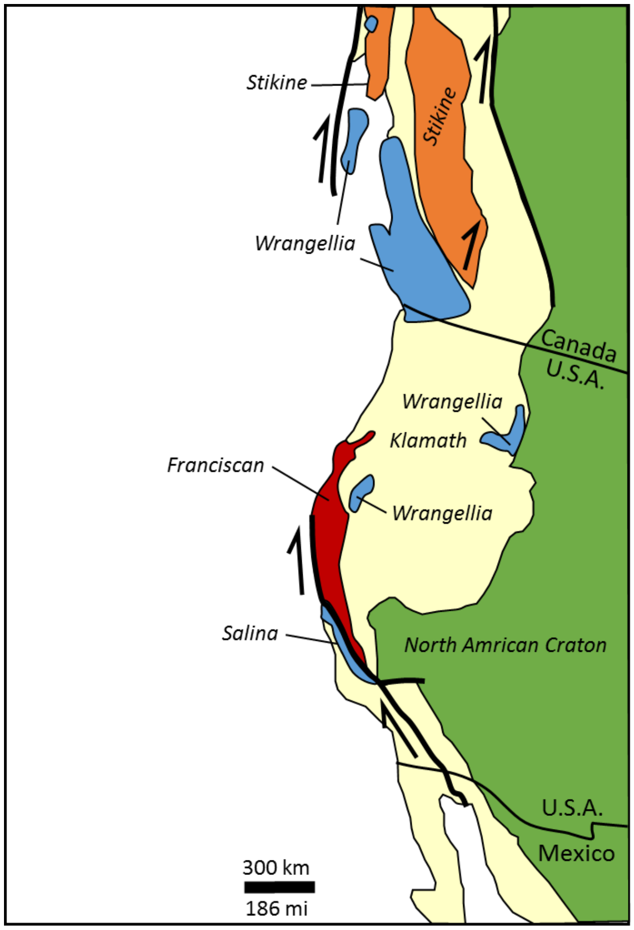

Figure 11. West coast terranes. Modified after DeCourten, online.


Figure 12. Blueschist outcrop at Moeser and Shevlin under the powerline.

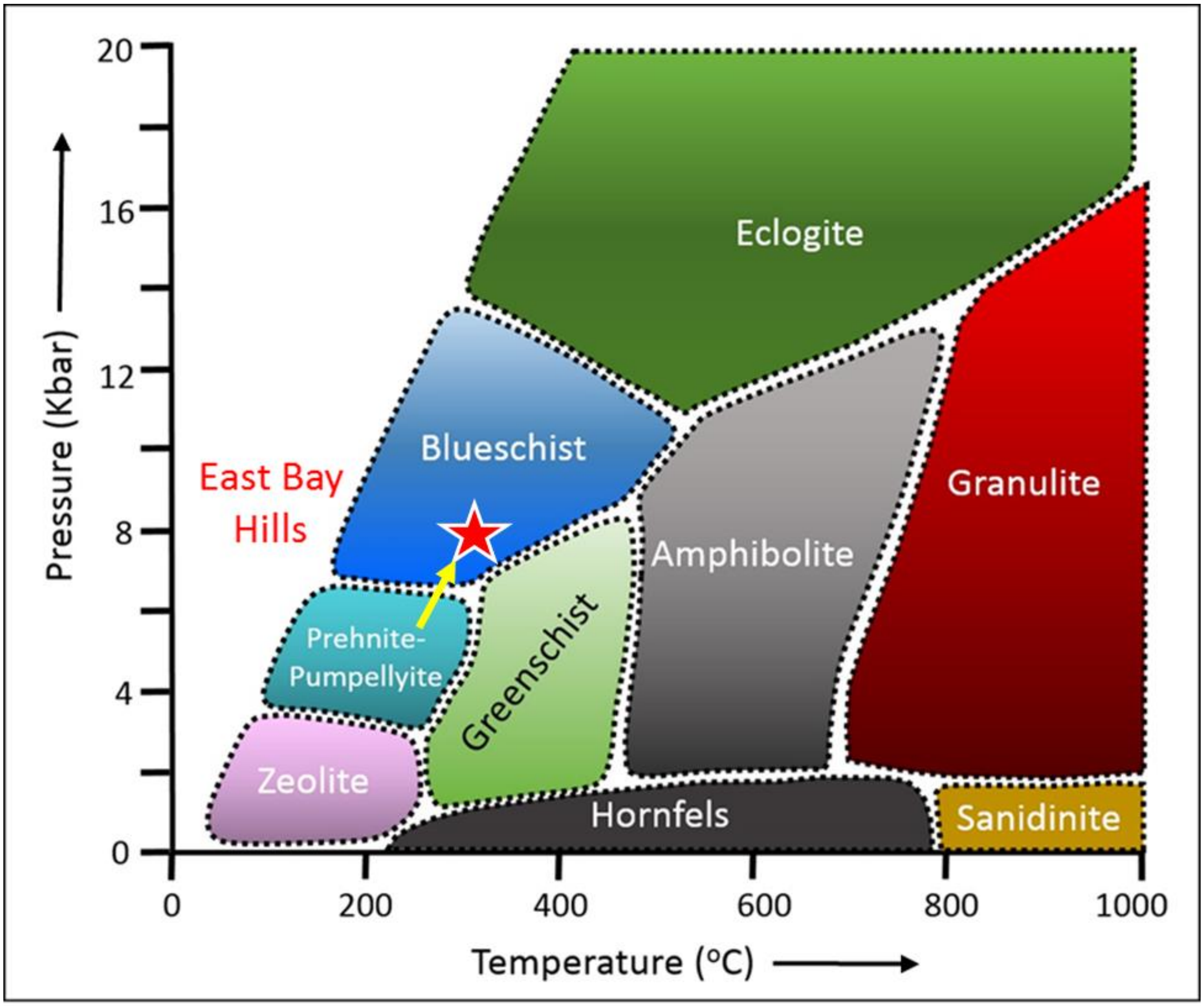

Figure 13. Pressure-Temperature diagram of metamorphic facies. The East Bay Hills rocks range from Prehnite-Pumpellyite facies to Blueschist facies.

Meta-Greywacke

The most common rock in the Hillside Natural Area is a meta-greywacke, a metamorphosed “dirty sandstone” composed of quartz, feldspar, and rock fragments such as chert, volcanic rocks, and shale. The sandstone layers tend to be thin and interbedded with shale layers (Figs. 14, 15). In some cases the sandstones are thick and massive, suggesting channelized deposits. These deposits accumulated on the ocean floor as turbidity currents carried sediments from the continent far out into the deep ocean (Fig. 16). These turbidites are, in effect, deep marine landslide deposits.

The meta-greywacke has been metamorphosed to both blueschist and prehnite-pumpellyite facies, depending on the thrust sheet (Wakabayashi and Rowe, 2015).

Figure 14. Bedded siliceous meta-greywacke or chert, mid-slope along a trail. This distal turbidite is part of the Hillside Melange of Wakabayashi and Rowe, 2015.

Figure 15. Close up of the meta-greywacke above the quarry showing bedding detail. Truncated crossbedding suggests up is to the left.

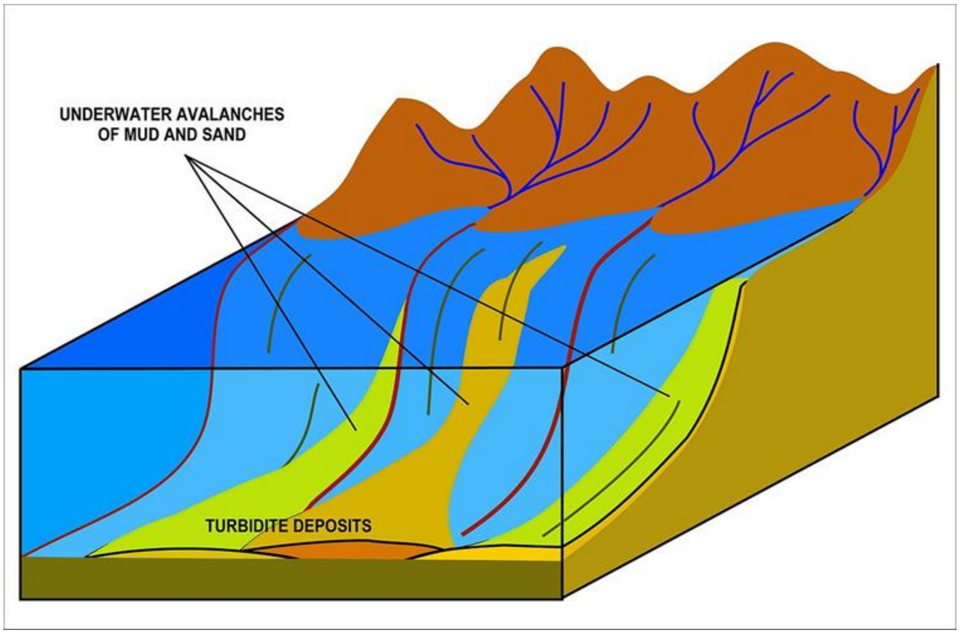

Figure 16. Turbidite deposition. https://commons.wikimedia.org/wiki/File:Turbidite_formation.jpg

Northbrae Rhyolite

Rhyolite is a light-colored, quartz-rich lava flow. The sticky lavas form domes, and flows usually don't extend far from the source. The Northbrea Rhyolite found in El Cerrito (Figs. 17, 18) is the same rock that forms Indian Rock in Berkeley. It exists as resistant erosional remnants only on the highest ridges. The source is thought to have been Round Top Volcano in the Sibley Volcanic Preserve, northeast Oakland. Some recent workers believe this is a welded tuff rather than a rhyolite flow.

Figure 17. Northbrae Rhyolite, Hillside Natural Area near Madera School. Some consider this a welded tuff rather than a rhyolite flow.

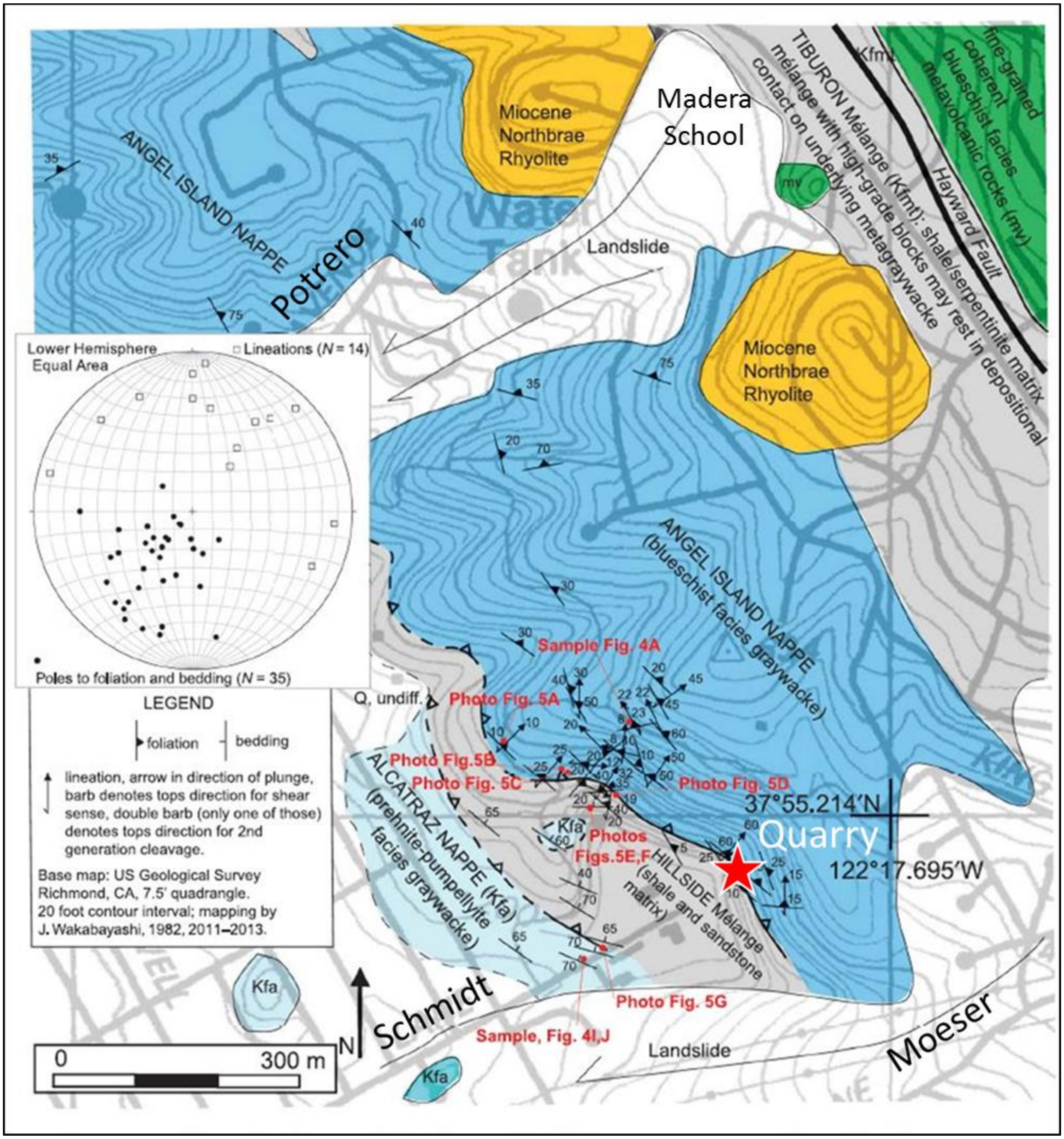

Figure 18. Geologic map of the Hillside Natural Area from Wakabayashi and Rowe, 2015.

The Hayward Fault

The Hayward Fault in El Cerrito runs near Arlington Blvd. and cuts through the Berkeley Country Club and golf course (Fig. 19). Based on offsets of the U.C. Berkeley Stadium and street curbs in Richmond, the fault appears to be creeping about 4 cm (1.6 in) every ten years (Figs. 20, 21). The last large rupture, according to Dave Schwartz of the USGS (oral comm., 2017), is dated around 1705 based on ash found in a trench across the fault in the Berkeley (formerly Vista del Mar) Country Club. Total offset in the past 12

Ma on the creeping section is about 4.8 km (3 mi). The Hayward Fault here winds in and out of the Jurassic (or more likely Late Cretaceous; MacKinnon, oral comm., 2021) Franciscan Complex and largely separates the Franciscan on the west from late Miocene conglomerates of the Orinda Formation on the east.

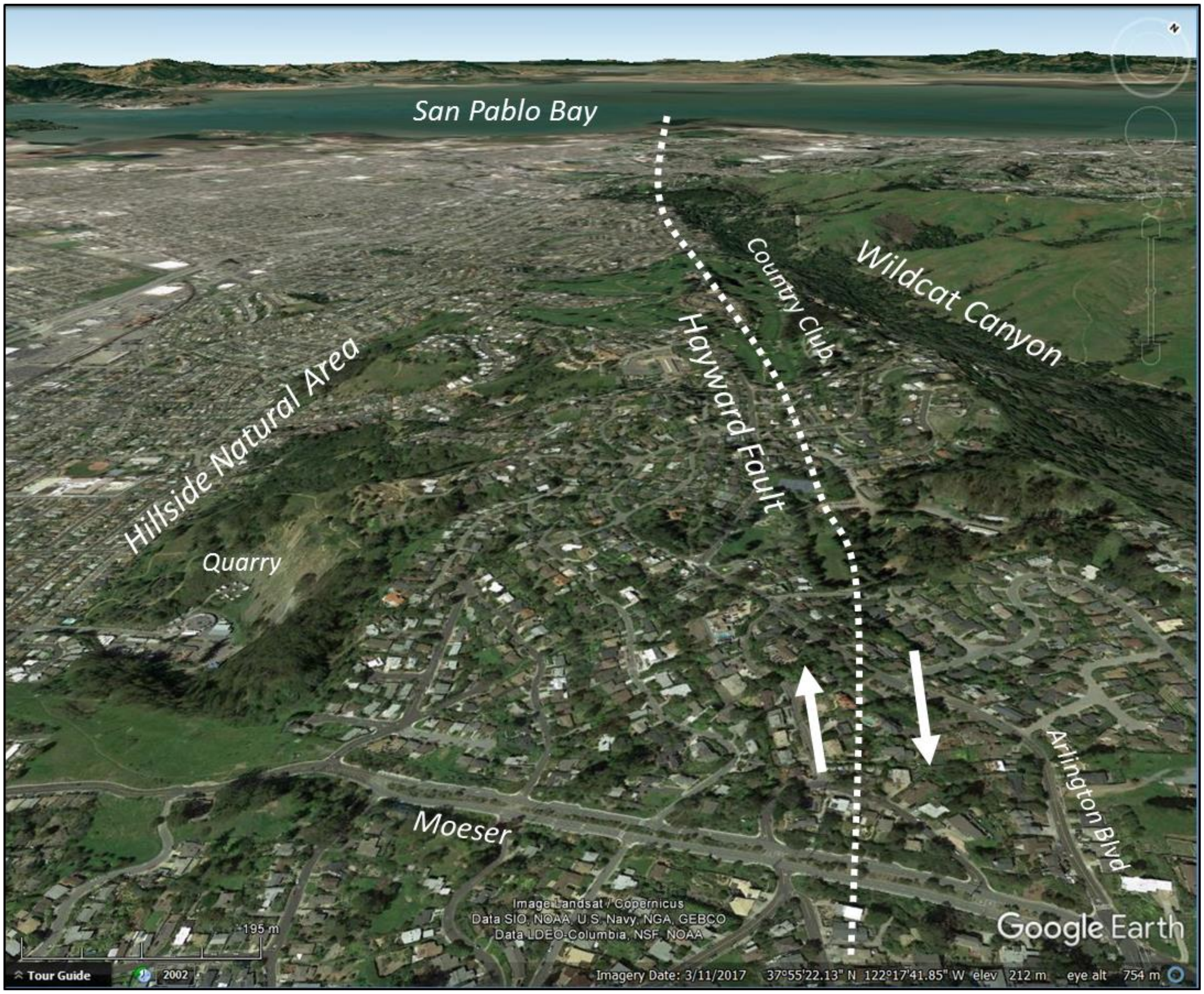

Figure 19. Google Earth oblique view north showing the trace of the Hayward Fault and the Hillside Natural Area.

Figure 20. Curb on the north side of Olive Ave., Richmond Heights, is offset about 2 inches in a right-lateral sense along the Hayward Fault. The fault is creeping here.

Figure 21. Façade of U.C. Berkeley Stadium is offset about 2 inches by creep along the Hayward Fault.

Earthquakes

Most earthquakes in the East Bay Hills are associated with movement on the Hayward Fault.

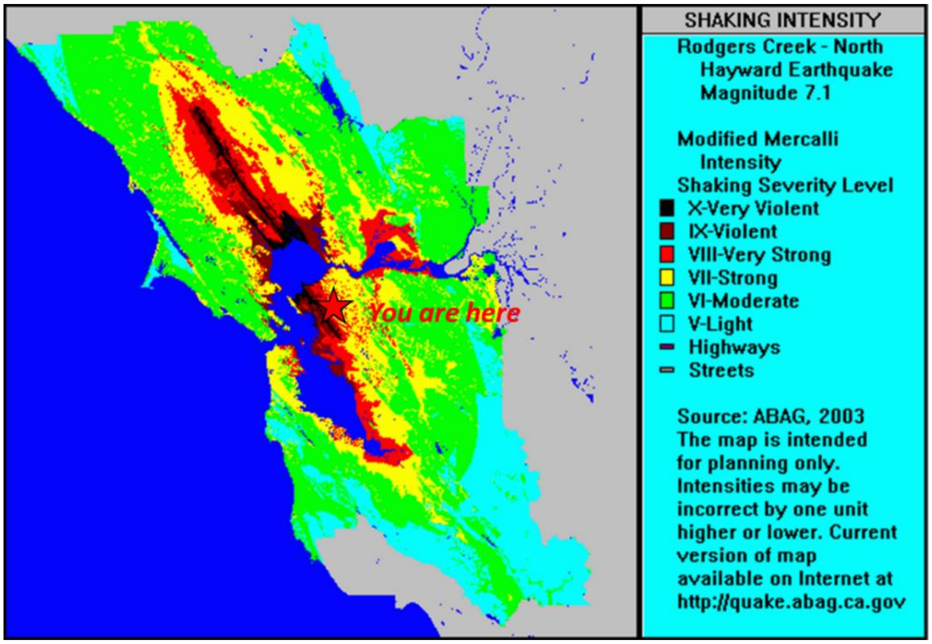

Figure 22. Shaking intensity map for a hypothetical 7.1 earthquake on the north Hayward Fault Zone and the Rodgers Creek Fault Zone. Created by the [Association of Bay Area Governments](#) (ABAG).

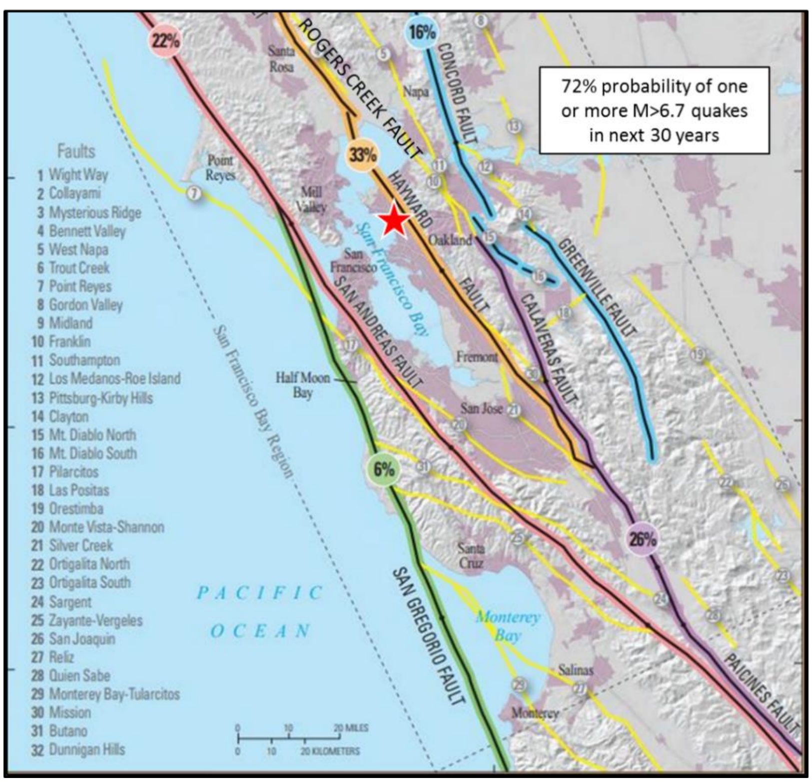

Figure 23. The USGS estimates there is a 33% chance of a 6.7 or greater earthquake on the Hayward Fault in the next 30 years (Aagaard et al., 2012).

The first recorded quake on the Hayward Fault in Hayward was a magnitude 6.8 to 7.0 in 1868. It was centered near the town of Hayward. Maximum offset was about 1 m (3 ft), up slightly to the east. There were 3 quakes along this fault zone with magnitudes 6-7 during the 1800s.

The USGS is currently monitoring the Hayward and other faults using instruments and public input. Using all available information they have generated maps showing predicted shaking intensity for earthquakes of a certain size (Fig. 22), and earthquake probability maps that give their best estimate of the likelihood of an earthquake of a given size in a 30 year period (Fig. 23). The estimate is that the Hayward-Rogers Creek Fault system has a 33% chance of one or more earthquakes greater than magnitude 6.7 in the next 30 years. For comparison, the 1989 Loma Prieta quake that caused $5.6 to $6 billion in damage was a magnitude 6.9.

Landslides and Downslope Creep

All rock and soil on slopes tend to move downhill under the influence of gravity. This is natural, and there is evidence of large natural landslides in the Hillside Natural Area and surrounding neighborhoods based on characteristic hummocky topography and large out-of-place boulders.

The natural tendency to slip downslope has been aggravated by human activities such as terracing hillsides for development and cutting roads across the slope (Fig. 24).

Figure 24. Downslope creep is a constant problem for roads and homes built on hillsides. This example is on King Dr. north of Moeser.

Field Trip Stops

A map of the walk through the Hillside Natural Area and Hayward Fault, with stops and outcrops, is shown (Fig. 25). Park on Schmidt Lane near the Recycling Center. The walk is about 2.5 miles. There is a steep section (550 ft up in ~1/4 mile) at the start, then it's moderate to level most of the walk.

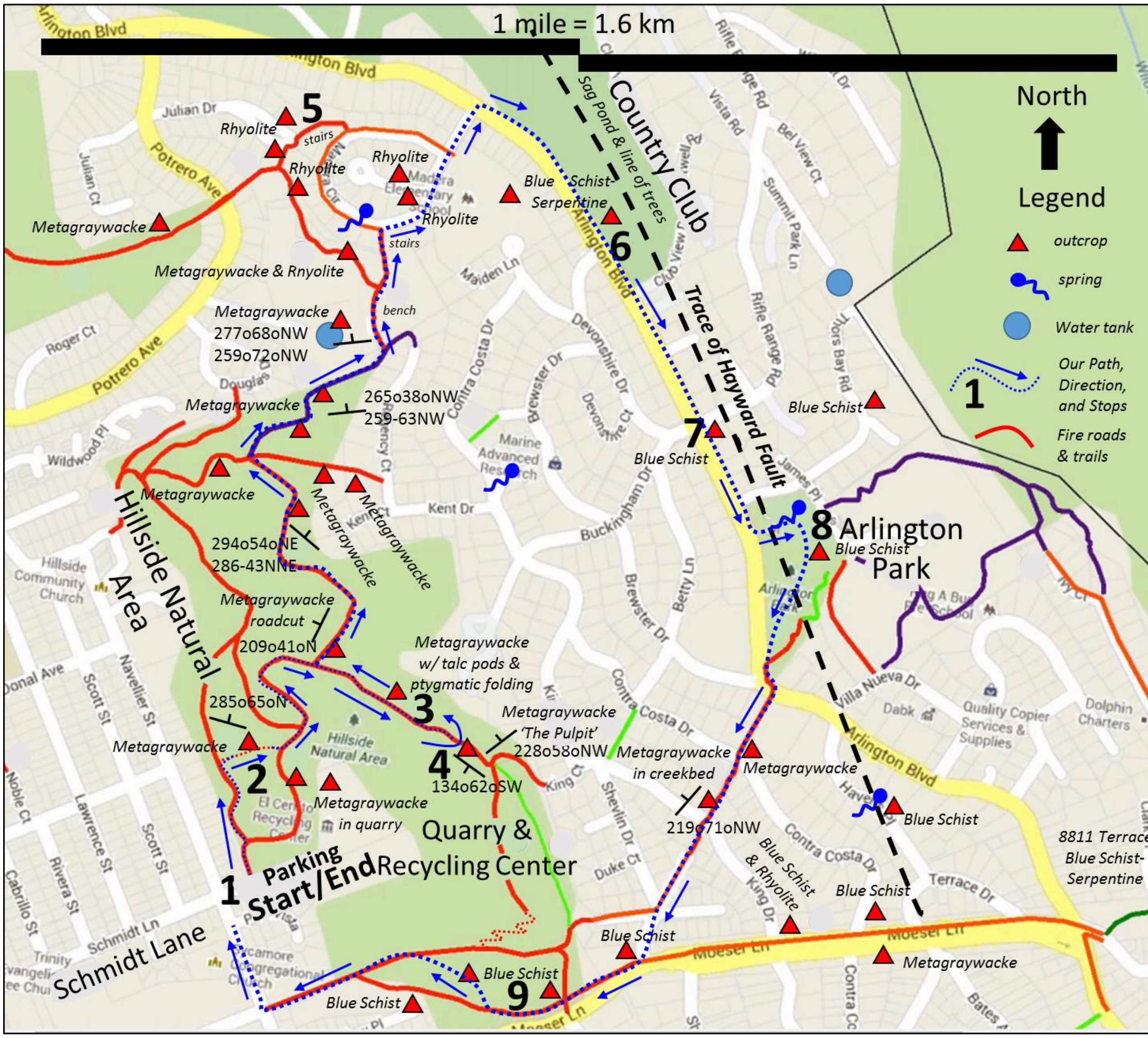

Figure 25. Map of geology walk route (dotted blue line) and numbered stops.

Stop 1

This overview of the quarry walls from the end of Schmidt Lane shows the position of a semi-horizontal thrust fault between darker sandstone-shale Hillside Melange below and the lighter brown metagreywacke of the Angel Island Nappe above. The rocks are all Jurassic or Cretaceous. Thrusting is related to the pre-25 Ma convergent margin.

A possible normal fault beneath a talus zone appears to drop the rocks and the thrust on the north relative to rocks and the thrust to the south.

Wakabayashi and Rowe mapped high-grade blueschist facies above and lower grade prehnite-pumpellyite below the thrust. The prehnite-pumpellyite facies indicates temperatures 250 - 350 °C and pressures ~ 2-7 kilobars. The actual mineral assemblage is dependent on the original rock composition.

Figure 26. View east of El Cerrito Quarry and Recycling Center. After Wakabayashi and Rowe, 2015.

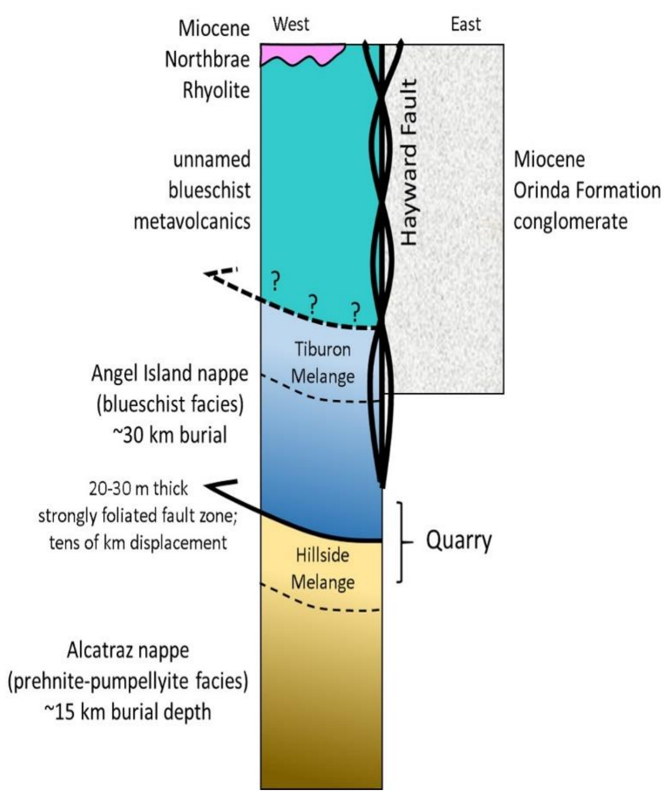

Figure 27. Tectono-stratigraphy of the Hillside Natural Area, El Cerrito.

Stop 2
Walk north up the fire road from the starting point near the Memorial Grove, then take the trail going uphill to examine an outcrop of layered turbidite of the Hillside Melange of Wakabayashi and Rowe, 2015 (Fig. 14). The west-northwest strike and northeast dips are consistent with most of those in the area, suggesting that thrusting is roughly southwest-directed here.

The outcrop consists of meta-greywacke or chert, a prehnite-pumpellyite facies “dirty siltstone” composed of quartz, feldspar, chert, and volcanic fragments. The layers are thin and interbedded with more easily eroded shale. These distal sediments were deposited on the ocean floor by turbidity currents that carried sediments from the west coast of North America far out into the deep ocean. Interestingly, there does not appear to be any graded bedding.

Stop 3
These rocks of the Angel Island Nappe are metamorphosed to blueschist facies (Wakabayashi and Rowe, 2015). The meta-greywacke is shot through with ptygmatic layering that indicates plastic deformation of pre-existing veins. Talc pods in the metagreywacke reveal a phase of retrograde metamorphism of the mafic minerals. This massive meta-sandstone suggests a thick submarine channel deposit.

Figure 28. Metagreywacke above the quarry. Note ptygmatic folding of quartz-rich layers.

Stop 4
A few meters south from the possible channel we are back in bedded greywacke. This time it strikes 134^o and dips 62^o southwest, suggesting there is folding in the area.

Figure 29. Exposure of bedded metagreywacke at 'The Pulpit,' a small outcrop above the quarry.

Stop 5

Extensive exposures of Northbrae Rhyolite occur near Madera School and Julian Drive. The Miocene rhyolite/welded tuff may have originated near Round Top volcano in Oakland or some closer, undiscovered source. It either moved north on the west side of the Hayward Fault, or was air-deposited. This unit outcrops throughout the hills and is famous as a climbing rock at Indian Rock in Berkeley.

Figure 30. Northbrae Rhyolite outcrop on Julian Drive. This may be a welded tuff rather than a rhyolite.

Stop 6

The trace of the Hayward Fault runs along a depression on the east side of the Berkeley Country Club. There is also a component of normal offset that raises the east side about 40 m (130 ft) with respect to the west side.

Figure 31. Looking northeast at the trace of the Hayward Fault in Berkeley Country Club, El Cerrito. A dry sag basin occurs here.

The last discrete offset along this segment of the fault occurred about 315 years ago based on trenching (Schwartz, USGS oral comm). This section of the fault has been creeping since then at the rate of about 4 cm (1.6 in) every ten years, which works out to 4 km (2.4 mi)/million years. The Hayward Fault here cuts through Franciscan Complex. Serpentine outcrops of the Tiburon Melange can be seen near Arlington Blvd, west of the fault. East of the fault are blueschist facies metavolcanics (Wakabayashi and Rowe, 2015).

Stop 7

Two large outcrops of gunmetal blue glaucophane schist (blueschist) occur at the corner of Arlington and Rifle Range Road. This is metamorphosed ocean-floor basalt.

Figure 32. Blueschist outcrop at Arlington and Rifle Range Road.

Stop 8

The trace of the Hayward Fault is seen as a smoothed escarpment, up-to-the-east, across Thors Bay Road.

The escarpment forms the east side of Arlington Park south of Thors Bay Road. Boy Scout Camp Herms occupies an old quarry on the upthrown (east) side of the escarpment.

A year-round spring issues from the trace of the fault in Arlington Park and feeds a small stream that runs through the park. Stream flow is a function of winter rainfall, and varies throughout the year.

Figure 33. View of the spring along the trace of the Hayward Fault in Arlington Park.

Stop 9

The PG&E powerline right-of-way north of Moeser is built largely across an old landslide (Figs. 18, 33). Hummocky topography is typical and indicative of landslide deposits. Several of the streets that cross the slide (Shevlin, King, Contra Costa) show downslope movement (Fig 22). The large blueschist outcrops, including some crenulated blueschist, may or may not be *in situ*.

Figure 34. Powerline right-of-way along the north side of Moeser. This area is largely hummocky landslide deposits (see Graymer, 2000; Wakabayashi and Rowe, 2015).

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