# San Francisco Bay Area
# Local Field Guide

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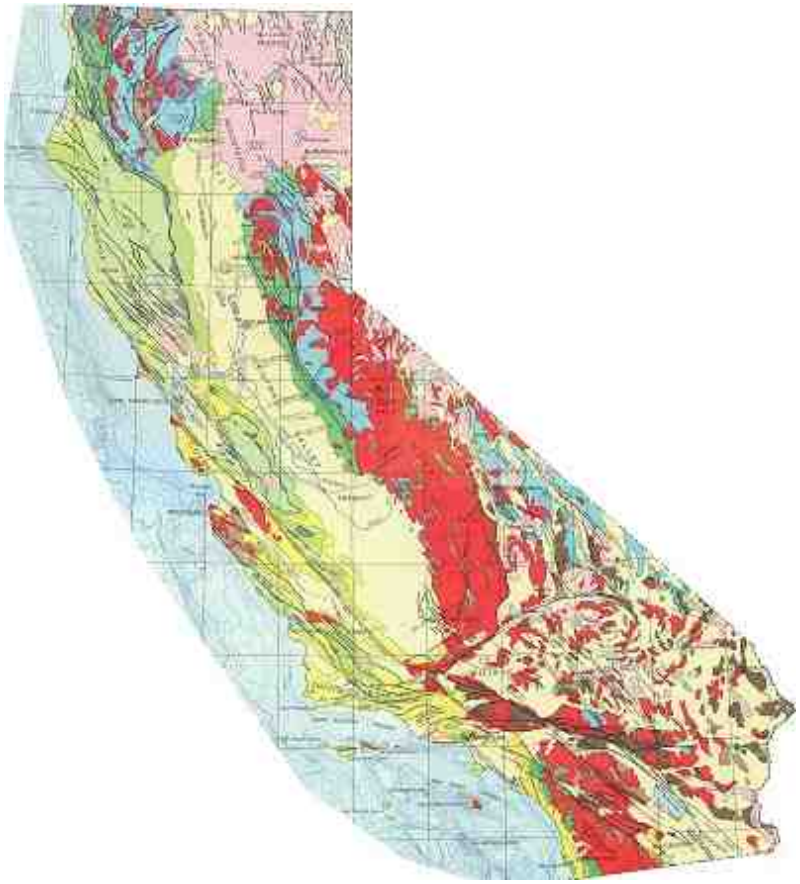
Geologic Map Of California



Map from: http://geology.about.com/od/maps/ig/stategeomaps/CAgeomap.htm

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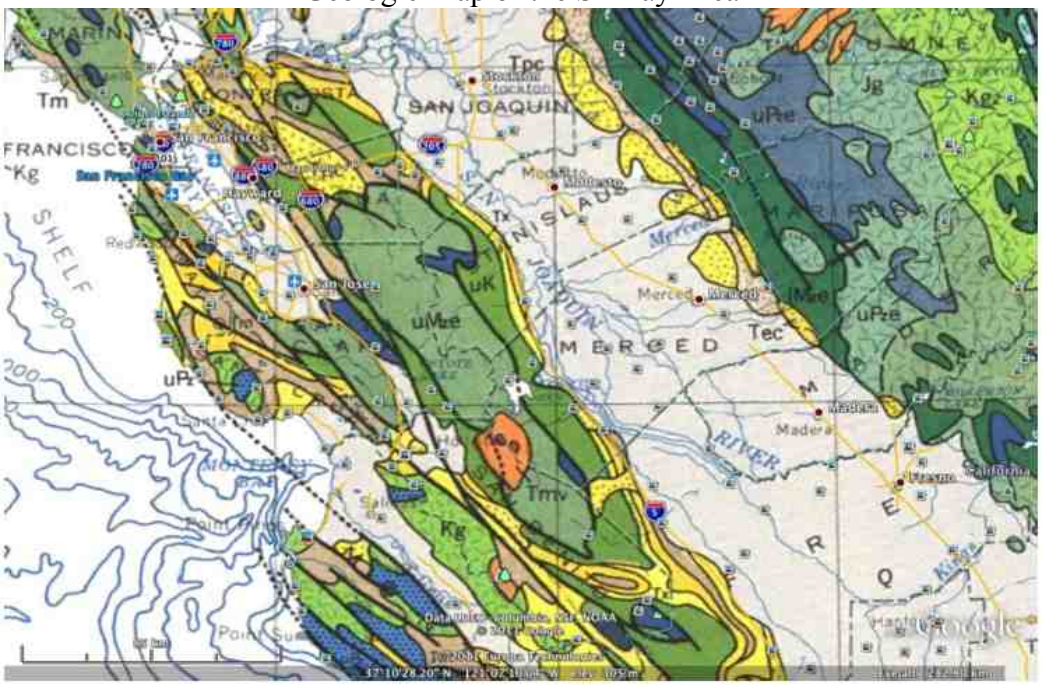
Introduction

The San Francisco Bay Area is a dynamic and interesting place to visit. The geology of the area is detailed more in the map below from Google Earth. We will investigate the complicated Coast Range Geology of the Bay Area- Looking at ophiolite sequences, evidence of multiple accretionary events, coastal processes, and the changing climate from coastal to inland. The San Andreas Fault system is currently the dominant geologic process in California, but we will go back in time to look at how California formed before the San Andreas Fault.

Geologic Map of the SF Bay Area




We will investigate the interesting and varied geology of the Coast Ranges and a little of the Great Valley Sequence, compare coastal and inland climates and weather, look at areas where only native plants exist, and others choked with invasive species. We will have a star party at the Pinnacles where no light pollution will interfere. Finally we will be looking at coastal erosional processes and peer into the ocean itself at the Monterey Bay Aquarium.

Most nights we will be staying at the Extended Stay America San Jose - Morgan Hill and driving out from there. One night we will be camping at the Pinnacles National Monument so that we can do the star party, but return to the hotel the following evening. A map from San Jose International Airport (SJC) to the Hotel is included below in the maps section. A list of what to bring is detailed later in this section as well.

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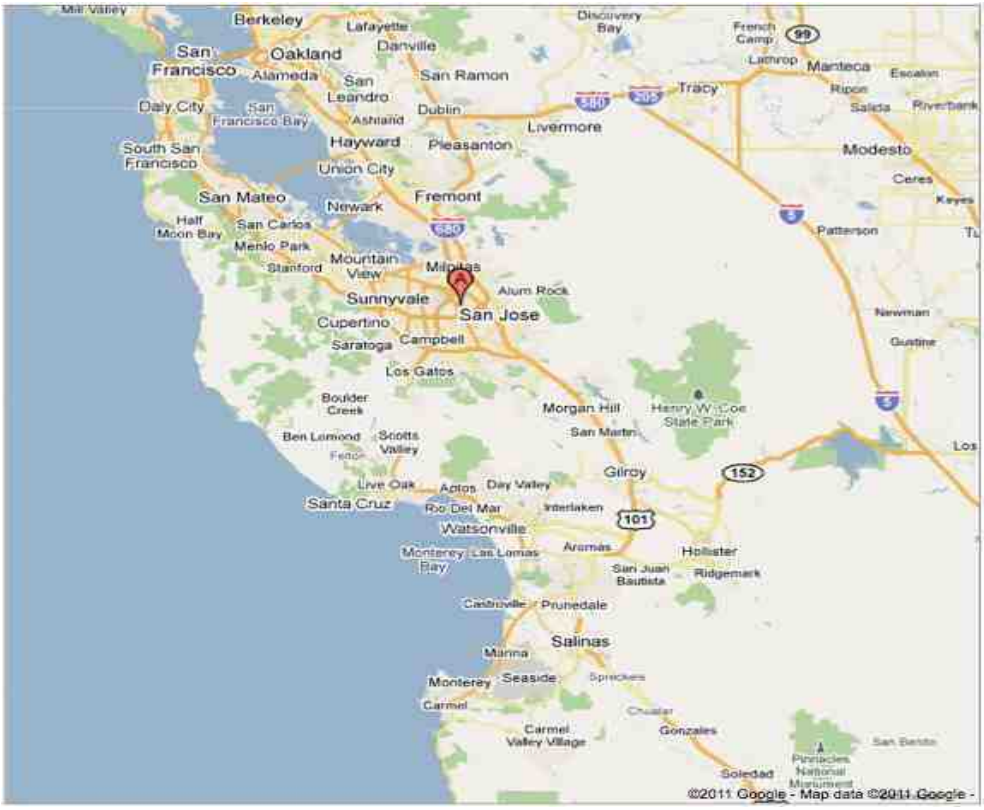
Highway and Location Map of The Bay Area (from Google Maps)




Field Trip Outline

Day 1

Marin Headlands.

We will investigate the Geologic history of the Coast Ranges, prior to the San Andreas Faulting system. We will look at various outcrops to reconstruct the plate tectonic history of the Marin Headlands, including pillow basalts, greenstones, folded cherts and turbidites representing the ophiolite sequences found regularly in the Coast Ranges. Discussion will focus on original formation locations, and how these exotic terranes were accreted to the North American Craton to form the Coast Ranges. To see all the outcrops and reconstruct will take most of the day. Weather and climate observations will be made daily, and comparisons of coastal climate versus inland climate will be made during the field course. Ocean processes and erosion will be discussed, as we will be observing wave action during this day trip.

Day 2

Santa Cruz.

We will be looking at road cut geology in the Santa Cruz Mountains as we head to Santa Cruz, observing littoral drift and erosion on a trail in Opal cliffs. We will be observing and discussing marine terraces and discussing emergent coastlines. We will also observe the Salinian block geology as compared to the Coast Range geology (previous day). Weather and climate observations will be made daily, and comparisons of coastal climate versus inland climate will be made during the field course. Ocean processes and erosion will be discussed, as we will be observing wave action during this day trip.

Day 3
Monterey

In Monterey we will go to Elkhorn Slough National Estuarine Research Reserve and take a tour of the estuary, as there are many in the Bay Area. We will continue down toward Monterey area to look at the sand dunes near the coastlines, and discuss formation of the dunes. We will then go to the Monterey Bay Aquarium to Investigate and discuss the Kelp Forests off the coastline. These Kelp beds are a major ecosystem in California- we will discuss their import, ecology and environmental temperature. Weather and climate observations will be made daily, and comparisons of coastal climate versus inland climate will be made during the field course. Ocean processes and erosion will be discussed, as we will be observing wave action during this day trip.

Day 4 (camping night on the East side of the Park)
The Pinnacles National Monument

We will go to the Pinnacles to investigate the volcanics of the park, the caves, and discuss why half of the volcano is missing (left in Southern California, divided by the San Andreas Fault). Weather and climate observations will be made daily, and comparisons of coastal climate versus inland climate will be made during the field course. We will do a star party tonight out in the Pinnacles area to take advantage of the low city light pollution.

Day 5
Morgan Hill

We will be hiking in Calero Reservoir CountyPark, looking at native species versus invasive species in the park. We will collect data on individual species we find in the park and compare number of natives to number of invasive species at the end of the day. Weather and climate observations will be made daily, and comparisons of coastal climate versus inland climate will be made during the field course.

Day 6
Newark, Hayward, and Oakland

In Newark we will investigate the Bay Salt evaporation flats, and the local Salt mining plant. We will then proceed up to Hayward to do the Hayward fault walk observing the fault creep and displacement along the hayward fault. There are several landslides on the route for this day trip, and we will be looking at at least one landslide up close somewhere between Hayward and Oakland. In Oakland we will look at more evidence of the Hayward fault displacement at the UC Berkeley stadium. Then continue to Mount Sibley Park to look at the volcanics and discuss how and when these were emplaced. Weather and climate observations will be made daily, and comparisons of coastal climate versus inland climate will be made during the field course.

Day 7
Almaden Quicksilver Mines State Park

Almaden Quicksilver Mines State Park and museum to look at the Mercury mining museum, and discuss the environmental impacts of the mining and the geology of why we have this mineral resource. Weather and climate observations will be made daily, and comparisons of coastal climate versus inland climate will be made during the field course.

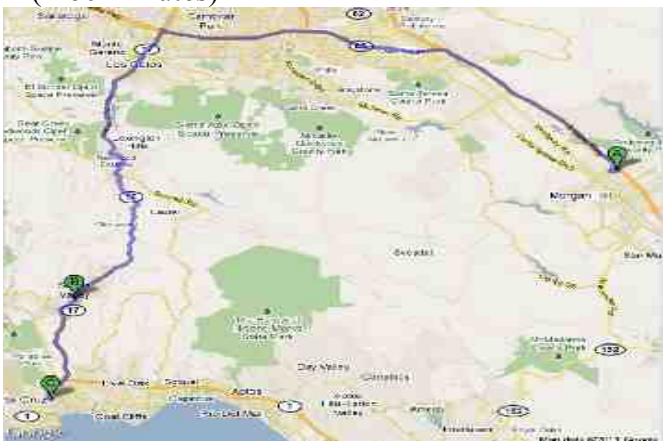
At the end of the field course, we will have a debrief discussion on the Geosciences of the Bay Area.

Maps to primary city locations by day (All Maps in this section were created using Google Maps)

Arrival day and to hotel: San Jose International Airport (SJC) to Extended Stay America San Jose - Morgan Hill (~30 minutes)

Day 1: Hotel to Marin ( ~1 hour 30 minute drive there and again back to Hotel- but on trip out we will make a few stops to see the San Andreas Fault trace.)

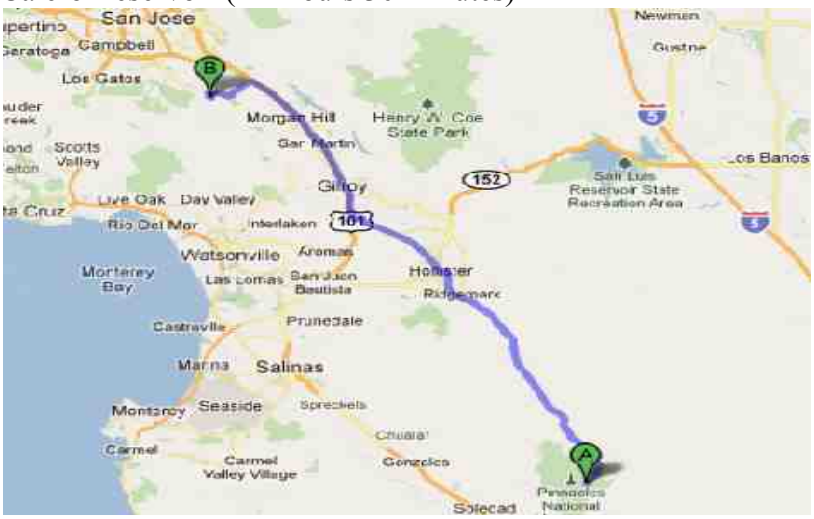

Day 2: Hotel to Santa Cruz ( ~60 minutes)




Day 3: Hotel to Monterey (~1 hour 20 minutes)

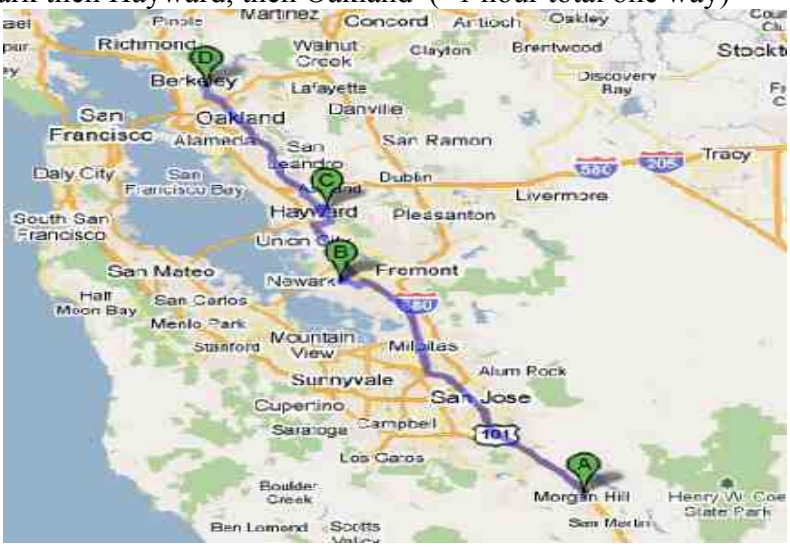
Day 4: Hotel to Pinnacles ( ~1 hour 15 minutes)


Day 5: Pinnacles to Calero Reservoir ( ~1 hours 30 minutes)

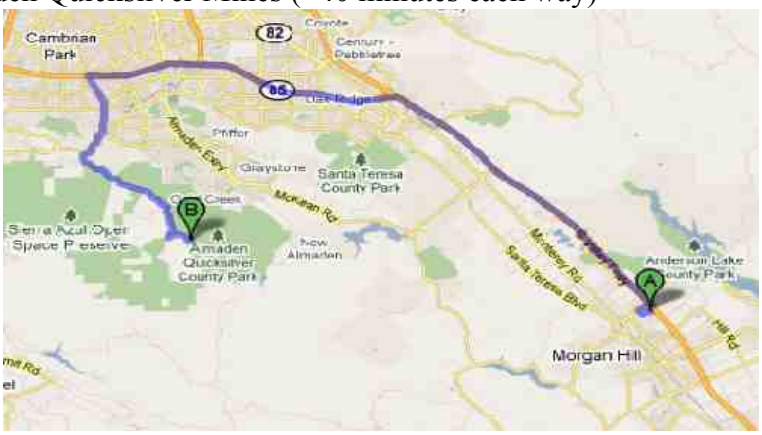



Calero Park to Hotel (~30 minutes)

Day 6: Hotel to Newark then Hayward, then Oakland (~1 hour total one way)




Day 7: Hotel to Almaden Quicksilver Mines (~40 minutes each way)




<u>Hotel and Meal Accommodations</u>

Airport:

San Jose International Airport- SJC

Hotel:

Extended Stay America San Jose - Morgan Hill ($85/night)

One Camping night at Pinnacles National Monument (Group tent camping up to 20 people $110/night)

Food:

Breakfasts will be continental breakfast provided by hotel- and on camping day provided by tour.

Lunches will be sack lunches: meat and cheese or peanut butter and jelly sandwiches, chips and fruit.

Dinners will be a local restaurants in Morgan Hill, except for Pinnacles night, we will barbeque hamburgers at the campground.

What to Bring

- hiking boots
- tennis shoes
- sunscreen
- star guide
- rock hammer
- hand lens
- sample bags
- sharpie
- hat
- bug spray
- pocket pack of kleenex
- small first aid kit
- comfy shoes for evenings
- jacket (coastal areas get cold compared to inland areas)
- field clothing
- layered clothing for warm weather (valley during the day) and cool (nights, coast)
- tent
- sleeping bag
- 1 liter water bottle (or two!)
- powdered Gatorade mix
- money for dinners, souvenirs, and $15.00 to chip on for lunches and campout dinner.
- camera with extra batteries and lots of memory (assuming digital camera)
- toiletries
- clothing for evening dinners (casual)
- notebook
- day pack (for notebook, samples, water bottle..)
- flashlight (for caves at the Pinnacles, and camping night)
- long pants for caving
- gloves for caving
- pj's
- socks
- belt
- watch and or alarm clock
- telescope or good binoculars for star party

Water coolers will be available on the van daily to refill water bottles.
Sling psychrometers and digital anemometers will be provided for use in weather observations.

Best Time to Visit the Bay Area

The Best time to visit the San Francisco Bay Area is in late spring or summer when the rains have stopped! Late spring is the prettiest with the wildflowers blooming- May to June are the best months. The winter and early spring time are the wettest times, and after July most valley temperatures get too hot to be comfortable in the valley areas. As the area is somewhat dry- about 30% relative humidity, so the heat can be very stressful on many. The coastal areas are tempered by the Pacific Ocean, so tend to be much cooler and foggy. So be prepared for a variety of temperatures.

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Overview of the Geosciences of the Bay Area

Geology

The San Francisco Bay Area has a unique tectonic setting. The area straddles the San Andreas Fault System, the dividing line and plate boundary between the North American Plate on the East and the Pacific Plate on the West. This plate boundary is evidenced by the completely differing geologies on each side of the San Andreas Fault system (SAF) shown below. However, California used to be dominated by subduction tectonics until about 35 mya. The main geologic unit of the Coast Ranges is the Franciscan Complex. We will also see portions of the Salinian Block and the Great Valley Sequence.


Image from: http://walkingthefault.wordpress.com/

A significant part of the Franciscan complex is the ophiolite sequence (diagram below) as well as Franciscan melange. The ophiolite sequence consists of ocean sediments, over pillow basalts, over sheeted dikes, over plutonic rocks such as gabbro, over mantle rock like peridotite and serpentine (McPhee, 1999). The melange is ground up bits of rocks that just looks like a jumbled mess. The Marin Headlands especially show off the ophiolite sequence, such that you can walk back in time as you walk towards the West. Pieces of the ophiolites and melange can be seen throughout the Bay Area at different localities, but the complete sequence is best seen at Marin. Many of the stops in the following field trip will be looking at various pieces of the Franciscan Complex.

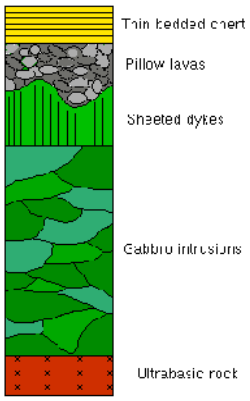


Image from: http://geologyrocks.co.uk/

On the West side of the San Andreas Fault (SAF) you have the Salinian block. These are

chunks of Sierran type granite originally formed in Southern California, that has been right lateral faulted about 200 miles north of where it was formed. The crystalline basement rock is Cretaceous granite with some ancient metamorphic rocks of schist, gneiss and marble similar to the Sierra Mountain range granites. This Salinian granite is exposed in a variety of places along the California coast in the Bay Area. Much of the granite is covered unconformably by sediments of Mid-Miocene age. Laird sandstone and the Monterey Formation (another sandstone) rest directly on top of the Salinian basement rocks in some localities. More sediments of late Miocene to Pliocene rest unconformably on the Monterey Formation. This consists of the Santa Margarita Sandstone, Santa Cruz Mudstone, and the Purisima Formations.

So how did Salinian Block come to be next to the Franciscan Complex? The original tectonic set up was a subduction zone of the Farallon Plate subducting under the North American Plate. But at some point the east pacific spreading ridge was subducted under the North American Plate. This changed what was going on drastically. The Tectonic plate boundary went from subduction to spreading then to a transform boundary because of the changes in tectonics. The Current San Andreas Fault system is an extensive track of several faults that extend from the Mendocino Triple Junction all the way south to the Bay of California. This transform boundary connects two triple junctions and spreading ridges through the North American Continent. The San Andreas Fault is the most well known, but the plate boundary defined by the SAF is thought to possibly extend to the Basin and Range Province as evidenced by the spreading from the Gulf of California up through the Basin and Range Province (McPhee, 199). The Salinian block has been moved Northward along the SAF system about 300km since late Miocene times.

On the East side of the SAF is the Franciscan complex that primarily makes up the Coast Ranges. This is a jumbled mix of oceanic crustal rocks accreted onto the continental North American margin by subduction of the Farallon plate under North America. The Coastal Ranges were formed during the late Mesozoic. Pillow basalts, gabbro, greenstone, and serpentinite known as the ophiolites and the associated melange are the predominant rocks of the Franciscan complex which are Jurassic-Cretaceous in age. It is known as a jumbled mess of deformed rocks, that is very difficult to make sense of if you don't evaluate carefully. Most of the Franciscan Complex was sheared off of the Farallon plate as it was subducting under the North American plate. The original ooze of the ocean sediments makes for very interesting rocks now in the form of folded radiolarian cherts.

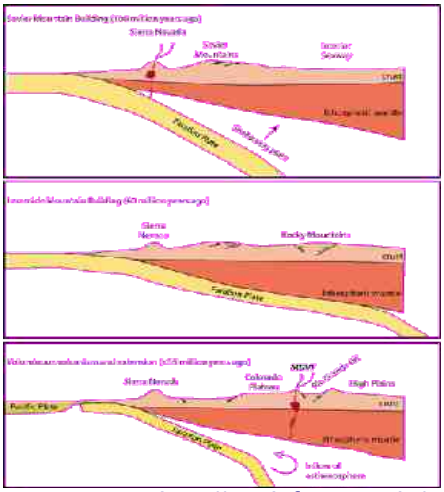

Image from: http://geoinfo.nmt.edu/

The image above represents what has occurred on the Pacific coast since 100 mya as the Farallon plate subducted underneath the North American Plate. As the Farallon plate subducted, many

exotic terranes were accreted onto the North American plate, expanding the land mass. By 60mya, the Laramide Orogeny was forming the Rocky mountains. By about 35 mya the subduction zone choked off from the Mendocino triple junction down south to the Gulf of California converting the boundary to a spreading then finally the transform plate boundary. As the California coastline changed from subduction to spreading briefly, then to a transform boundary, the San Andreas Fault system emerged as the dominant plate activity. The current SAF zone, including the Hayward, Calaveras and many other faults, has bends causing areas of compression and extension, causing the many valleys and mountains and continued complexity of the Coast Ranges.

East of the Hayward fault, part of the SAF system, you encounter the Great Valley sequence rocks. These sedimentary rocks are contemporaneous with the Franciscan Complex. The sandstones were deposited in a shallow seaway prior to the accretion of the Franciscan Complex. One of the courses I have taken estimated the thickness of the great Valley sediments to be several tens of miles thick. Where the Great Valley Sequence meets the Coast Ranges, the Great Valley has been folded, upturned and deformed. This is seen in the Hayward hills, and in the hogbacks east of these hills toward the city of Tracy. Driving through the Altamont Pass you can see the upturned edges of the Great Valley Sequence very clearly. In the picture below, the beds are dipping about 25-30°West.

Road cut in the Altamont Pass showing Great Valley sequence, Cierbo Formation from: http://ncgeolsoc.org/

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Climatology

The San Francisco Bay Area climate is a Mediterranean climate, Csa by the Koppen Classification System, with hot dry summers and mild wet winters (see Koppen World Climate figure below). Looking at the Temperature and Precipitation graphs below, you can see that Morgan Hill which is considered inland, compared to San Francisco which is coastal, have similar climates. The major difference between the two is that average temperatures in Morgan Hill are much higher than in San Francisco, with temperatures reaching 100 not uncommon in Morgan Hill during the summer months. I use these two cities for comparison as Morgan Hill is where I teach, and San Francisco is the city best known in the Bay Area, and these show a distinct difference in temperature ranges because of their proximity to the coastline.

The summer months in the Bay Area are dominated by the North Pacific High Pressure zone, which contributes to the southern California deserts. This high pressure zone caps the marine layer, making it difficult for precipitation to form in the summer months in the bay area. The wet winter months are driven by the Polar Jet Stream that brings cold moist air in from the North Pacific. This brings the majority of the precipitation for the year, primarily in the from of snowfall to the Sierra Nevada Mountains. The snow melts in the spring and summer, bringing fresh water to the Bay via the rivers from the Sierra, and to Los Angeles via the aqueduct system.

The Air masses that affect California weather and climate are the maritime polar and the maritime tropic as shown on the diagram below. The mP air mass most dominates the San Francisco Bay Area bringing in cool moist air. This drives our winter precipitation patterns, and keeps the summer months cooler on the coastline. The mT air mass primarily affects Southern California, but occasionally impacts Northern California weather.

Diagram from: http://rst.gsfc.nasa.gov/Sect14/Sect14_1b.html

San Francisco Temperatures are moderated by the Sea Breeze during the day. The Sea breeze comes in from the West, over the Pacific. The Pacific- California current brings cold waters southward down the coast of California from the Arctic. The typical ocean water temperatures off the Coast of California are about 50-54° F. This cold current moderates the temperatures of the Bay Area keeping them more stable than inland areas, and much cooler that would be expected at 37°47' latitude. This cool water offshore drives the daily Westerly sea breeze. The evenings on warmer days often experience a land breeze, where the land has heated up during the day, and cools faster, causing the winds to come from inland out to the west (an Easterly land breeze).

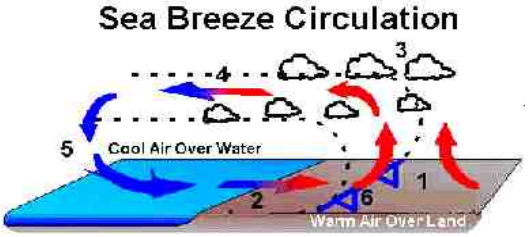
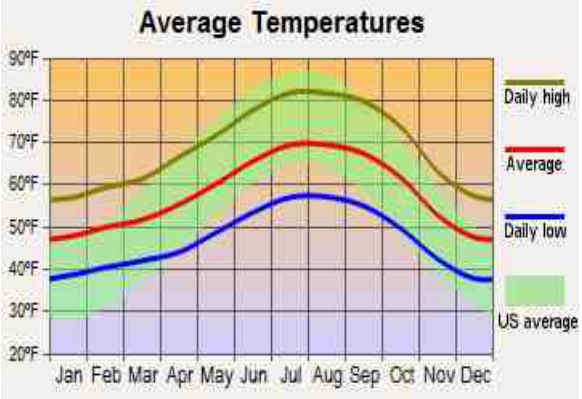
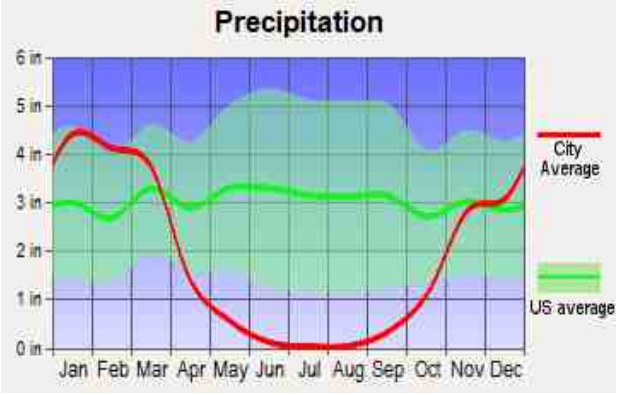



Diagram from: http://mail.colonial.net/

## Morgan Hill Temperature and Precipitation Averages by Month

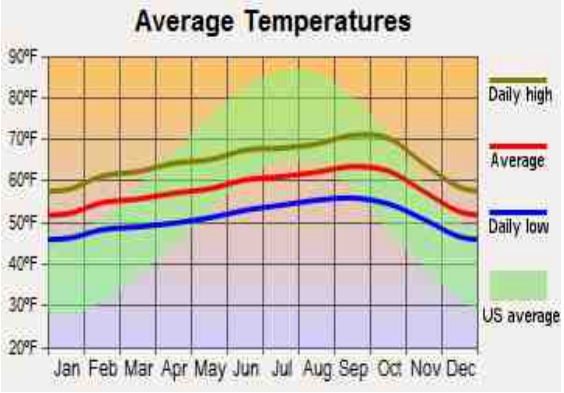
Temperature and Precipitation graphs from: http://www.city-data.com/city/Morgan-Hill-California.html

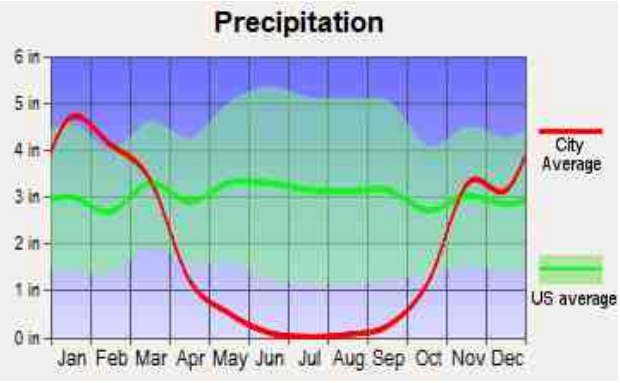


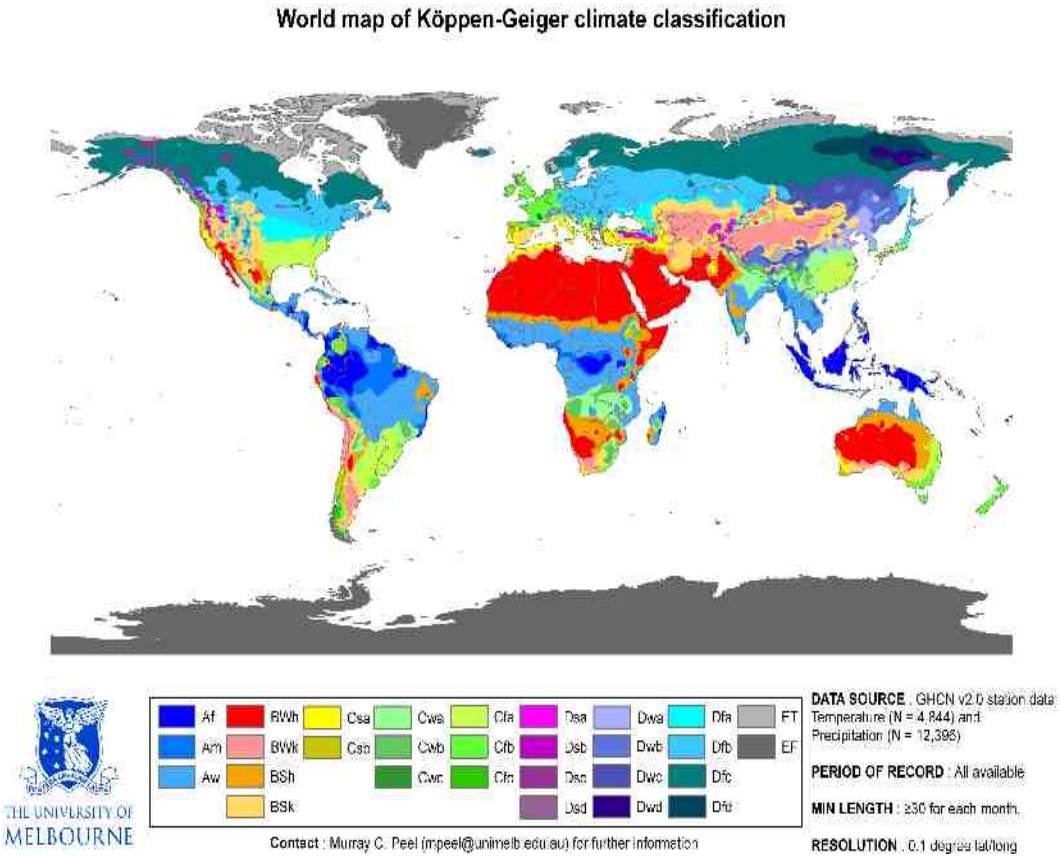

## San Francisco Temperature and Precipitation Averages by Month

Temperature and Precipitation graphs from: http://www.city-data.com/city/San-Francisco-California.html




Koppen Climate chart from: people.eng.unimelb.edu.au

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Environmental

Invasive Species:

Invasive species are a problem everywhere. In the San Francisco Bay Area, we have both land and water invasive species that are wrecking havoc on our ecosystems. Our primary water invasive species are the zebra and quagga mussels. Both of these species of mussels clog water ways, pipes and take over native habitats. Many lake areas are now closed to water recreation like boating, or seriously restricted, due to the rampant spread of the zebra mussels. The San Francisco Bay and area lakes are trying to minimize the spread of and eradicate the quagga mussel brought in via ballast from ships.

Zebra Mussel

Quagga Mussel

Images and information from: http://www.invasivespeciesinfo.gov/aquatics/main.shtml

Major plant invasive species include the pampas grass and french broom. Both of these were originally introduced as garden plants, then escaped. They spread easily, overrunning the native plants and squeezing them out. The proliferation of these plants increase fuel loads which increase fire hazard, and degrade wildlife habitats. These are only two plant invasive species, there are many more species than can be covered here in detail. Another big invasive is Bermuda grass. Planted as lawns, this grass is not adapted to the climate, so needs lots of water to survive. Planting Bermuda as a lawn also completely destroys the native clump grasses that are not only adapted to the climate, but have deep roots that help control soil erosion. Many people are trying to re-introduce California native clump grasses into their lawns, including my family. We are working to find sources of native grass seeds to re-seed our lawn area before the winter rains.


Images and information from: http://stopwaste.org/home/index.asp?page=416

Another land invasive is the European Starling. Introduced in the US so that we would have all of the birds mentioned by Shakespeare. Unfortunately this little bird destroys crops and competes with native bird species. Again, this is only one example, there are many other animals, invertebrates and vertebrates that are invasive in this area. Another bird that is particularly invasive is the House Sparrow. This little bird kicks out native songbirds from their nests, destroying the song bird eggs. Bluebirds have be particularly affected by sparrows invading their nests.

Image and information from: http://www.invasivespeciesinfo.gov/animals/eurostarling.shtml

Natural Resources:

The biggest natural resource of the Bay Area is Mercury, or Cinnabar. The Coast Ranges with the serpentine bands were ideal locations for cinnabar to form. Cinnabar is a result of heated water altering serpentine. As Serpentine is the California state rock, there is a lot around. As a result of the amount of serpentine in the Coast Ranges, there are many mercury mines. One of the most productive of these, the Almaden Quicksilver Mines, is on the south side of San Jose, and is one of our stops on this field trip. Mercury was discovered here shortly before the Gold Rush. As mercury is used in gold mining to capture gold flakes via amalgamation, the Almaden mine became very profitable during the gold rush.

Unfortunately, mercury is also a neurotoxin that builds up in a body's system and can cause mental problems and eventually death. This buildup also occurs in wildlife such as fish and birds. A consequence of using mercury in mining was that not all of the mercury adhered to the gold. Some was lost to the rivers and soils. The San Francisco Bay, as the end point of all of the gold country rivers, now contains high levels of mercury. You do not want to fish and eat anything from the San Francisco Bay! At Almaden, they did significant clean-up after the mine was closed and converted into a park.

Image of cinnabar from: daviddarling.info

Another resource of the Bay Area is wind power. Many locations in the Bay Area have significant winds much of the year, in a consistent direction. This makes it perfect for harnessing the power of the wind via windmills or turbines and converting the power into electricity. A huge wind farm is situated on the hills of the Altamont Pass. The pass is a lower point in the range that funnels the wind from the Bay into the Central Valley. Because of the funneling effect, it is very windy, from a Westerly direction most of the time. The area is thus covered with wind farms, with cattle happily grazing underneath. Image from: http://www.sciencephoto.com/media/340590/view


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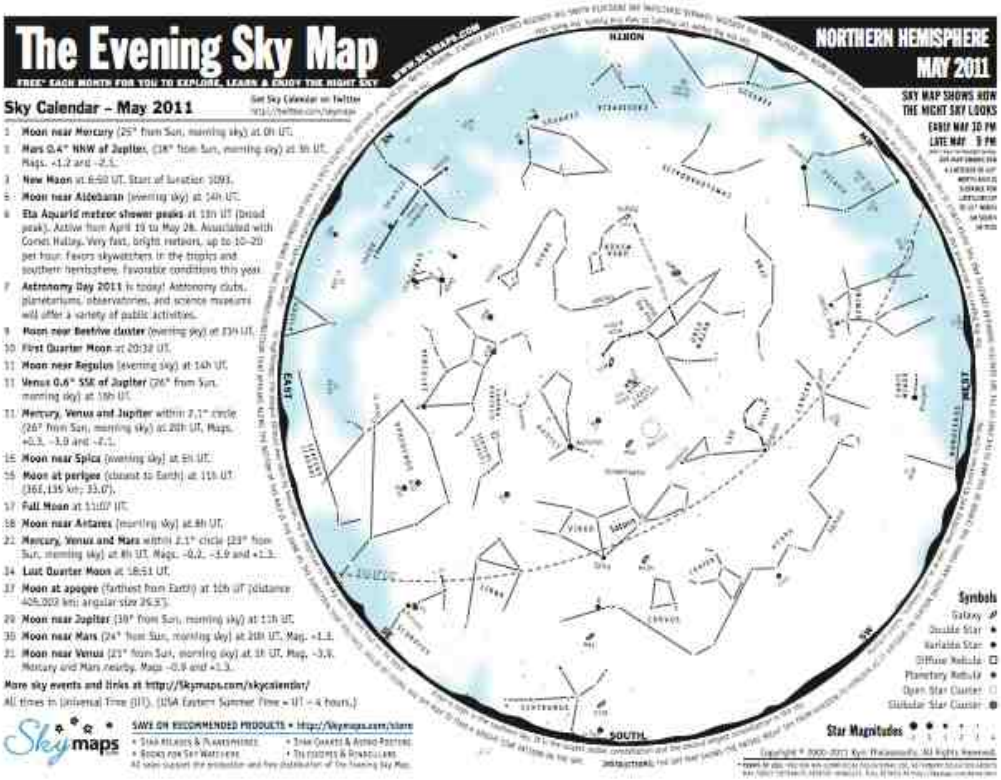
Planetary

Much of the San Francisco Bay Area has too much light pollution to see many stars or constellations, but if you get out of the cities, into the country areas more, you will be able to see much more of the fabulous Milky Way Galaxy that we live in. For the Spring months, I chose May as the optimum time, if you go out to the Pinnacle National Monument you will see incredible amounts of stars. With no light pollution nearby, the Milky Way Galaxy spiral can be seen above. Constellations will be easier to recognize with the reduced light pollution as well. The Star Chart below show the constellations visible during May of 2011. If you visit the Bay Area in May, you will also be able to catch some of the Eta Aquarid Meteor Shower. Venus and Jupiter will be visible as well as Mercury- If you are there on the right day! Bring a telescope or good binoculars to see the craters of the Moon.




May 2011 sky map from: http://www.skymaps.com/downloads.html

My favorite constellations to look for in the Spring are Draco and Orion. Draco is just neat to think about the mythology of: Dragon spirits moving to that constellation after death to look over the Earth. Orion is particularly fascinating as you can see with the naked eye on clear nights the color of two of the constellations stars. Rigel is a blue giant, and appears light blue on a clear night. Betelgeuse is a red giant that actually appears red. Even in moderate light pollution the red of Betelgeuse can sometimes be seen. With a good telescope you can see the nebulae around Orion's belt on a clear night. Something to look for on our star party night.

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Oceanography

The Pacific coast of California is an emergent coastline due to the active plate tectonics. The continental shelf is narrow, dropping off quickly to deeper waters. As a result, wave cut platforms, sea cliffs and small narrow beaches are the norm. There are areas of the coastline with gorgeous sea stacks and sea arches, one of which we will see on this trip in Santa Cruz. During this trip we will be able to observe the wave action as it moves beach sediments, and erodes coastal cliffs. Some areas on the itinerary we will have to check tidal charts before going out to make sure we do not get stuck on a small beach when the tides come in. Swimming is not recommended on many stretches of this coastline due to rip currents, which can pull you under water and way out into the ocean. So please observe any posted signs on swimming.

Natural Sea Bridge off coast of Santa Cruz image from:http://vabulous.com/

Being on the Pacific Rim, the California coastline is susceptible to tsunamis. When the March 2011 Honshu, Japan quake hit, Santa Cruz Harbors experienced over 8 foot tsunami waves that tossed the boats around like tinder, and destroyed much of the harbor. Coastal bays tend to be the most susceptible- except for the San Francisco Bay- due to the refraction of the wave energy into the bay during a tsunami. In the San Francisco Bay itself, there is such a narrow inlet at the Golden Gate, that tsunami energy is quickly dissipated once the wave passes the Golden Gate.


Santa Cruz harbor after the March 2011 tsunami. Image from: http://sacramento.cbslocal.com/

As mentioned in the Climatology section, the current off the California coast is a cold one. The Pacific- California current brings cold Arctic waters down the California coastline to eventually join the warmer waters near the equator. The North Pacific current moves warm waters west and north from the equator up the western Pacific countries of Japan and China, to the Arctic where it looses its heat, then down the Eastern Pacific back to the equatorial waters. This is an important factor in normalizing the heat budget on the planet. Without these currents, ice would pile up quickly in the polar areas, and climate would change drastically.

A major ecosystem in the Pacific Ocean off the Coast of California are the Kelp Forests. We will get to see these up close in Monterey. The kelp forests, actually a brown algae, are dynamic environments. These forests are teeming with life such as fish, invertebrates, shell fish, sea otters and more. Thriving in the cold waters, about 50°F, the kelp can grow over 100 feet tall, and can grow up to 10 feet per day once established (Hill, NoDate). These areas are spectacular diving areas with their diversity, but you definitely need a wetsuit to enter the water.

Kelp forest picture from: http://thekelpbed.com/

TOC

Field Trip Details

Day 0:
Arrival day via San Jose International Airport and arrive at Extended Stay America Morgan Hill Hotel. Get checked in to hotel. Meet after dinner at 7:30-8:30 pm in conference room of hotel for field trip overview, and logistics for the trip.

Day 1
Marin Headlands.

| Time | activity/location |
|---|---|
| 7:00am-10:00 am | Drive to Marin, 2 stops on way to observe SAF |
| 10:00-10:05am | Weather observations |
| 10:00am-4:00pm | Marin Headlands hike/observations (sack lunch) |
| 4:00-4:05 pm | Weather observations |
| 4:05-4:30pm | Weather discussion |
| 4:30-6:00pm | Drive back to hotel |
| 6:30-7:30pm | dinner |
| 8:00-9:00pm | Daily debrief and logistics for tomorrow |

SAF observation stops:

On the drive up to Marin, we will be making 2 stops along the way to view areas that show the SAF trace exceptionally well. The fault runs through and creates sag ponds- two of which are used as lakes/reservoirs: San Andreas Lake and Crystal Springs Reservoir. The first stop will be at Crystal Springs Reservoir, where much of the water comes from Hetch Hetchy Reservoir in the Sierra Nevada and is piped in for San Francisco to use. We will stop at the Crystal Springs Dam off of Skyline Blvd. The second stop is off of Skyline Blvd and Sneath Lane. Once there, we will hike about 200 yards for the best view of the San Andreas Lake and The San Andreas Fault zone. (reservoir stops from Brabb et al, 1969)

At both of these stops we can easily see where the SAF trace is: right through the ponds. We will discuss the formation of sag ponds here. As the fault slides, the rocks in the trace get ground up. As the SAF is a right- lateral strike slip, that does have bends, the northern end of the bends (on the SAF) are divergent, forming basins. The ground rock and basins areas are perfect places for water to collect.

San Andreas Lake aerial view from: http://sepwww.stanford.edu/


Crystal Springs Reservoir on theSAF aerial photo from: http://aerialarchives.com/

Marin Headlands:

The Marin Headlands offer a short cut glimpse into the formation of the Coast Ranges. In a relatively small area, you can go back into the past and read the history of the Earth as it unfolds in the rocks. By looking at the types of rocks present at different locations in the Marin headlands, you can collect data on depositional environment, sources of the rocks, and how the rocks got to where they are now. The Coast Ranges are much larger than can be handled in a short field trip, but the Marin Headlands offer a glimpse into the Ophiolite Sequences that make up much of the Coast Ranges.

The Marin Headlands are located just North of San Francisco, off of the Golden Gate Bridge. The map below outlines the road access to the Headlands. They consist of layers of folded cherts,

sheeted dikes, pillow basalts, greenschist, sandy turbidite sequences and some serpentinite that make up the Franciscan Assemblage of the Coast Ranges. In case you are unfamiliar with any of these terms, there is a table with links to help you understand how these layers form, what an ohpiolite sequence is and more.
(From personal notes taken during Field Trip by DiLeonardo March 10, 2011)


Map shows approximate locations of STOPs 1-4.
Modified From: http://www.google.com/images?q=marin+headlands&oe=utf-8&rls=org.mozilla:en-US:official&client=firefox-a&um=1&ie=UTF-8&source=og&sa=N&hl=en&tab=wi&biw=1176&bih=519

How were the Marin Headlands and the Coast Ranges of California formed? What tectonic processes were in play prior to the San Andreas Fault System? How can we reconstruct the history of this area?

We will reconstruct the geologic history of this area by taking a virtual field trip to the Marin Headlands. As we go to the "Stops", we evaluate what is happening at each location, and what forces, depositional environment, and or tectonic/volcanic processes might be at play. From the "Stops" we will be able to reconstruct the geologic history of the Marin Headlands and thus the Coast Ranges.

STOP 1: Look at the outcrop and talus at STOP 1. (STOP links will take you to outside website with additional pictures of the stop area. These are optional.)

- What type of rocks are in this outcrop? Bedded radiolarian cherts
- Where and how does this rock normally form? Deep ocean environments, from the tests of microscopic organisms called radiolarians
- Why is the rock all twisted and folded? The rocks were compressed in a convergent boundary/ subduction zone
- When was the rock twisted and folded- during deposition or after? rocks were folded post deposition.
- What is the dark sheen on some of the hand samples? Patina from black smokers
- Where might that have formed? near hydrothermal vents at a spreading ridge

- Take temperature and humidity readings with the sling psychrometer, and wind speed with the anemometer.

Folded Radiolarian Chert from stop 1. Black patina on outcrop indicates formed near black smokers. Photo by Heather Marshall

STOP 2: Look at the outcrop at STOP 2.

- What type of rocks do you see in this outcrop (2 types)? Greenstone/greenschist on the left and sandstones on the right
- Where and how do each of them form? greenstones are altered basalts formed originally at spreading ridges from pillow basalts, the sandstones are from turbidites from landslides near coastlines underwater
- What type of boundary is the contact of the two rocks (where the people are)? a fault

Picture of the fault from Stop 2, taken by Heather Marshall

STOP 3: Look at the outcrop at STOP 3.

- What type of rock is the main lighter colored rock in this outcrop? Pillow basalts altered to greenstone/greenschist
- Where does it normally form? At spreading ridges
- What type of rock is the darker rock, and where does it normally form? deep marine shales
- What process probably caused this finger of darker rock into the lighter colored rock? Could have formed from compression, and the shale got pinched up into the pillow basalts as the pillow basalts formed, based on deformation of both along contacts of the finger of shale.

Stop 3 photo by Heather Marshall

STOP 4: Look at the outcrops at STOP 4.

- What type of rocks are in the outcrops? (look closely at the arch, this gives the best glimpse of the freshly eroded rocks) pillow basalts. the arch shows fresh pillow surfaces, the lighter colored rocks are the weathered and altered pillow basalts- altered to greenstone/greenschist.
- Where do these rocks normally form and how? Form at spreading ridges by magma welling up and cooling rapidly in the seawater at the ocean floor
- How might these rocks have gotten to where they are now, from where they form? being scraped off of a subducting sea floor, and then accreted onto the continent
- Observe the waves at this location. What is occurring as these waves crash into the headlands? Erosion of coastline, forming sea arch, sea stacks, wave cut platforms. Fresh exposure of the pillow basalts.

Arch showing Pillow basalts at Stop 4 by Heather Marshall

STOP 5: Look at the outcrop at STOP 5.

- What does it look like happened to form this outcrop? looks like the basalts were shoved up under the sandstones, probably via scraping off a sea floor subducting plate.

Photo from stop 5 by Heather Marshall- depending on tide- this outcrop can be walked up to.

Discussion:

How might all of these rocks gotten from where they were deposited or formed, to where they are now? Prior to the San Andreas system, the Pacific boundary was a subduction zone, with the oceanic plate being subducted under the North American continent. As the sea floor subducted, surface material was scraped off and accreted on to the continent- including small volcanic sea mounts and guyots, pillow basalts, and sea floor sediments.

What type of tectonics do you think were prevalent on the Pacific coast around 175 my to about 65 mya, prior to the San Andreas Fault taking over as plate boundary? Subduction of a ocean plate under a continental plate.

Does this type of tectonics explain the features seen in the Marin Headlands today? yes. Subduction zones are known to scrape material off of the subducting plate and accrete this material onto the continent. The scraping action of subduction adds "exotic terranes" to the continent, such as the pillow basalts, sheeted dikes, deep marine sediments and more. All of these get deformed and folded as they are accreted (hence the folding of the cherts), and faulted by the compressional action of accretion.

Before we leave: take temperature and humidity readings again with the sling psychrometer, and wind speed with the anemometer. Compare to morning readings. Was there a significant difference in temperature? Humidity? What did you notice on the Point in terms of wind speed? Wind speed is significantly higher at the point, than at other stops because we are on the headlands- with no wind breaks. Temperatures and humidity will remain fairly constant throughout the day.

TOC

Day 2

Santa Cruz.

| Time | activity/location |
|---|---|
| 7:00-9:00am | Drive to SC- road cut geology discussions on drive where too dangerous to get out. # stops |
| 9:00-1:00pm | Natural Bridges State Park and Marine Terraces- North of Santa Cruz proper. (sack lunch on the beach) |
| 1:30-4:30pm | Opal Cliffs |
| 4:30-5:00pm | Weather discussion |
| 5:00-6:00pm | Drive back to hotel |
| 6:30-7:30pm | Dinner |
| 7:30-8:30pm | Daily debrief and logistics for tomorrow |

Once we arrive on the beach, we will take temperature and humidity readings with the sling psychrometer, and wind speed with the anemometer.

Natural Bridges State Park offers an excellent view of the Salinian Block geology. The Bridges and sea stacks are Salinian granite, while the shoreline features are the Granite overlain by the Monterey Formation mud and sandstones. The Sedimentary layers are very prone to landslides and other mass wasting. The Salinian Granite has moved northward about 200 miles from where it was formed at the southern extent of what we now call the Sierra Nevada, by the San Andreas Fault. As we hike through this area, we will investigate croups of Monterey Formation Mudstone, look at the joints and faults in the outcrops, and look out into the water to see the sea arch.

Sea Arch carved out of the Santa Cruz Mudstone at Natural Bridges State Beach. Image from: http://www.es.ucsc.edu/~es10/fieldtripNBridge/

Marine Terraces north of Santa Cruz. Marine Sediments overlay Salinian geology. From: http://www.cfses.org/salmonid/html/water/geo.htm

As we wander the coastline, we will also see evidence of the marine terraces (above). As the coastline emerges from the sea due to tectonics, more terraces are exposed. These are great views into history as to where the coastline was, and show the power of wave action in eroding the coastline.

Opal cliffs show another erosional and emergent feature of the shoreline, sea cliffs. The Sea cliffs here are mostly Monterey Formation mud and sandstones, and thus very easily eroded. These cliffs are very susceptible to landslides, yet people still insist on building homes and other structures on the sea cliffs overlooking the ocean. The beach here has greatly reduced since the building of a jetty at Seabright Beach, which caused a reduction of sediment supply via littoral drift (from: http://www.beachcalifornia.com/opalclif.html)

Before we leave: take temperature and humidity readings again with the sling psychrometer, and wind speed with the anemometer. Compare to morning readings. Was there a significant difference in temperature? Humidity? Temperatures and humidity will remain fairly constant throughout the day. We can easily discuss the Sea breeze as we will be in it all day. The sea breeze will be a westerly breeze, keeping the coastline cool. We will not be here late enough to experience the evening land breeze unfortunately, but we will discuss that as well.

TOC

Day 3
Monterey

| Time | activity/location |
|---|---|
| 7:00-8:20am | Drive to Elkhorn Slough |
| 8:30-11:30pm | Elkhorn Slough National Estuarine Reserve |
| 8:30-8:35 am | Weather observations |
| 11:30-12:00pm | Drive to Monterey Bay Aquarium, with drive-by observation of sand dunes |
| 12:00-5:30pm | Monterey Bay Aquarium $29.95/person entry. (lunch at Aquarium restaurant- bring $ for souvenirs and lunch) |
| 4:30-5:00pm | Coastal processes observations/discussion |
| 5:00-5:30pm | Weather observations and discussion |
| 5:30-7:00pm | Drive back to hotel |
| 7:00-8:00pm | dinner |
| 8:00-9:00 | Debrief today, logistics for tomorrow |

In Monterey we will be focusing on the ocean, estuary and ocean processes. Our first stop today will be the Elkhorn Slough National Estuarine Research Reserve, where we will look at where the river meets the ocean creating a mixes salinity wetland area called and estuary. We will tour the Research Center, and the Estuary paths. The Research center is conducting monthly water quality testing at multiple locations within the reserve, and as volunteers we may be able to help with testing if we go on the right day. They monitor weather conditions, updating every 30 minutes. Their research also includes biological monitoring, including early notification of invasive species. The Reserve also supplies lesson plans for teachers, weather or not near an estuary, to teach kids about this fascinating environment. The following website is a link to all of their lesson plans: http://www.estuaries.gov/Teachers/Home.aspx

During our tour of the Estuary Reserve, we will participate in the lookout for any organisms they are currently tracking, do weather observations, and do water quality testing (salinity, pH, dissolved Oxygen, nitrate, phosphate, and ammonium) using the Reserves' testing procedures. We will also take temperature and humidity readings with the sling psychrometer, and wind speed with the anemometer.

From the Reserve we will continue on to The Monterey Bay Aquarium. On the way we will go past some huge sand dunes on the coastline. Unfortunately these are on a military gun range- so we cannot stop and go walk in the dunes, but we can pull over and get some pictures and discuss how dunes are formed from the wind and sand. These particular dunes are thousands of years old, but sand is continuously added from the ocean, and continues to build the dunes from a northwest wind. (from: http://www.mtycounty.com/mbs_pgs/BchDune.html )

Upon arrival, we will have lunch at the restaurant in the Aquarium. After lunch we will enjoy the numerous exhibits at the Aquarium. Exhibits that students should spend some time at include: Monterey Bay Habitats, Open Sea Exhibit, California Spiny Lobster Exhibit, Mystery of the Deep

Presentation (2 and 4 pm- 15 minute programs), The Kelp Forest Exhibit (feeding of sharks at 4 pm!), The Secret Lives of Seahorses, and the Sea Otter Exhibit. These exhibits all add to the experience of what is in the Pacific Ocean just off shore in Monterey. There are many more exhibits to see than these, but these give a good picture of the Monterey Bay environment.

Open Sea Exhibit image from: http://thenewsinn.com/

While at the Aquarium, go to the deck overlooking the Bay and spend some time observing the tidal action, the seabirds and the coastline. You will be able to see wave cut platforms, sea cliffs, sea stacks, the top of the kelp forest, and maybe sea otters playing in the waters! I have known people that would sit for hours in from to the Kelp Forest exhibit, contemplating the fascinating organisms as the live out their lives. So it is very easy to get lost in the exhibits.

When we are done looking, we will discuss what we have seen, and what was the most interesting, impressive to us. Then before we leave: take temperature and humidity readings again with the sling psychrometer, and wind speed with the anemometer. Compare to morning readings. Was there a significant difference in temperature? Humidity? What did you notice at the Aquarium vs the Estuary in terms of wind speed? Wind speed is significantly higher at the Aquarium, than at the Estuary because we are on the shoreline- with no wind breaks. Temperatures and humidity will remain fairly constant throughout the day.

TOC

Day 4

The Pinnacles National Monument

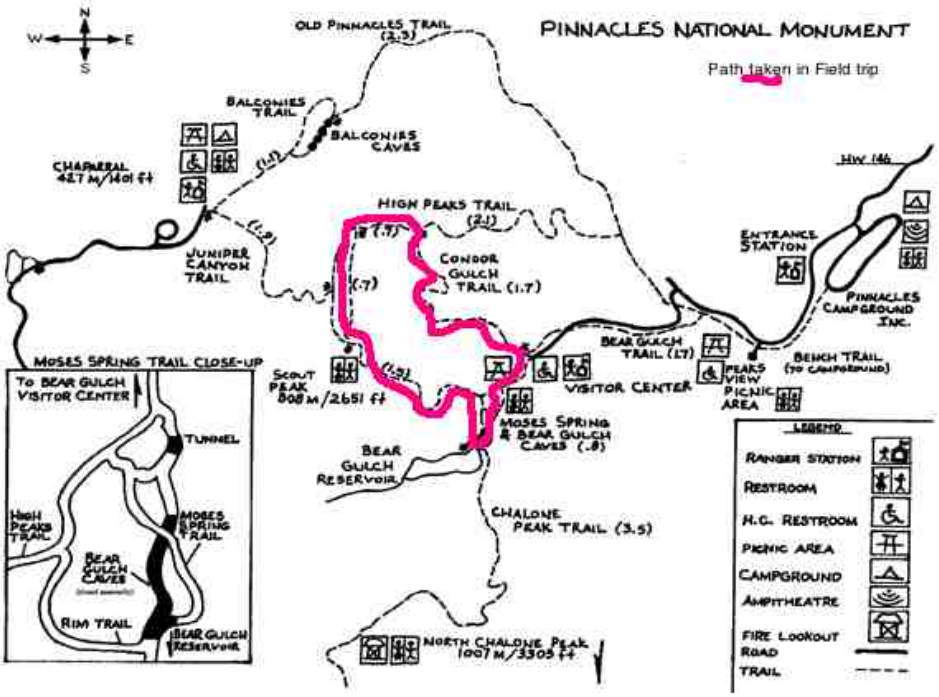
| Time | activity/location |
|---|---|
| 7:30-8:45am | Drive to Pinnacles |
| 8:45-9:15 | Set up tents |
| 9:15-9:20am | Weather observations |
| 9:20-6:00pm | Pinnacles hike, observe volcanics, talus caves, CA native species (sack lunch) |
| 5:00-5:30pm | Weather observations and discussions |
| 7:00-8:00pm | dinner/debrief |
| 9:30-11:30pm | Star party |
| | |

The Pinnacles were formed 40 mya, when the Farallon Plate was subducting under the North America Plate forming California. During this time of subduction, volcanoes formed in a back arc situation on the North American Plate. The Pinnacles was one of the volcanic areas. Once subduction ceased, and the transform plate boundary followed, the Pinnacles was cut in two by the San Andreas Fault system. Since, the Part we know as the Pinnacles National Monument, has moved almost 200 miles North of the original volcano. Traveling to the southern part of California, you can visit the other half at the Neenach Formation. The volcanic rocks are primarily rhyolite and tuff, much of it brecciated and all very weathered now. The talus from rubble have created caves that now house bats. The Park is full of native Californian species, including the California Condor- of which only about 180 individuals are known to be alive in the wild. One of the trails we will go on today will give us opportunity to view this rare vulture.

California Condor image from: http://fws.gov/

We will start the morning by taking temperature and humidity readings with the sling psychrometer, and wind speed with the anemometer at the campsite. After recording the data, we will start our hiking for the day. We will be doing about 7 miles of hiking today, so bring lots of water with you (2 liters at least). We will start with the Bear Gulch Trail to the Bear Gulch Cave Trail, then Follow the Rim Trail to the High Peaks Trail to the Juniper Canyon Trail, to the tunnel Trail, to the High Peaks Trail again (different section) then the Condor Gulch Trail back to the Bear Gulch Trail to

head back to the campsite.




Trail map modified from:
http://www.classbrain.com/artmonument/publish/pinnacles_national_monument_trail_map.shtml

The first "stop" on the hike today will be at Moses Spring Reservoir. As we hike here, we will observe the talus slopes and rock formations along the trail edge. As this is a National Park, we cannot collect samples here, but we can take a lot of pictures. The second "stop" will be at Bear Gulch Cave. Here we will investigate the talus cave, and, using flashlights, do some cave exploration. We might get to see some bats in here if we are lucky!

Bear Gulch Caves image from Keith, 2005.

From here we will continue up the High Peaks Trail into the heart of the Pinnacles rock formations. We will get to see up close and in person the heart of the original volcano, As we descend down Condor Gulch, we will have the opportunity to view the California Condor in its native habitat.


Volcanic rocks along the High Peaks Trail image from: http://chrismurdoch.com/

While on this hike today, look for native plant species as well. Some wildflowers include: larkspur, california buckeye, elegant clarkia, california buckwheat, mariposa lily, bush poppy, gray mule-ears, and sticky monkey-flower ( from Pinnacles National Monument Trail Map handout). You should also see Valley Oak, Blue Oak, Coast Live Oak, Gray Pine, Fremont Cottonwood, and Western Sycamore trees (Keith, 2005).

When we return to the campsite, we will take temperature and humidity readings again with the sling psychrometer, and wind speed with the anemometer. Compare to morning readings. Was there a significant difference in temperature? Humidity? Temperatures will be cooler in the morning than the late afternoon, with afternoon temperatures around 80-90 degrees depending on May or June visit. The humidity will be relatively low, about 35%. Winds will be much less than coastal areas, because we are inland, and depending on where we are in the park, we could have no breeze due to the blockage by the mountain.

We will do a star party tonight out in the Pinnacles area to take advantage of the low city light pollution. If we are visiting in May, we will look for evidence of the Eta Aquarid Meteor Shower. We will definitely be able to see the constellations of Orion, Draco and The Big and Little Dippers. With telescopes, you should be able to see the nebulae in Orion's belt.

TOC

Day 5
Morgan Hill

| Time | activity/location |
|---|---|
| 8:00-9:00am | Breakfast and Break down campsite |
| 9:00-10:30 am | Drive to Calero Reservoir County park |
| 10:30-10:35am | Weather observations |
| 10:35-5:30pm | Calero Reservoir County Park ($6.00/car entry fee)- observe native species, riparian habitats and geology (sack lunch) |
| 5:30-6:00pm | Weather observations and discussion |
| 6:00-6:30pm | Drive to hotel |
| 7:00-8:00pm | dinner |
| 8:00-9:00pm | debrief/logistics for tomorrow |

When we arrive at Calero County Park, we will take temperature and humidity readings with the sling psychrometer, and wind speed with the anemometer.

Calero Reservoir County Park offers us a day to enjoy the native species in the Bay Area. This park is full of trails that allow us to see the wildflowers in bloom, see the California Oak Woodland habitat, and see a chaparral riparian habitat all in one park. As we hike the park today we will explore these three different habitats and look out for invasive species as well. The reservoir is man-made to help supply water needs to the Silicon Valley, but you do not want to eat the fish here. The Reservoir has a catch and release policy if you do fish. Mercury is naturally occurring in these mountains, and accumulates in the sediments in the reservoir here. We discussed mercury in the Environmental section, and discussed it's build up of toxicity already.

As we hike today look for the following native species in the California Oak woodlands: humming birds, butterflies, valley oak, blue oak, coast live oak, gray pine, manzanita, coffee berry, currant and goose berry, California holly, poppies and lupines.

Look out for the following native wildflowers: lupines, poppies, baby blue-eyes, monkey flower, coast buckwheat, columbine, flax, iris, prickly pear, tree anemone, wild onion, and yarrow.

Look for these natives in the chaparral riparian habitat: beaver, raccoon, fish, crawdad, ducks, swallows, warblers, willow, sycamore, alder, maple, cottonwood, cat tales, monkey flowers, dogwood and wild grape.

Unfortunately we will also see invasive species such as: tamarisk, giant reed cape and german ivy, johnson grass, kudzu, star thistles, scotch broom, brown tree snake, european starling, cane toad, hydrilla, water hyacinth, purple loosestrife and bullfrogs.

As we hike, we will make note of the species we see, both native and invasive. At the end of the day we will compare notes and see how many different native species we see, compared to invasive species. I recommend having a copy of Plants of the San Francisco Bay Region: Mendocino to Monterey, Revised Edition by Linda Beidleman and Eugene Kozloff (May 15, 2003) to help us identify

plants as we hike.

Before we leave: take temperature and humidity readings again with the sling psychrometer, and wind speed with the anemometer. Compare to morning readings. Was there a significant difference in temperature? Humidity? WE are inland as compared to coastal, so we will compare our coastal data to todays inland data. We will be at about 1500 feet elevation for this day, so temperatures will be cooler than the valley, but still warm as compared to the coastline. The morning will be cooler than the afternoon. The winds will be from the southwest, and warm at this time of year. Often the winds from the mountains will cause very windy conditions in the valley below in Morgan Hill, as the valley acts like a funnel for the winds.

TOC

Day 6

Newark, Hayward, and Oakland

| Time | activity/location |
|---|---|
| 7:30-8:00am | Drive to Newark |
| 8:00-9:00am | Salt flats and salt mine |
| 9:00-9:05am | Weather observations |
| 9:05-9:30am | Drive to Hayward |
| 9:30-10:00am | Landslide stop |
| 10:15-11:45pm | Hayward fault walk |
| 11:45-12:00pm | Weather observations (sack lunch) |
| 12:30-1:00pm | Drive to oakland |
| 1:00-2:00 | UC Berkeley stop |
| 2:00-6:00pm | Mt Sibley Volcanic Preserve (includes short drive from UC to Sibley) |
| 6:00-6:30pm | Weather observation and discussion |
| 6:30-7:15pm | Drive to hotel |
| 7:30-8:30pm | dinner |
| 8:30-9:30pm | debrief/logistics for tomorrow |

Newark:

Cargill Salt Ponds and Plant: In the Don Edwards San Francisco National Wildlife Refuge was created in and around Cargill's salt flats. This National Refuge was created to preserve the salt flat habitats that have been in commercial production since 1854. The salt flats are actually a part of the San Francisco Bay, near the edges where the Bay is relatively shallow. Salt ponds are built by dredging mud from the bay floor to create levees along natural contours so that the flats will be the same depth throughout. Bay waters flood the salt ponds, then are allowed to evaporate naturally. While the waters are evaporating, different salts crystallize at different rates, so salt makers try to keep the non sodium chloride salts in solution until after the NaCl precipitates, then the other salts are harvested after the NaCl. The briny water is circulated through ponds closer to the mining station as they become more saturated with NaCl, so that it is easier to mine once precipitated. The process from initial flooding to salt mining takes about 5 years.

Once ready to mine, the red bittern (magnesium rich solution above the NaCl crystals), must be drained off. Then a mechanical harvester brings in the salt crystals to the wash house where the crystals are washed in a brine solution to get impurities out. Once purified, it is moved to the salt stacks where it awaits the refining process. Depending on the use of the salt- industrial or home use, will depend on how fine the salt needs to be after refinement. The best is used for home use, while the coarser salt is for industrial use.

The salt flats are home to over 70 species of birds, different salinity brine shrimp and more. There are several associated habitats to the salt flats, including tidal mudflats, marshes and tidal ponds. There are also seasonal wetlands and even freshwater marshes near the salt flats. This habitat is

dynamic, and worth preserving. (salt information from Cargill Salt website)

When we go to the Newark Salt flats, we will be able to investigate that variety of colors of the different salinity ponds, and see the Salt stacks at the Newark Plant. We will be able to tour the plant and see how the refinement process works while we are here. We should also note how many different bird species we see today at the flats.

While we are here, we will take temperature and humidity readings with the sling psychrometer, and wind speed with the anemometer.

Cargill salt plant and ponds, Newark, CA from: http://www.flickr.com/photos/greenjay2/4105808334/

Cargill salt plant image from: http://wegmuller.org/

Hayward:

The Hayward Fault is part of the San Andreas Fault system. About 50 miles long, it is also a right-lateral strike slip fault as is the San Andreas. It is estimated that the Hayward Fault is responsible for over 100 feet of movement in the last 12my, and it is known to produce large earthquakes. Mostly, however, the Hayward Fault is known for creep. This is where the fault moves slowly over time instead for producing larger jolts. As a result of the continuous creep along the Hayward Fault, structures are constantly being modified by the fault. The pint of the Hayward Fault walk today is to look at some of the features that are being offset by the Hayward fault.

The following table, from The USGS OFR 1135 ,shows where to go to see some interesting features such as en echelon cracks, creep and more. We will be visiting some of the Hayward and

Oakland sites on todays trip.

| **Fault and landscape features** | **Places where best to see them** |
|---|---|
| Offset curbs, sidewalks, and walls | Contra Costa College, Berkeley Memorial Stadium, Monclair Village, downtown Hayward, and Fremont Central Park area |
| En echelon cracks | Contra Costa College, downtown Hayward, Arroyo Agua Caliente Park (South Fremont) |
| Fault scarps | Point Pinole, Hayward |
| Sag Ponds | Lake Temescal (Berkeley), Tule Lake and Lake Elisabeth (Fremont) |
| Linear valleys, shutterridges | Lake Temescal, Hayward, views from Oakland Hills |
| Landslides | Point Pinole, Mission San Jose (Mission Peak landslide) |
| **Cultural or historic features** | |
| Historic buildings from 1868 era | Downtown San Leandro, Mission San Jose |
| Museums and exhibits | Mission San Jose, Tule Pond, Hayward Area Historical Society Downtown Museum, Oakland Zoo |

Another feature we have as a result of the Hayward fault is some uplift. The Hayward hills are partially a result of uplift in a compressional bend on the strike slip fault. The uplifted, sheared Franciscan rocks and Great Valley sequence are prone to mass wasting. Along the hills bordering the Hayward fault are many landslides. One of the more recent slides, that I recall when it slid in 1998 while a student at Cal State hayward, is the Mission Peak Landslide. This is our first stop today. We will stop and hike near the landslide and observe and discuss the parts of the landslide. The diagram from the USGS OFR 1135, shows the landslide scarp and toe of the landslide below, as well as the direction of slide.

Mission Peak Landslide from Stoffer 2008.

On to the Hayward Fault Walk. Below is a map of the Hayward Fault Walk from USGS OFR 1135. This OFR (open file report) is what I used the first time I went on the fault walk, and as it gives such great instructions on how to get to the points of interest, I use it here.


WE will go to each of the places marked on the map above to look at offsets, alluvial fan exposures, en echelon fractures in the pavement, and if they have not recently repaved, drive over the Hayward Fault on Foothill Blvd.. The city repaves a section of Foothill Blvd. About twice a year because of the creep of the Hayward Fault buckling up the road. The walk takes about an hour and a half to complete, depending on how many pictures we want to take. One example of an offset curb is

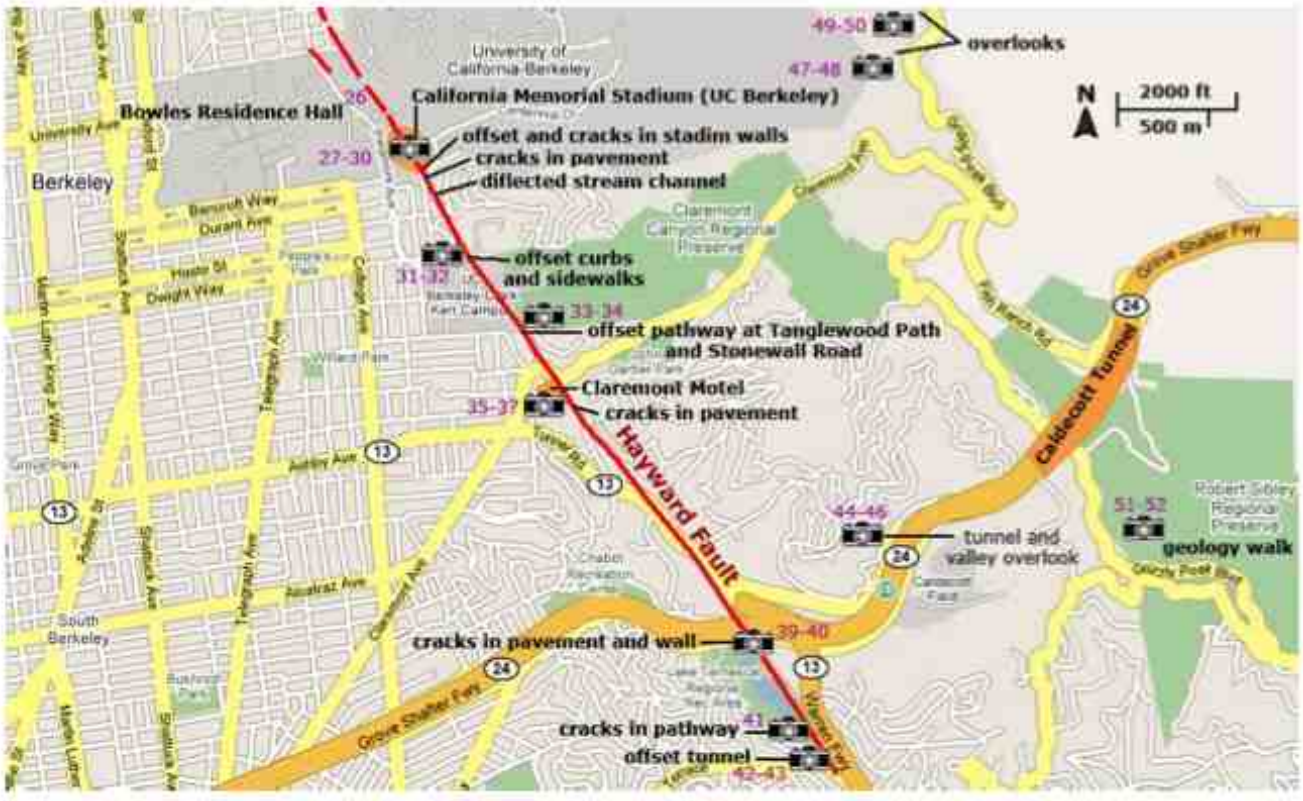
in the picture below.

Offset curb at Prospect St and Rose St downtown Hayward showing right-lateral displacement from Stoffer 2008.

Oakland:

In Oakland we have more of the Hayward Fault to explore, then we will go to Mt Sibley Volcanic Preserve. As I have already discussed the OFR 1135 Field trip guide on the Hayward fault, I will not repeat it here. Mt Sibley Volcanic Preserve is the remnant of a volcano that formed about 10mya via a rupture in the San Andreas Fault system, allowing magma to well up and form a volcano. The peaks of Round Top Hill are the volcanic stock remnants, where the magma flowed through to the surface. As we walk through Sibley Park, we will see mudstone, sandstone and conglomerates as well as the stocks once we get to Round Top Hill.

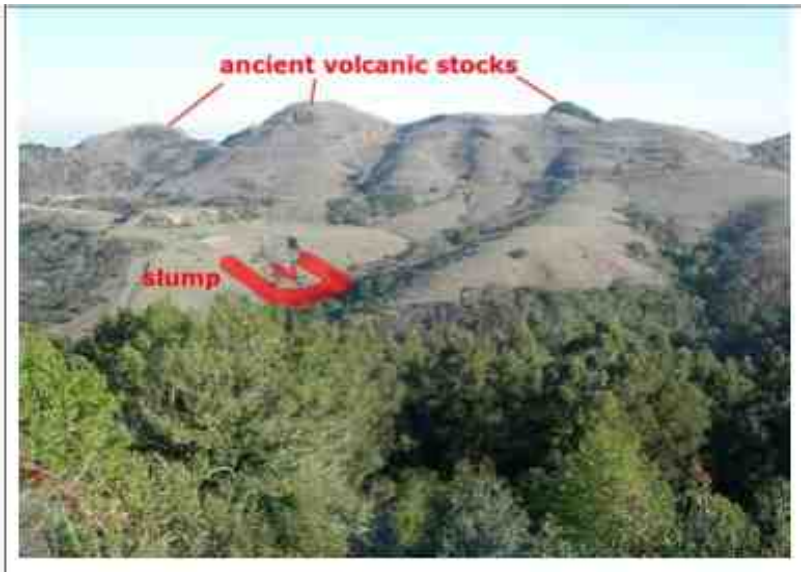
For the Oakland Fault walk, we will be on and around the campus of the university of California Berkeley. The campus stadium straddles the Hayward fault line, as does much of the campus. The map below, again from USGS OFR 1135, show the stops and what we will be looking at at each stop around the UC campus.





Offset of rim wall of California Memorial Stadium from Hayward fault, section KK, Row 64 offset of 7” between seats 22 and 23 from Stoffer 2008.

At Mount Sibley, we will hike the trail to Round Top Hill and stop to look at the sedimentary rocks mentioned above, and then to the Hill itself to observe the rocks of the volcanic stock. Below is a picture showing Round Top Hill, and in the forefront a slump off of the hills.



Mount Sibley Volcanic Preserve, Round Top Hill- the remains of ancient volcanic stocks from Stoffer 2008.

Before we leave Mt Sibley we will again take temperature and humidity readings with the sling psychrometer, and wind speed with the anemometer. Compare to Newark and Hayward readings. Was there a significant difference in temperature? Humidity? The temperatures will have gotten warmer as we moved inland from Newark to Oakland, partially because we moved inland, and partially because readings were taken at three different times of day. The humidity should be about the same for each of these areas, about 35%. Winds would have been higher and cooler at Newark, then less in Hayward, and even less in Oakland, due to moving inland and a lessening of the sea breeze from the Bay.

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Day 7

Almaden Quicksilver Mines and museum

| Time | activity/location |
|---|---|
| 7:30-8:15am | Drive to Almaden Mines |
| 8:15-8:30am | Weather observations |
| 8:30-11:00am (lunch 11:00-11:30) | Tour Almaden Mining Museum (sack lunch) |
| 11:30-3:00pm | Hike Almaden trails to observe geology |
| 3:00-3:30pm | Weather observations and discussion |
| 3:30-4:15pm | Drive to hotel |
| 4:30-6:15 | debrief/post field trip wrap up |
| 6:30-7:30pm | Dinner |
| After 7:30pm | Pack and get ready for departure tomorrow |

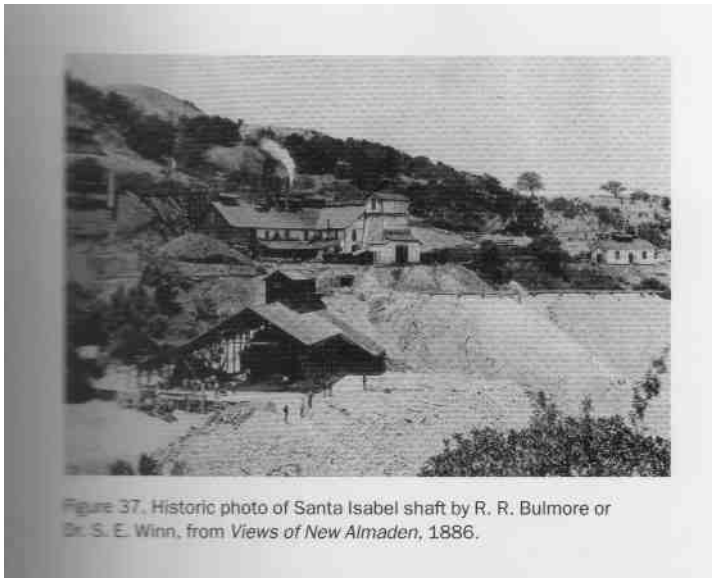
Almaden Quicksilver Mines were in operation from the mid 1800's through1981, and was one of the most profitable Mercury mine. Cinnabar, mercury ore, would be removed from the mines then heated in furnaces to remove the mercury. The processed ores, calcines, were dumped near the processing area. The calcines still contained some mercury, so they contaminated the soils nearby.

The mercury mining was so profitable because of the use of mercury in gold mining. Mercury was introduced into the system in trying to amalgamate the mercury to the gold, helping to extract gold from the rock in hydraulic mining. As the hydraulic mining used pressurized water, some of the mercury would be washed downstream during the process, contaminating the downstream waterways and sediments.

When Alamden Quicksilver Mines was converted to a park, cleanup had to take place first. Much of the mining equipment was removed, and tailings were removed. The water sediments still contain mercury, but the water itself is ok. Currently the Almaden Park has a Mining Museum, that shows the history of the active mining that took place on site, as well as some of the minim buildings and equipment to view. The Park also has many hiking trails in which you can see some of the mines (not accessible to enter the shafts) and mining equipment. We will tour both the museum and then hike the trails in this park today.

First upon arrival we will take temperature and humidity readings with the sling psychrometer, and wind speed with the anemometer.

We will first take the Guided tour of the Museum, taking us through a mine diorama showing us what the mine conditions were like, we will also view the technological advances in mining that occurred throughout the mine's history. We will get to see some of the equipment, and historical photos of the mine when it was in operation.



Historic photo of Santa Isabel Shaft from Sloan, 2006.

Once we are done in the Museum, we will head to the Park trails. On the trails we will see remnants of the mining area, remaining mining tools and buildings, and the closed shafts to the mines. We will also get to see how the land has recovered since the cleanup of the mining contaminants. Once cleanup was completed, native plants started to recover. We can do more ecological studies her of natives versus invasive species, and compare the numbers at the end of the day.

As mercury is naturally occurring in the Coast Ranges, much of the soils in the area also have trace mercury. Many of the native plants are able to tolerate the trace amounts. However, fish, birds and humans are all susceptible to long term accumulation of mercury in our systems. This is why we should not eat too much fish that may be contaminated with mercury, or play with the cool looking silver liquid.

Before we leave we take temperature and humidity readings again with the sling psychrometer, and wind speed with the anemometer. Compare to morning readings. Was there a significant difference in temperature? Humidity? The temperatures were cooler in the morning than in late afternoon. The humidity would remain relatively constant throughout the day. We should experience some form of land breeze coming from the higher hills down through the Almaden Park toward the San Francisco Bay due to the cooler mountain tops.

Before dinner, we will have a post field trip wrap up in the conference room of the hotel. This will consist of summarizing the Geosciences of the Bay Area by the students, and questions about further study by the students.

Day 8:
Departure day.

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References


Alpers, C.N. And Hunerlach, M.P. (2000). *Mercury Contamination from Historic Gold Mining in California.* USGS Fact Sheet FS-061-00.

Alt, D, & Hyndman, D.W. (2000). *Roadside Geology of Northern and Central California*. Missoula, Montana: Mountain Pr.

Brabb, E.E., Maddock, M.E, and Wallace, R.E. (1969) *Guide to San Andreas Fault from San Francisco to Hollister.* Field Trip C, Bulletin 190 California Division of Mines and Geology.

Calero Reservoir County Park information retrieved July 15, 2011from: http://www.sccgov.org/portal/site/parks/parksarticle?path=%252Fv7%252FParks%2520and%2520Recreation%252C%2520Department%2520of%2520%2528DEP%2529&contentId=3b4598ba77784010VgnVCM10000048dc4a92

Department of Toxic Substances Control (2006). Changes to the Cleanup Plan at the Almaden Quicksilver County Park is Available for Review and Comment. Fact Sheet .

DiLeonardo, C. (2011). *Written in Stone: Lessons from the Field for the Earth Science Classroom*. Marin Headlands Field Trip, March 10, 2011 National Science Teachers Association Annual Meeting 2011 San Francisco. (handout and personal notes taken during field trip)

Elkhorn Slough Information Retrieved July 1, 2011 from: http://www.elkhornslough.org/esnerr/index.htm

Estuaries 101 Curriculum retrieved July 1, 2011 from: http://www.estuaries.gov/GetInvolved/Default.aspx?id=117

Harden, D.R. (2003). *California Geology 2nd Edition.* New Jersey: Prentice Hall

Hill, H. *Point Lobos State Natural Reserve – The Great Kelp Forest*. *Point Lobos State Natural Reserve*. Retrieved May 20, 2011, from http://pt-lobos.parks.state.ca.us/Kelp.html

Invasive species information retrieved on June 15, 2011 from http://stopwaste.org/home/index.asp?page=416

Johnson, R.C, & Lofstrom, D. (2004). *Geology Trails of Northern California*. Baldwin Park, CA: Gem Guides Book Co.

Keith, S. (2005). *Pinnacles National Monument*. Western National Parks Association.

McPhee, J. (1999). *Assembling California*. New York: Farrar, Straus and Giroux.

Opal Cliffs information retrieved July 5, 2011 from: http://www.beachcalifornia.com/opalclif.html

Salt mining information retrieved on June 15, 2011 from http://www.cargill.com/cs/sf_bay/

Sand Dune information retrieved on July 1, 2011 from:

http://www.mtycounty.com/mbs_pgs/BchDune.html

Santa Cruz Sate Beach information retrieved July 1, 2011 from:
http://www.santacruzstateparks.org/parks/natbridges/

Sloan, D. (2006). *Geology of the San Francisco Bay Region*. London, England: Univ of California Pr.

Stoffer, P.W., 2008, *Where's the Hayward Fault? A Green Guide to the Fault*: U.S. Geological Survey Open-File Report 2008-1135, 88p.

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