Faults, Fossils, Fronts, Fire & Ice:

Central California & Western Nevada 7- Day Geoscience Field Trip Guide

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Introduction

Tur-where? Several Good Reasons to Explore Central California and Nevada from the "Dry Lake".

From the viewpoint of an uninitiated geoscientist or layperson, Turlock, California is a rather bland and uneventful place. Its location smack-dab in the middle of the Great Central Valley, one of the least topographically varied regions in the entire world, has contributed to the teenage angst-ridden perception that Turlock, a town of just over 70,000 residents, is the most boring place on the face of the planet. Indeed, Turlock is flat, dry, hot and hazy in the summer with little in the way of amusement venues. Winter isn't much better; occasional rains dampen the ground just enough to create a seemingly unending thickness of Tule Fog that can dampen even the most optimistic spirits. Turlock experiences virtually no severe weather, has no beaches, no ocean, no mountains and even the night skies leave a lot to be desired. Turlock, on paper at least, seems utterly un-Californian and gives good cause for the local teenagers to wallow in their murky mental anguish.

This field guide, however, aspires to take advantage of Turlock's rather bland offerings by highlighting a mantra that many Turlock teenagers deprived of a valid driver's license tend to overlook, but those with means of driving have known about for over a century: location is everything. Turlock's location in the Great Central Valley (atop a heap of awesomely-thick forearc basin sediments) is perfect for exploring many stunning geoscientifically-rich locales literally just miles away.

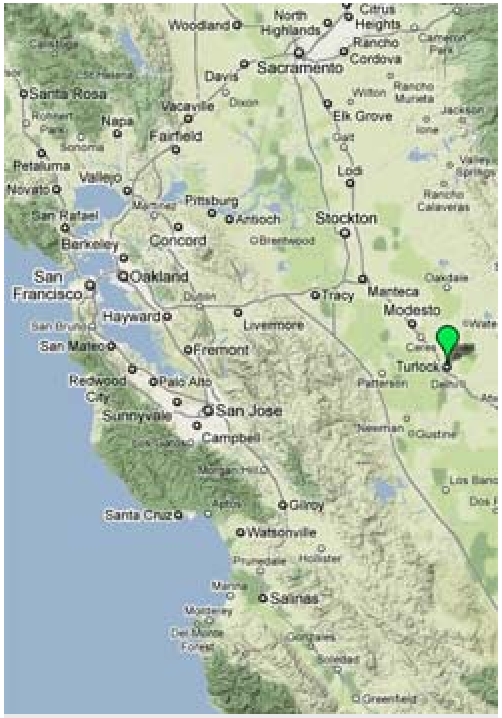


Figure 2 - Turlock, CA - Smack dab in the middle of everywhere.

Figure 1- Half Dome as seen from Turlock (Photo by Tony Immoos)

Thirty miles to the west of town lie the California Coast Ranges, which include peaks ruggedly jutting over 3000' above sea level. Another ten miles beyond the Coast Range lies the San Andreas Fault system with the indescribably beautiful Pacific Ocean lapping at rocks once found hundreds of miles to the south. Thirty miles to the east of Turlock, in the Sierra Foothills, lay the westernmost remnants of what used to be the North American continental shelf. It has since been accreted, uplifted, fractured and hydrothermally intruded by some of the world's richest gold-bearing veins that led to the settlement and acquisition of the State of California. Beyond the foothills, only sixty miles from Turlock, lies the heart of the Sierra Nevada, offering an oasis of alpine scenery and textbook examples of glaciation, not to mention impressive summer thunderstorms and winter snow accumulations. So close are the Sierras to Turlock that Yosemite's Half Dome can be seen from the outskirts of town on a clear, high pressure winter's day. To the north of Turlock less than an hour's drive away is the Sacramento- San Joaquin Delta, the world's largest example of an inverted river delta. Far beyond the delta another 180 miles north lies the southern extent of the Cascade Range, evidenced by Mount Shasta, a looming composite volcano.

While Turlock Proper might not offer the best roadside geoscience, it's proximity to many such sites makes the town a great base camp for deciphering the geologic and climatologic past of the Golden and Silver states. This field guide will take the reader to many of the areas mentioned above, and even venture into the oft-forgotten, yet equally spectacular, Basin and Range Province of Nevada. For those angst-ridden teens unable to drive, this guide will give them something to look forward to when they can. For those who can drive and are in possession of this guide, please continue reading for instructions and tips on how to conveniently and successfully complete the trip. And then, by all means have fun exploring!

Guide Set-up.

The intent of this guide was to create a fun-filled, scenic and geoscientifically-comprehensive seven day road trip accessible to anyone for free from the author's website, www.mrhollsiter.com. The fully described stops are written in a book-like manner so that anyone with the slightest background in the geosciences will be able to understand and appreciate the significance of each area visited. The landscape orientation of the pages was used to allow for spiral binding should the reader feel inclined to print a physical copy of the guide. Spiral binding allows easy front-to back reading and also stores much better than a traditionally bound book.

The trip is very adventurous and there will be an average of two to three miles of walking or hiking each day. It is important to keep time spent outside the vehicle much higher than time spent in the vehicle for maximum enjoyment of the trip. Rest assured, the trip may seem long, but each day is feasible and has been completed by the author to no ill effect.

To prevent the reader from being victimized in the middle of a desert or high atop a mountain pass by a poorly written and described field guide, complete detailed driving directions and GPS coordinates have been included for this action-packed (some may say rigorous) loop adventure. Below is an outlined itinerary of the trip which begins and ends at the San Jose International Airport in San Jose, California. Trip suggestions will follow the outline. The detailed trip descriptions begin on page (*).

* **Please note, that unless otherwise specified, all photos within the guide are property of the author, Ryan J Hollister***

Central California and Western Nevada Geoscience Field Guide Stops Itinerary

Figure 3- Map of field guide stops, starting in Watsonville and heading West to East. Color Coded by Day.

Day 0 - Flight to San Jose.

Take airport shuttle or rental car to Watsonville for first night. Large filed trip groups would meet at airport and drive to Watsonville together.

Day 1 - Watsonville to Mariposa

- Oceanography of Monterey Bay & Vicinity.
- San Andreas Fault System and visible offset.
- Origins of California Coast Ranges.
- California's water woes and environmental impacts of water shipments.
- Fairmead fossil assemblage – the largest late Pleistocene fossil bed in North America.
- Gold dredging remnants – environmental and economic impacts.
- Quartz crystal hunt.

Day 2 - Mariposa to Yosemite (Curry Village)

- California State Mining & Mineral Museum.
- Mariposa Museum and stamp mill.
- Bear Creek slates and pillow basalts.
- Ferguson Rock Slide.
- 1997 Merced River Flooding Damage.
- Elephant Rock Rockfall.
- Tunnel View.
- Taft Point Fissures hike.
- Glacier/Washburn Point stroll.
- Bridalveil Falls & moraine.
- Curry Village Camp.

Day 3 - Curry Village to Lee Vining via Yosemite High Country

- Crane Flat (possible bear sightings)
- Olmstead Point Overlook of Yosemite Valley.
- Tuolumne Meadows formation and ecology (Yosemite high country).
- Lembert Dome roche moutonnee.
- 20-Lakes Basin roof pendant & glaciation hike.
- Lee Vining Canyon overlook of glacial valley and Eastern Sierra escarpment.
- Dinner at Whoa Nellie Deli.
- Lodging at Lee Vining.
- Chalfont pumice mine.
- Ancient Bristlecone forest.
- Poleta Folds, desert erosional features.
- Lida alluvial fans.
- Check-in to Ramada Tonopah.
- Star party in desert.

Day 4 - Lee Vining to Tonopah, NV - Basin & Range Exploration

- Mono Lake Visitor Center and South Tufa.
- Panum Crater hike.
- Obsidian Dome sample collections.
- Convict Lake.
- Long Valley Caldera overlook.
- Bishop Tuff/ Sherwin till roadcut.

Day 5 - Tonopah to Fallon via Big Smoky Valley.

- Manhattan historic mining district & ghost town.
- East Manhattan mining district and geologic map deciphering.
- Round Mountain Mine tour (open-pit gold and silver mine).
- Kingston Canyon traverse, caldera complexes and Lahontan trout.
- Reese River plain.
- Iron Mountain plug dome.
- Carroll Summit and Desatoya Tuff.
- Sand Mountain dunes.
- Grimes Point Petroglyphs.
- Lodging in Fallon.

Day 6 - Fallon to South Lake Tahoe

- Soda Lake maar / Carson Sink.
- Lahontan Reservoir & Pleistocene Lake Lahontan.
- Virginia City & the Comstock Lode.
- Lake Tahoe vista.
- Taylor Creek visitor center and stream profile.
- 2007 Angora Ridge Fire & Fallen Leaf Lake submerged trees/ drought implications.
- Eagle Falls and Eagle Lake Hike
- Lodging in South Lake Tahoe

Day 7 - South Lake Tahoe to San Jose

- Carson Pass lahars and paleo-canyons.
- Black Chasm National Monument limestone caverns with helictites.
- Kennedy Mine tailings wheel & impoundment dam.
- Sutter Mine underground gold tour.
- Ione Formation overview and samples.
- Rancho Seco decommissioned nuclear power plant.
- Inverted Delta, tracts and levees.
- Black Diamond historic coal mine.
- End at San Jose with lodging near airport.

Day 8 - Fly home.

Trip Suggestions & Accommodations

Gear -

This route traverses varied terrains, elevations and climates and is intended for SUMMER travel only and preferably between July and September. Many of the mountain passes traveled on this trip are buried under tens of feet of snow the majority of the year. Accordingly the participant should be prepared for possible overnight lows into the low 40's and highs over 100°F. Most days participants will be comfortable wearing shorts, a short sleeve shirt and broad-billed hat, but unpredictable sierra tempests bring the possibility of drenching rains and hail which make a waterproof lightweight jacket a necessity. Pants and a sweatshirt may be desirable during two occasions: the star party when nightly desert temperatures rapidly cool, and during the 20 Lakes Basin hike which is at 10,000' of altitude *and* can be full of mosquitoes several weeks after snow melt. Otherwise, a week's worth of clothes are suggested as laundry facilities aren't readily available mid-trip in Nevada. For the hikes, sturdy trails shoes or boots and a small daypack with hydration bladder or water bottles is a must. The daypack will be used to store your water, extra layers, notebook, camera snacks and sometimes lunch. The easternmost part of the trip is very dry, and it is suggested participants drink three to four liters of water per day during that time.

Food -

Breakfast will be continental style at most hotels along the way, otherwise there will be local cafés or diners. Lunch will be picked-up as we go, except during our 3rd, 4th and 5th days during which lunch will need to be bought in the morning and packed in an ice chest prior to departure. Snacks should always be on hand just in case the munchies strike when least expected. Snacks are also great to have on the hikes to help sustain energy and enthusiasm levels. Dinners will be at restaurants within the towns of lodging. And just because this can't be stated enough, water bottles or bladders are a must to stay hydrated. Sodas during the day will only exacerbate dehydration.

Lodging-

In the age of Priceline.com and Google search, motel accommodations can be easily found and reservations made several days prior to leaving the trip. Hotels in each city range from truck stops to high-end resorts (except in Tonopah) so finding a room to fit your comfort level is as easy as reading a few online reviews. For a group field study, Yosemite lodging will be at the Curry Village tent cabins.

Vehicle Clearance -

The trip takes several long, but good, dirt & gravel roads in Nevada and thus it is advisable to drive a vehicle that has reasonably high clearance and good tires. Vans with a truck chassis or any SUV will suffice for the roads specifically listed on the trip. Should one feel adventurous, there are many side roads along the Nevada portion that require four wheel drive to explore. The rewards, including fossils and hot springs, are well worth the bumpy ride.

Tour Reservations -

Several stops within the trip include tours of various mines and caverns and will require prior contact with those companies and concessionaires to assure your spots on the tour. The Round Mountain Mine in Nevada will require the most advanced notice as tours are only given to those who inquire ahead of time. Also of note is that Black Chasm and Sutter Gold mine charge a $14.75 fee for their tours. Yosemite National Park also charges a $20 entrance fee. Below is the contact information for the tours.

Round Mountain Mine, NV - (775)-377-3162

Black Chasm National Natural Landmark; Volcano, CA - (866)-762-2837

Sutter Gold Mine; Jackson, CA - (866)-762-2837 [same concessionaire as Black Chasm]

Geoscience Relevance of Turlock, California.

While the field guide has been written to be the main descriptor of geoscientific phenomena found within central California, Turlock must be given special attention as it is the author's hometown. While there may be some redundancy found in the daily field guide, the information below should provide a bit of background on Turlock before departing on the field study.

Geologic Setting of Turlock

Turlock is situated within one the most topographically featureless regions in the entire world: the Great Central Valley (Figure 4). The valley stretches over 400 miles from north to south yet only attains a maximum altitude of 400 feet at its southern-most terminus near Bakersfield. The Great Central Valley averages nearly fifty miles in width and is bounded by the Coast Ranges to the west and the Sierra Nevada to the east. Turlock's geology isn't nearly as obvious as the marvelous features that surround the area, yet it has played a role much larger in human society than any other dirt known to man.

Farmers were the first to appreciate the soils of the fertile Central Valley (Figure 5). Positioned between the Tuolumne, Merced and San Joaquin rivers, frequent spring floods from Sierra snowmelt brought immense amounts of eroded sediments from upon high into the river system. As the rivers lost velocity in the broad and flat valley flood plains, their sediment-rich lode was deposited. The soils were so rich that virtually anything planted would grow (with enough water). Water was, however, in short supply due to Turlock's semi-arid steppe climate and a mere twelve inches of annual precipitation. Ironically, the search for more water to irrigate the soils yielded a far better understanding of the rather amazing subsurface geology under the city.

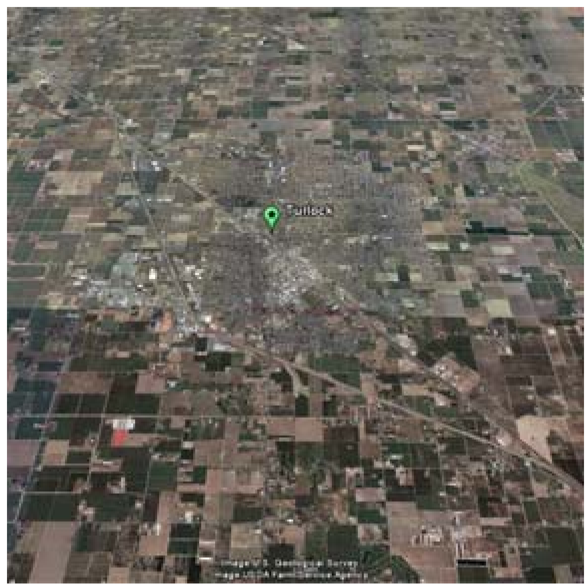


Figure 5 - Oblique aerial view of Turlock and surrounding farm lands. (Google Earth)

Figure 4 - Great Central Valley from space. (www.greatvalley.org)

Through hundreds of monitoring well core samples, geologists began piecing together evidence that the sediment thicknesses were vast. Easily observable in the cores were formations of glacial outwash from the Cenozoic glaciations in the Sierras that dipped gently from east to west (figure 7). Below the Cenozoic formations of alluvium are tremendously thick (800') layers of volcanic sediments of that also share a west-trending dip (TGBM Report, 2008). It wasn't until further study was done throughout the entire Great Central Valley that the layers of sediments were correlated and their extent realized. Following the mapped dip of the sediments, it can be derived that Turlock sits atop over 15,000 feet of sediments (figure 6)!

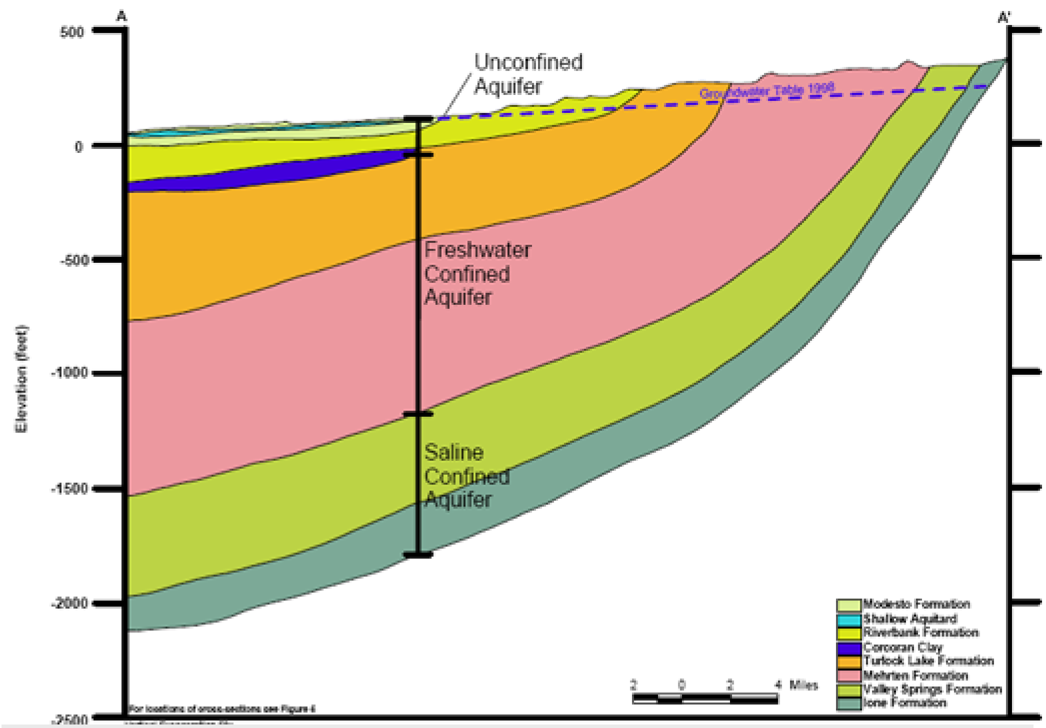


Figure 6 - Moderate depth geologic cross section of northern Turlock acquired from well samples. *(from 2008 Turlock Groundwater Basin Management Report)*

How could such a large amount of sediment accumulate? Today it is understood that what is now the Great Central Valley was once a great forearc basin during the Jurassic and Cretaceous, which bordered the ancestral Sierran Arc along the subduction between the oceanic Farallon Plate and the North American Continent (figure 8). The sediments continued to accumulate as the basin subsided from isostasy and further subduction along the plate boundary. The field study will present many outcrops of uplifted regions of the accretionary wedge, forearc basin, and accreted terranes to the east.

During Cenozoic time subduction ceased when the Farallon plate was completely consumed, causing a transform boundary to form at the new contact of the Pacific & North American Plates. For reasons still not fully understood, the transform boundary (San Andreas) jumped to the west of the forearc basin to its present day position. The slight oblique motions of the ancient San Andreas caused the Central Valley to completely rise above sea level nearly two million years ago while at the same time uplifting the California Coast Ranges (Harden, 1997). Between 1 million and 600,000 years ago the rising Coast Ranges

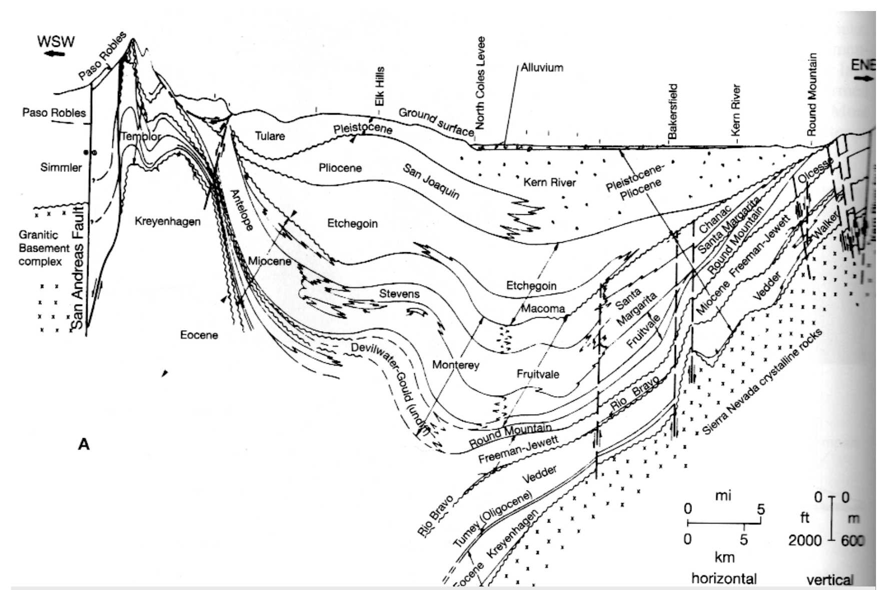


Figure 7 - Simplified complete geologic cross section of Great Central Valley near Bakersfield, 100 miles south of Turlock. (*Harden, 1997***)**

completely severed a drainage link between the Great Valley and the Pacific Ocean, creating the massive Lake Clyde (figure 9) as evidenced by a uniform layer of the thick (150') Cocoran Clay. In Turlock, the clay acts as a shallow aquitard allowing early farmers easy access to shallow water supplies which have since been over-utilized. Finally, by about 400,000 years ago, drainage of Lake Clyde occurred near the present day San Francisco Bay leaving behind the large flood plains for the Sacramento and San Joaquin Rivers that are currently visible (Harden, 1997). Interestingly, "Turlock" the word is thought to be an English corruption of the Irish or Scotch "turlough" which means "dry lake". The city founders couldn't have been more prescient.

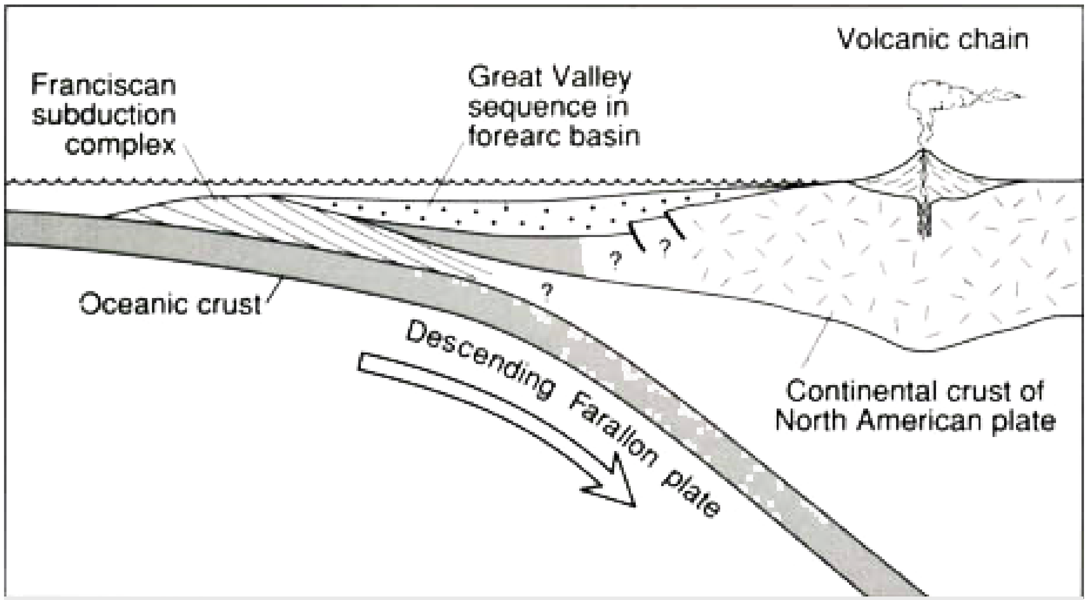


Figure 9 - Late Mesozoic Great Central Valley forearc basin schematic. (*Berlin, 2005*)

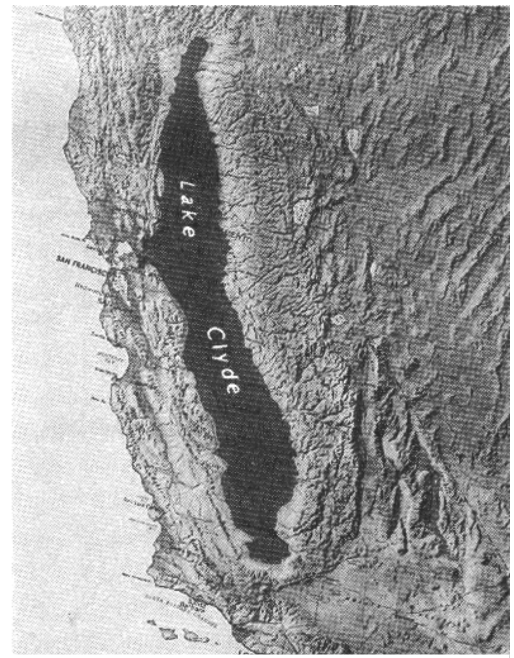


Figure 8 - Maximum extent of Lake Clyde based on Cocoran Clay deposits. (Harden, 1997)

Climatology & Meteorology of Turlock

Turlock's climate is classified as a semi-arid steppe under the Modified Köppen Climate Classification System (figure 10). The warm, dry summers and mild wet winter season have helped Turlock and Stanislaus County become one of the richest agricultural production areas in the world. In 2009 nearly one million acres surrounding Turlock were being farmed, taking advantage of the climate and rich soils to produce $1.27 billion in tree, fruit and vegetable crops. Turlock's climate is moderately influenced by its proximity to the Pacific Ocean, Coast Range rain shadow and the Central Valley's basin-like shape.

During the long, hot, and dry late spring and summer months, a strong high pressure center develops over the cool waters of the Pacific (known as the Pacific High), limiting storm development and pushing the jet stream far to the north of Turlock. Separated from the immediate temperature control of the ocean by the Coast Ranges, Turlock warms to an average daily high of 95°F during July and August, creating an area of localized low pressure. The pressure gradient eventually becomes strong enough at the end of the day to create a local variant of a sea breeze known as the Delta Breeze. Instead of the cool, damp air pushing directly across the valley, the breeze is funneled through a narrow gap in the Coast Ranges where the Sacrament-San Joaquin delta meets the San Francisco Bay. After shooting the gap, the air spreads across the delta region providing a cooling, southwesterly flow for points north of the gap and a cooling, northwesterly flow for Turlock and all points south of the gap (Figure 11). The Delta Breeze brings rapid relief to the day's heat and accounts for much of the cooling associated with Turlock's summer 30°F diurnal temperature variations.

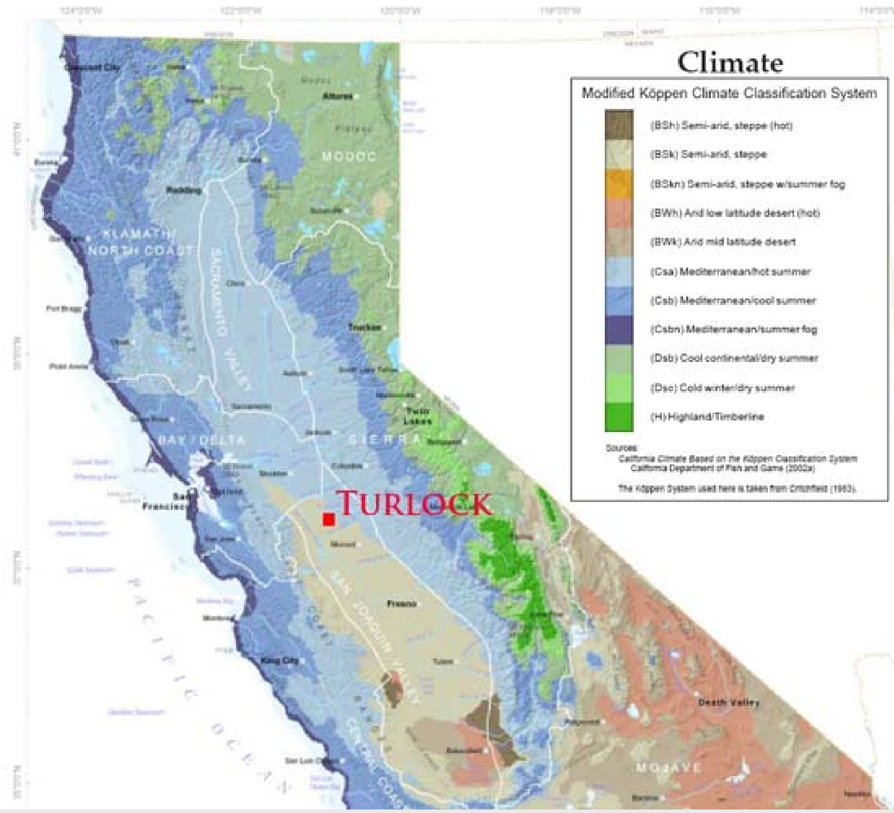


Figure 10 - Modified Koppen Climate of Central and Northern California, including Turlock. (*California Dept of Fish & Game*)

The Delta Breeze can create air quality havoc in the summer. The cool, humid and dense air will sit in the Great Valley basin and actually prevent the valley floor from warming as quickly as surrounding elevated land on the east slopes of the Coast Range and western slopes of the Sierra foothills. Because of the unequal heating, a temperature inversion of warmer air lying over cooler air is created and prevents vertical convection from occurring. Pollution from vehicles and power plants within the valley and San Francisco Bay Area remain trapped under the inversion during the day and react with the sun to create photochemical smog. The smog contributes to Turlock having the 15th worst air quality in the nation¸ the full ramifications of which will be discussed in the Environmental Geoscience section.

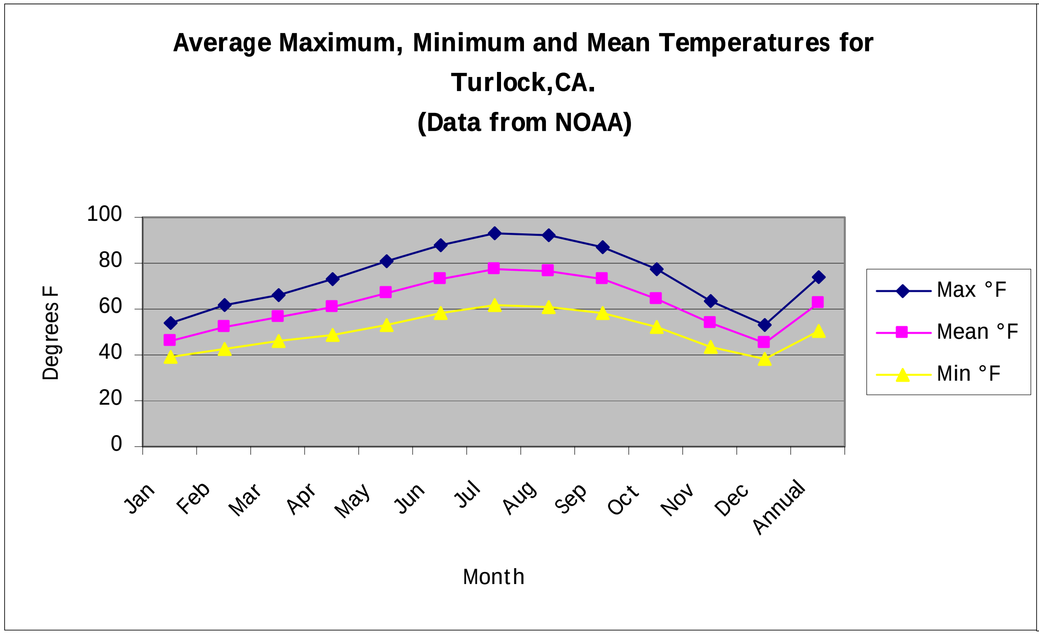
During the winter months, Turlock's weather is dependant on the Aleutian Low which develops in the relatively warm waters of the Gulf of Alaska. Because the Pacific High weakens as continental temperatures dip cyclones from the strongly developed Aleutian Low are allowed to drop far to the south along the jet stream, and bring with them substantial moisture to California. Turlock, being on the leeward side of the Coast Ranges, averages a mere 12 inches of precipitation annually, most of which falls during the rainy season between November and March. Half Moon Bay, a city directly west of Turlock on the Pacific Coast averages over 25 inches of precipitation a year illuminating the rain shadow effect of the Coast Ranges.

Figure 11 - Delta Breeze genesis.

Turlock's average winter temperatures hover near 45 F° with very little diurnal temperature variation. The lack of variation is due in part to the moderating effects of the Pacific, as well as the thick, sun-filtering radiation fog regionally known as Tule Fog. The fog forms during the rainy season when high pressure settles over California. Sinking cold mountain air along with nighttime surface radiation quickly chills the surrounding moist air to its dew point creating the Tule Fog, which usually decreases visibility to less than 1/8th of a mile and can blot out the sun for days on end (figure 12). Many adult valley residents can recall childhood experiences of literally not being able to see their outstretched hand in front of their face. Due to the expanding footprints of cities, urban heat islands have significantly reduced the ability of fog to form at low levels with city limits. Thick fogs that don't burn off during the day will trap infrared radiation in the evening preventing a severe loss of heat. Diurnal temperature variations during a thick fog may only range a few degrees.

Figure 12 – Tule Fog as seen from space. (Modified from *NASA VisibleEarth, 2005***)**

Spring and autumn are generally considered to be the best climates in Turlock as they tend to be an intermediate to the foggy winters and blazing summers. Daytime highs in the 70's and 80's, with lows in the high 40's and low 50's, allow residents to fully enjoy and take advantage of their city. Occasionally, extremely cold fronts will pass through warmer spring air, and create thunderstorms via frontal wedging. Residents of Tornado alley would most likely scoff at a Turlock thunderstorm, likening it to a mild drizzle. Mild and quick-moving as they may be, the storms provide Turlockers a rare glimpse of valley thunder and lightning, and have been known to bestow adrenaline rushes upon high school teenagers and teachers alike (figure 13).



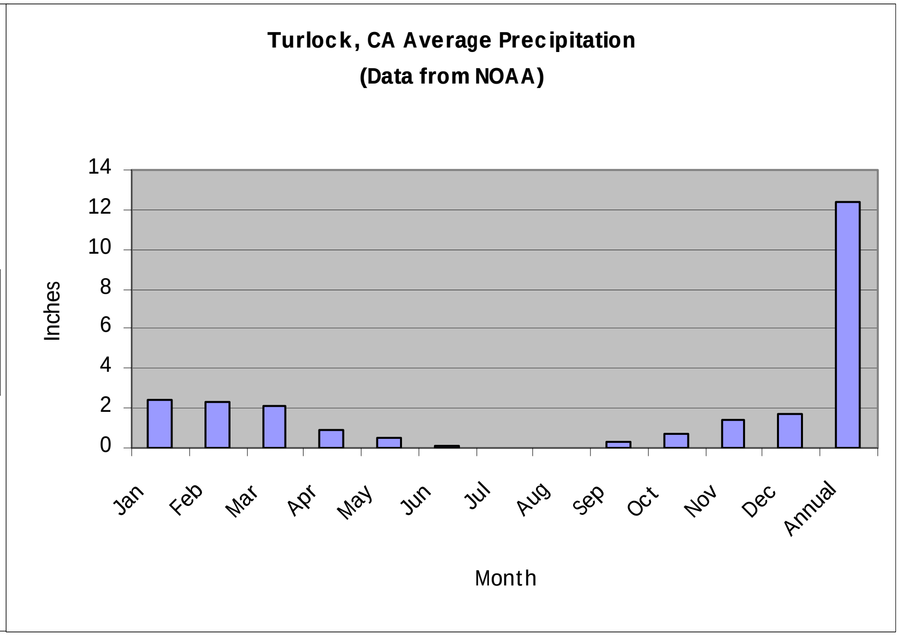


Figure 14 - Rare lightning in Turlock caused by frontal wedging.

Figure 13 - Rainbow shines through after a passing spring squall line flooded the track at the author's high school.

Environmental Geoscience Issues within Turlock

The three largest environmental issues surrounding the Turlock area revolve around best farming practices, water usage and atmospheric pollution. Water diversions, deliveries, and excess aquifer pumping are issues that will be covered in more detail at individual stops within the field guide. Briefly, The Turlock Irrigation District claimed water rights to the Tuolumne River in 1893 and has since built several diversion dams and reservoirs on the river to provide irrigation for large farms as well as hydroelectric power generation for the local energy grid. The diverted water flows have since wreaked havoc on native salmon and steelhead runs that once numbered in the hundreds of thousands and have now dwindled to a paltry several hundred (California Department of Fish and Game, 2010). Spawning gravel restoration and increased dam outflows are currently being used to encourage a return to large salmon populations within the river and to help lessen the salinity of the Delta downstream of the Tuolumne River's confluence with the San Joaquin River.

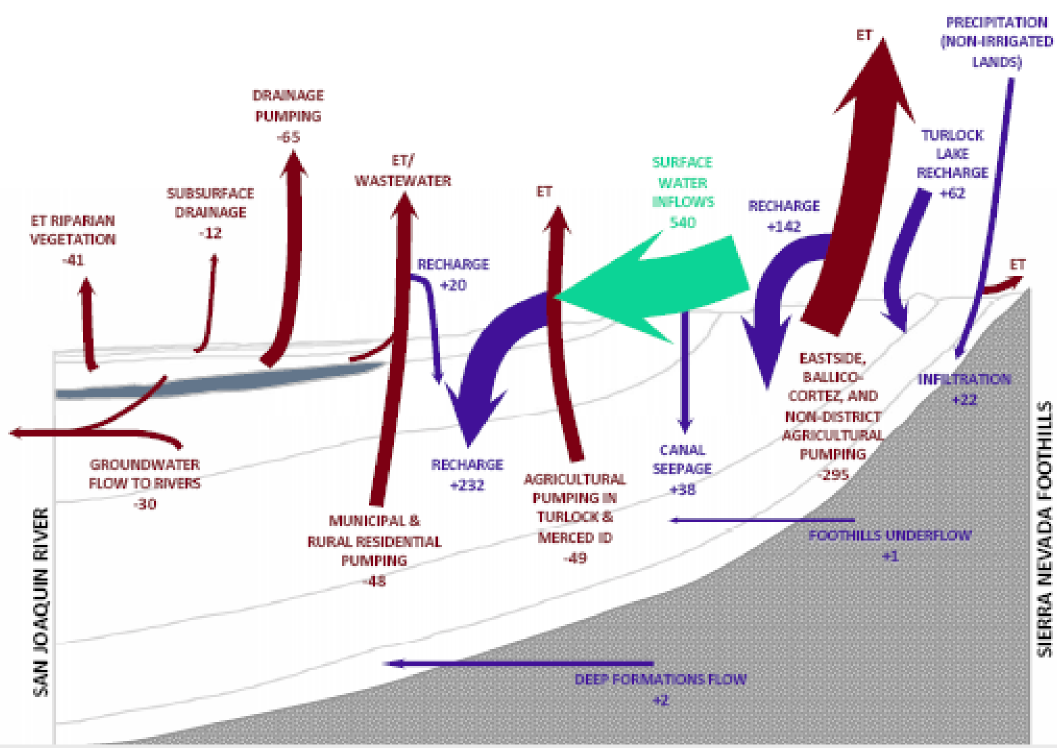


Figure 15 - Turlock Ground Basin's esitmated water budget 1997-2006 (*TGBM report, 2008)*

The majority of Turlock households rely on city-pumped well water from the Turlock Groundwater basin. Because Turlock's population has increased from a mere 18,000 in 1970 to a whopping 70,158 as of this writing, strain on the 542 square-mile aquifer has dramatically increased. Luckily a recharge rate of 520,000 acre feet per year still outpaces the 457,000 AF/yr pumping outflow (Turlock Groundwater Basin Management report, 2008). It should be noted, however, that over 300,000 AF/yr of recharge is attributable to irrigation infiltration from surface water sources, much of which is laden with pesticides and fertilizer excess (TGBM report, 2008). The Turlock Groundwater Basin managers clearly understand that the future will place more demands on the system and are looking for ways to conserve water within the basin and to prevent the severe ground

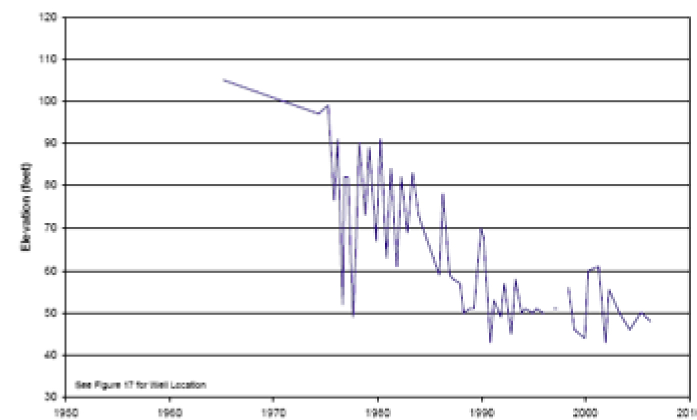


Figure 16 - Monitoring well water levels for well 05S11E25A001M. A sharp decline in aquifer levels is evident. (*TGBM report, 2008*)

subsidence seen elsewhere in the valley. So far the free market has played a large role in conservation. Increased costs of water delivery have persuaded many almond farms to convert from flood irrigation to sprinkler drip irrigation reducing the amount of water lost to evaporation.

As touched upon earlier in the climatology section, Turlock is surrounded by cities ranked in the top 15 nationally for worst air quality. The valley's summer inversion layer prevents circulation and acts as a sump for various combustion emissions and particulate pollution generated by local farms. The winter inversion layer traps particulates from wood-buring stoves also creating a large health hazard. In the American Lung Association's 2010 State of the Air study, Stanislaus County (of which Turlock is a part) had 51 days of unhealthy air for sensitive populations, 7 days of unhealthy air for all groups, and 2 very unhealthy air days. It should come as no surprise then that there are nearly 14,000 cases of pediatric asthma and over 30,000 cases of adult asthma in Stanislaus County's 510,000 residents. Asthma continues to be the number one reason for emergency room visits in the lower two thirds of the valley known as the San Joaquin Valley and it is also the number one cause for school absenteeism (McCabe, 2002).

Figure 17 - Photochemical smog and wildfire smoke captured by the ISS on November 2, 2003. (Modified from NASA's earthobservatory.gov)

To combat the atmospheric pollution, strict state-wide emission standards have been emplaced to reduce vehicle emissions and increase vehicle fuel efficiency and to implement "No Burn" days when a strong inversion layer exists (California Air Resources Board, 2010). Public education is also being used to combat the pollution through the use of "Spare the Air" and "No Burn" warnings broadcast across various mediums when the Air Quality Index (AQI) is forecast to reach unhealthy levels. During "Spare the Air" days valley residents are encouraged to not do any unnecessary driving or use excess amounts of power at home. The campaigns are working, as particulates and ozone levels are slightly decreasing, even with an increase of population (San Joaquin Valley Air Pollution District, 2009).

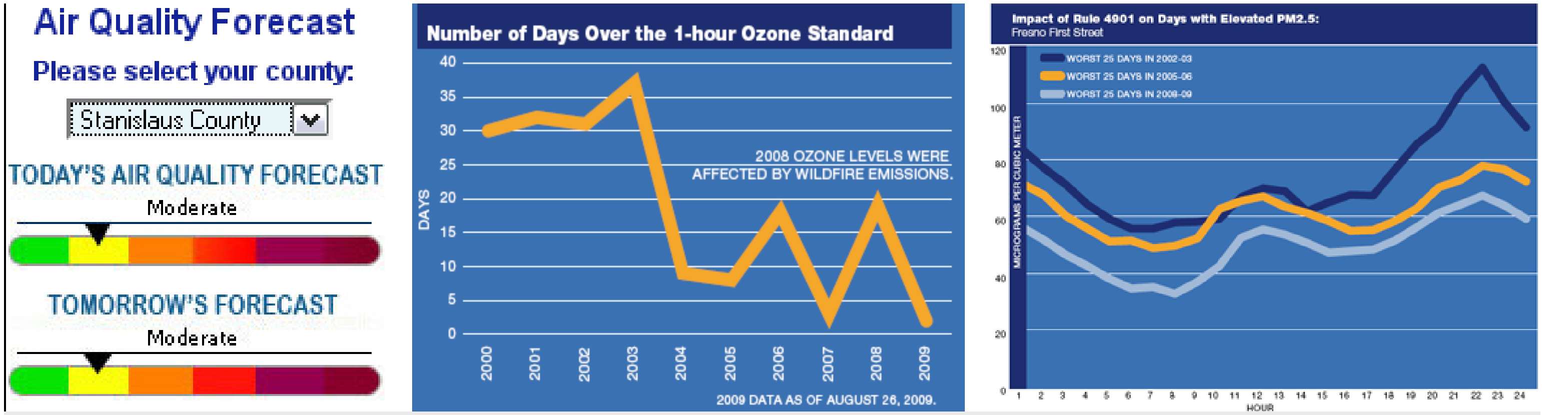


Figure 18 - Sample air quality forecast from SJV Air Pollution Control District's website and signs that air quality is improving.

Astronomy viewed from Turlock.

Because of the pollution during the summer, the night sky within Turlock is not as clear as it could be, still offers casual observers a peek at the universe. To better attain a view of the night sky during the summer it is highly suggested that one “run for the hills” to escape the light pollution and inversion layer of the valley. Generally a trip of less than 45 minutes is needed to attain decent view. Below are a series of guides created by Starry Night for the Turlock area. The charts will help those stargazing with the naked eye pick-out common northern hemisphere summer constellations. The grey band along the bottom of the images represents light pollution from cities to the north and south. Consult online planetary tables to find rise and set times of the planets before venturing out. The author also recommends purchasing a green laser to point out the constellations as well as the “Pocket Universe” App for the iPhone which allows the user to point the phone at a celestial object and have the phone identify the object.

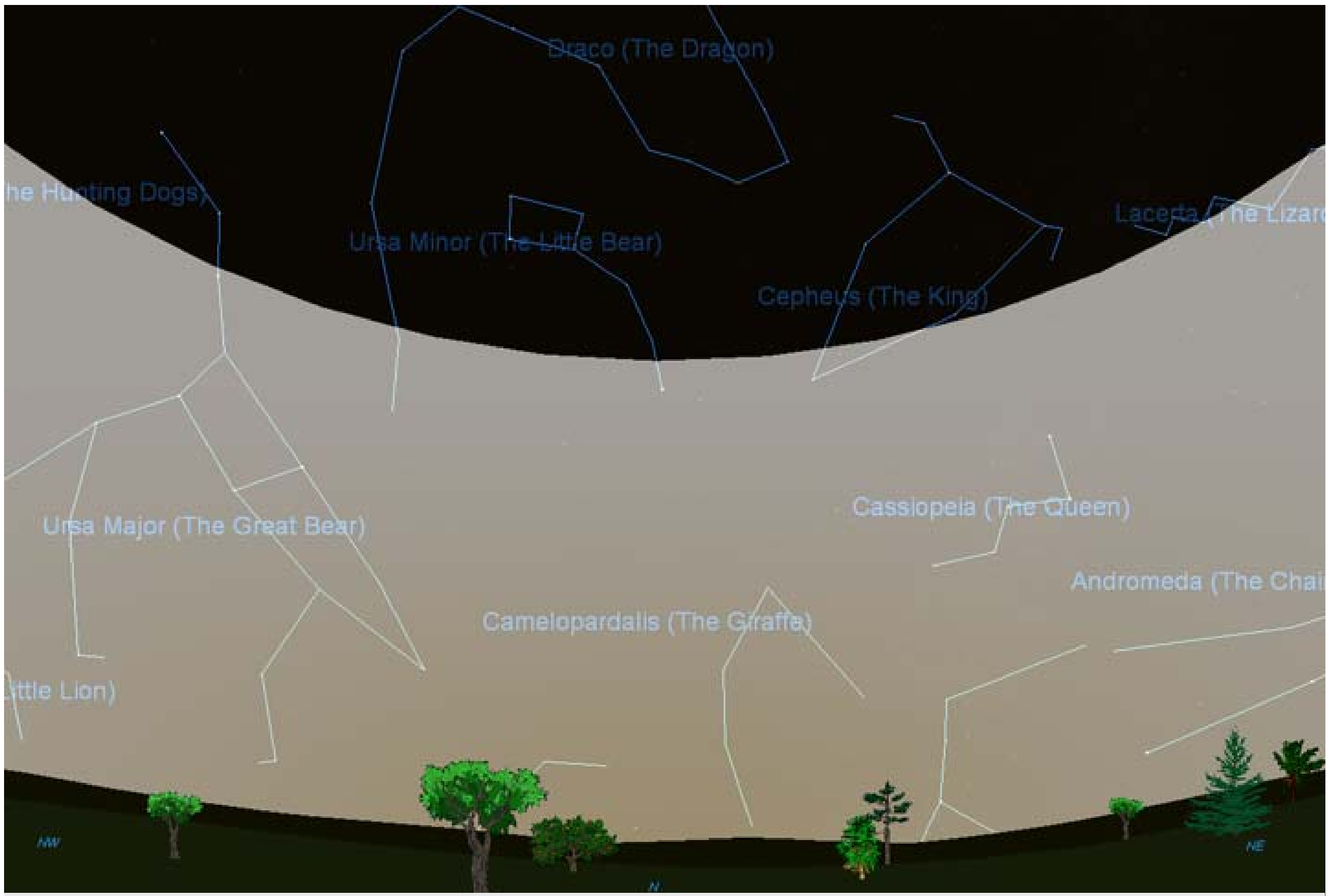


Figure 19 - View to the NORTH at 10pm (Starry Night)

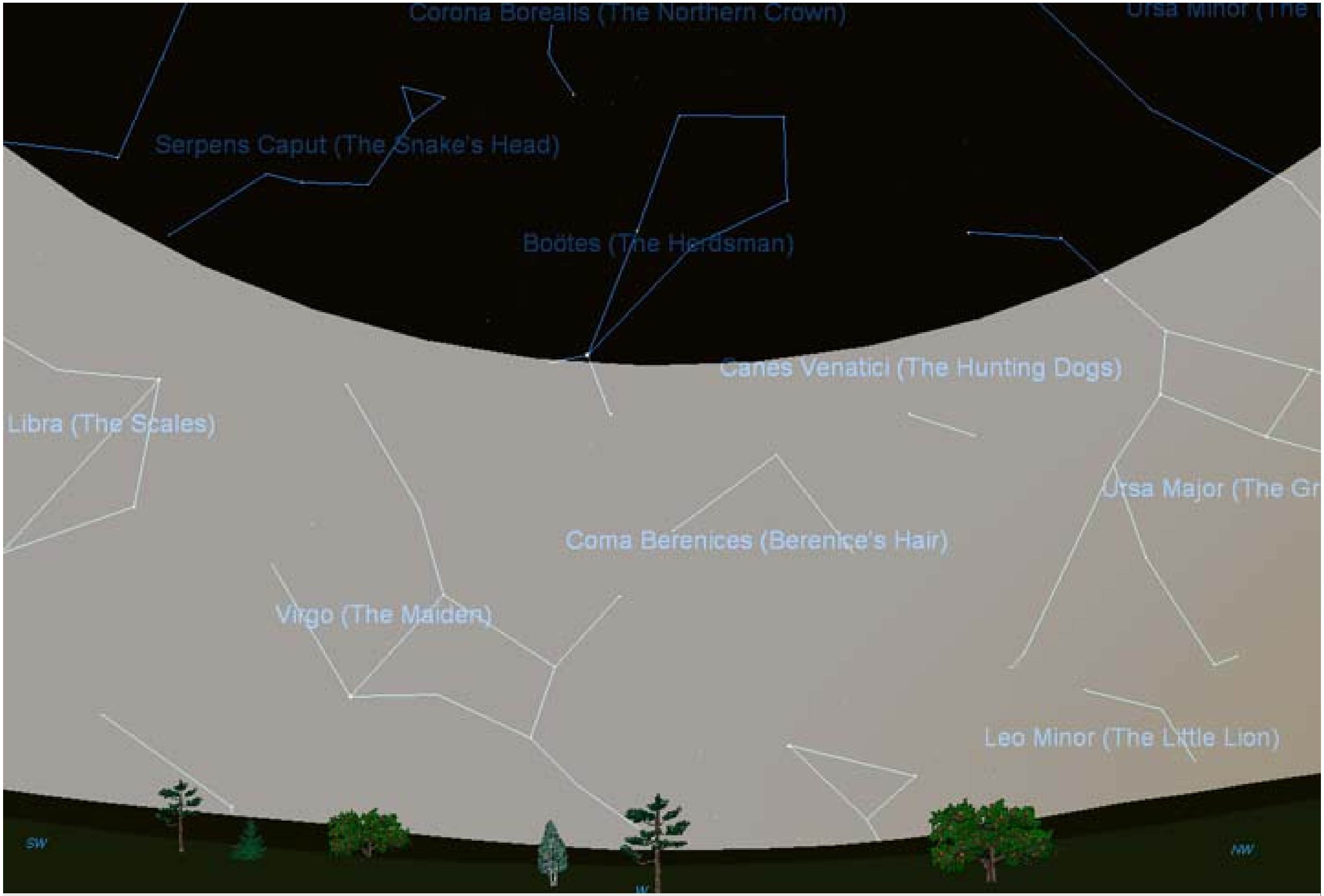


Figure 20 - View to the WEST at 10pm. (Starry Night)

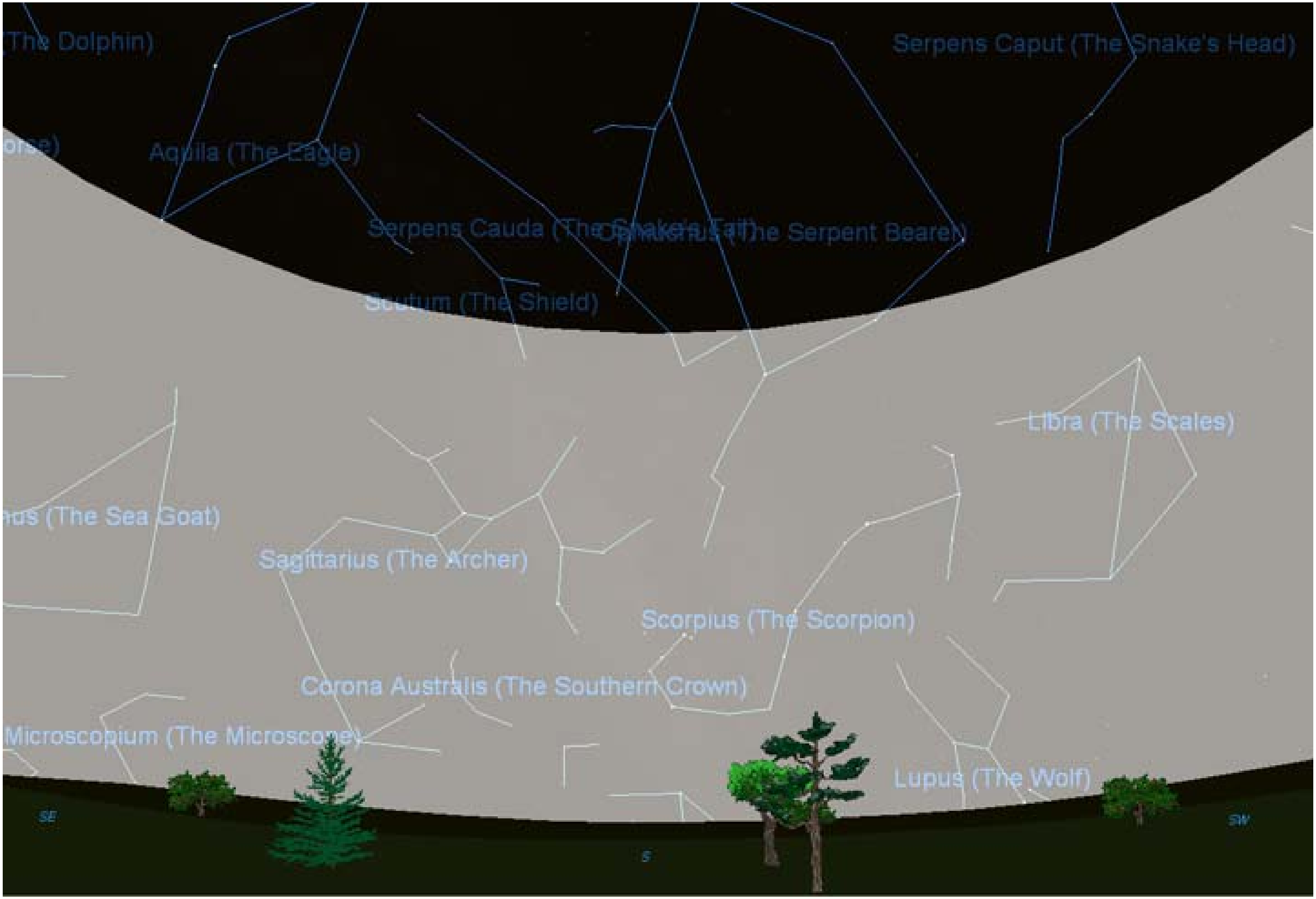


Figure 21 - View to the South at 10pm (Starry Night)

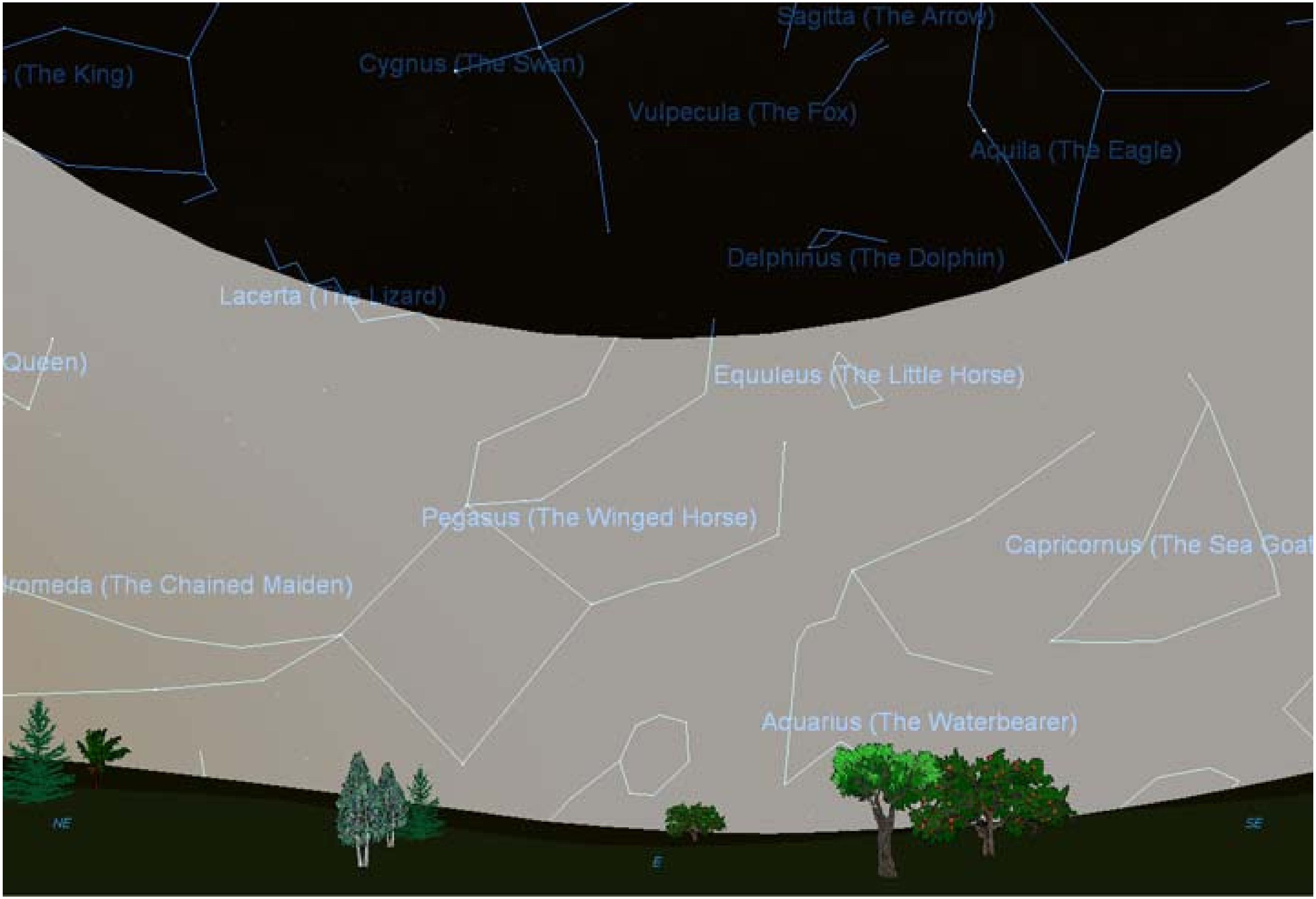


Figure 22 - View to the East at 10pm

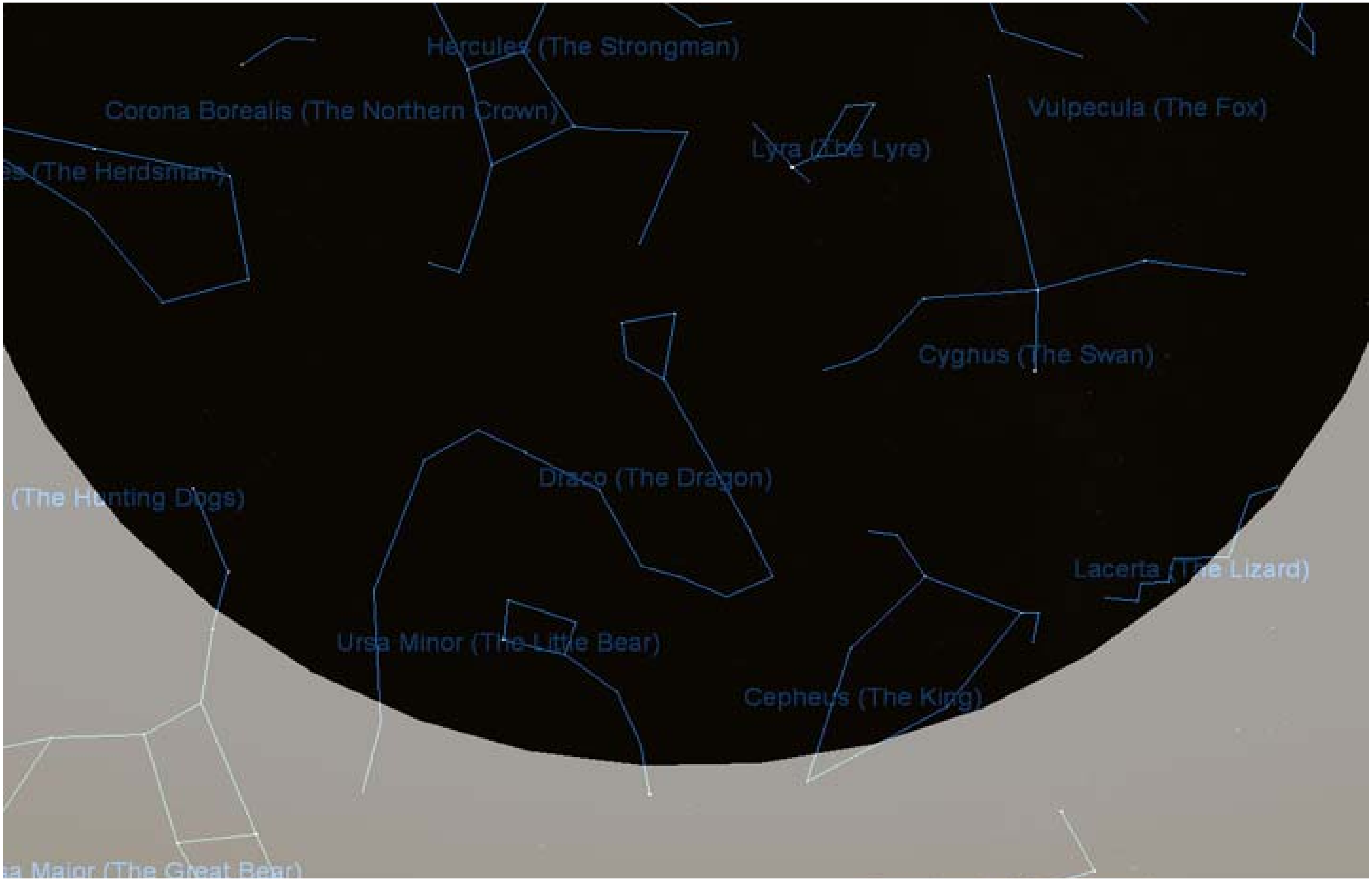
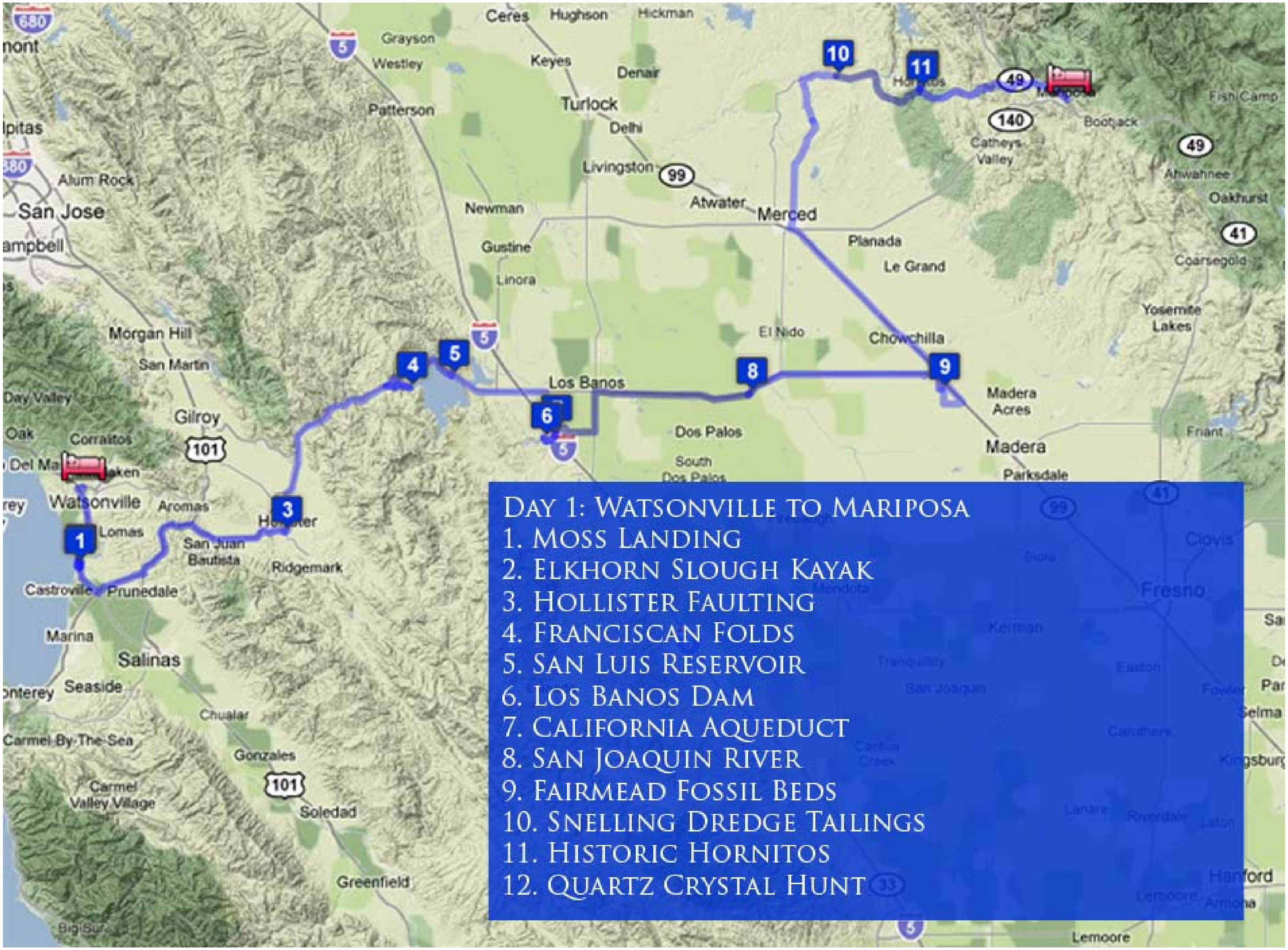


Figure 23 - View overhead to the North at 10pm

Day 1 – Watsonville to Mariposa: For our Journey's Beginning, an Arc through Time.

Day one will guide us through lots of beaches and oceanic sediment, but for the most part we'll be no where near the ocean. We'll see faulting galore, traverse what used to be a forearc basin, look at great fossils and end the day hunting for crystals. It's a busy and long day, but worth it!



Mileage

Cum.	Interval	To Stop #1-1 Moss Landing (36.804817°, -121.787910°)
0.0	0.0	Head east on Main St toward Clifford Ave/Ohlone Pkwy - go 0.2 mi
0.2	0.2	Take the 1st right onto Ohlone Pkwy - go 0.2 mi
0.4	0.2	Take the 1st right onto Harkins Slough Rd - go 0.4 mi
0.8	0.4	Take the 2nd left to stay on Harkins Slough Rd - go 0.1 mi
0.9	0.1	Turn left onto the State Route 1 S ramp to Monterey - go 0.2 mi
1.1	0.2	Merge onto CA-1 S/Cabrillo Hwy/State Route 1 - go 8.3 mi
9.4	8.3	Turn right at Moss Landing Rd - go 0.2 mi
9.6	0.2	Take the 1st right onto Sandholdt Rd - go 0.5 mi
10.1	0.5	Turn left at Clam Way - go 259 ft.
10.1	259 ft	Arrive at Moss Landing
		Time allocated: 30 min

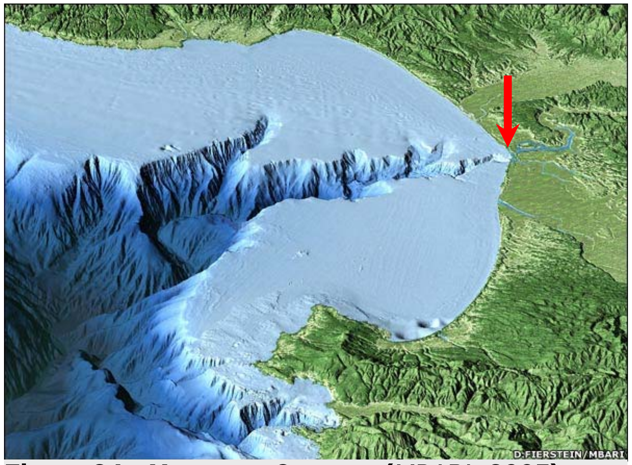


Figure 24 - Monterey Canyon. (*MBARI*, 2005)

Our first observations for the trip will be made with our feet and eyes. The glistening cream colored quartz-rich sands before us were deposited in the aftermath of crashing winter waves and by ocean currents within Monterey Bay that flow both from the north and south. Unlike the main flow of the California current, which generally travels from north to south, Monterey Bay's unique shape creates the southern, eddy-like flow. The relatively large (by Northern California standards) continental shelf accumulates sand that drops out of suspension as the fair weather seas return to their more normal and less tempest state. The majority of the erosional winter sands are deposited via the bay's north-south currents to the middle of the bay here at Moss Landing. Just offshore from our vantage point lies the head of one of the most spectacular submarine canyons and fans on the eastern Pacific. The Monterey Submarine Canyon reaches depths of nearly 12,000ft, leading the local tourism industry to anoint it the "Blue Grand Canyon" in hopes of attracting rich wine connoisseurs who will never actually get to visit the canyon unless they own a research submersible. The canyon also harbors unusual marine communities (besides rich Stanford graduates) that are currently being studied.

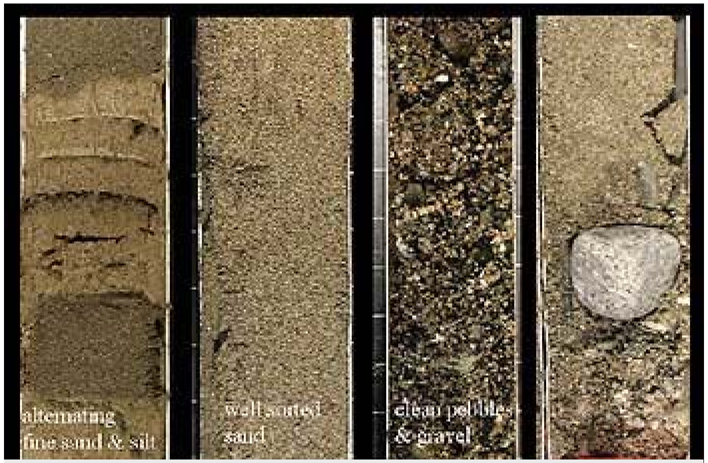


Figure 25 - Sediment cores from Monterey Canyon. Some cores are well sorted, others not so much so. (*MBARI, 2005*)

The canyon's origins are still an intriguing mystery, as the Elkhorn Slough doesn't provide nearly the volume of material or water needed to have carved the canyon. Evidence is also lacking to support an early hypothesis that an ancient, larger river version of the Elkhorn Slough might have carved through exposed rocks during the Pleistocene when ocean levels were nearly 300' lower than present. While the origins of the canyon are little understood we do find evidence for massive turbidity currents that have swept terrigenous deposits nearly 600 miles out to sea. Recent core samples place the oldest deposits at nearly one million years old, making the canyon relatively young. Also intriguing is the fact that sonar soundings indicate that the fan is comprised of two distinct periods of turbidity flows originating from different directions. Keep the turbidites in mind. We may not be able to afford a trip to the bottom of the Blue Grand Canyon in a personal submersible, but we'll observe rocks similar to those the Monterey Canyon produces later in the trip.

Take note of the climate here. We will compare the humidity and temperatures at each of stops throughout the trip to determine the influence of continentallity and rain shadows on an area's climate.

		To stop #1-2 Elkhorn Slough Kayak (36.810314°, 36.810314°)
10.1	0.0	Return to Sandholdt Rd. Turn right onto Sandholdt Rd - go 0.5 mi
10.6	0.5	Turn left at Moss Landing Rd - go 0.2 mi
10.8	0.2	Turn left at CA-1 N - go 0.7 mi
11.5	0.7	Arrive at Elkhorn Slough Kayak
		Time allocated: 1hr

We will take a brief tour of the Elkhorn Slough estuary via kayak or guided boat tour to view the habitats created by the fluctuations of brackish water. We'll also investigate the effects of water-coolant discharge into the estuary from of Duke Energy's powerplant, which has raised local sea surface temperatures marginally. Ongoing tests of the discharge plume show exceptionally higher concentrations of nitrates and high sediment loads, the result of organisms flourishing in the warmer waters (Fischer, 2006).

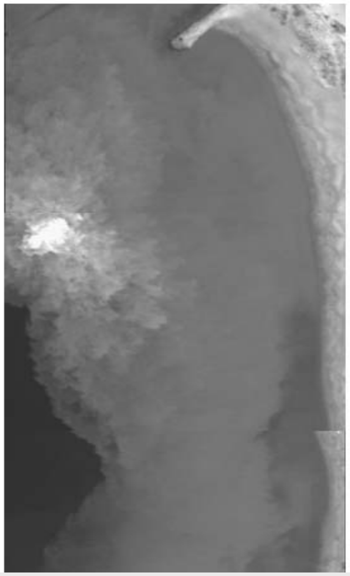


Figure 26 - Infrared view of the thermal discharge plume from Duke Energy plant. Lighter colors are warmer. (Fischer, 2006)

Figure 27 – Boating over discharge plume.

<u>To Stop #1-3 Hollister Faulting (36.850529°, 36.850529°)</u>

11.5	0.0	Head south on CA-1 S/Cabrillo Hwy toward Dolan Rd - go 3.2 mi
14.7	3.2	Turn left at Merritt St - go 1.0 mi
15.7	1.0	Turn left onto the State Route 156 E ramp - go 0.2 mi
15.9	0.2	Merge onto CA-156 E/State Route 156 - go 5.0 mi
20.9	5.0	Merge onto CA-156 E/US-101 N via the ramp to Hollister/San Francisco - go 8.9 mi
29.8	8.9	Take the CA-156 exit toward San Juan Bautista/Hollister - go 0.4 mi
30.2	0.4	Slight right at CA-156 E - go 7.6 mi
37.8	7.6	Continue onto CA-156 BUS E/San Juan Rd (signs for Hollister) - go 2.7 mi
40.5	2.7	Turn right at Powell St - go 0.1 mi
40.6	0.1	Take the 4th left onto 6th street - go 269 ft
40.6	269 ft	Arrive at Hollister Faulting
		Time allocated: 40 min.

The Calaveras Fault, part of the San Andreas Fault system, bisects the city of Hollister running from SE to NW. The right-lateral offset of this creeping section of the fault slips on average about half an inch per year without ever experiencing large earthquakes. The most likely explanation for the creep along this section of the fault is a zone of talc-rich serpentinite (figure 28) that acts a lubricant at depths of over two miles (San Andreas Faulr. Unlike the rapid offset and instantaneous damage that occurs from sporadic, large earthquakes caused by many years of fault strain, the continual slip of the Calaveras Fault in Hollister gradually deforms structures along a narrow swath of the fault trace. Though the damage is not immediate, the march of time slowly but surely ruins the infrastructure that crosses the fault trace. Our perusal through town along the trace will find evince of the deformation in the form of offset curbs, streets, walls, off-kilter houses and an obliquely thrusted chunk of land that sits between two branching strands of the fault (figures 30-32). We should be able to estimate installation ages of roads, wall and sidewalks based on observed offset.

Understanding the relationship of the creeping fault segment through Hollister to the bigger picture of the San Andreas Fault system is of utmost importance. Because the fault is creeping in its middle section, the movement must be accounted for elsewhere along the fault. Thus, it can be assumed from current measurements and past earthquake

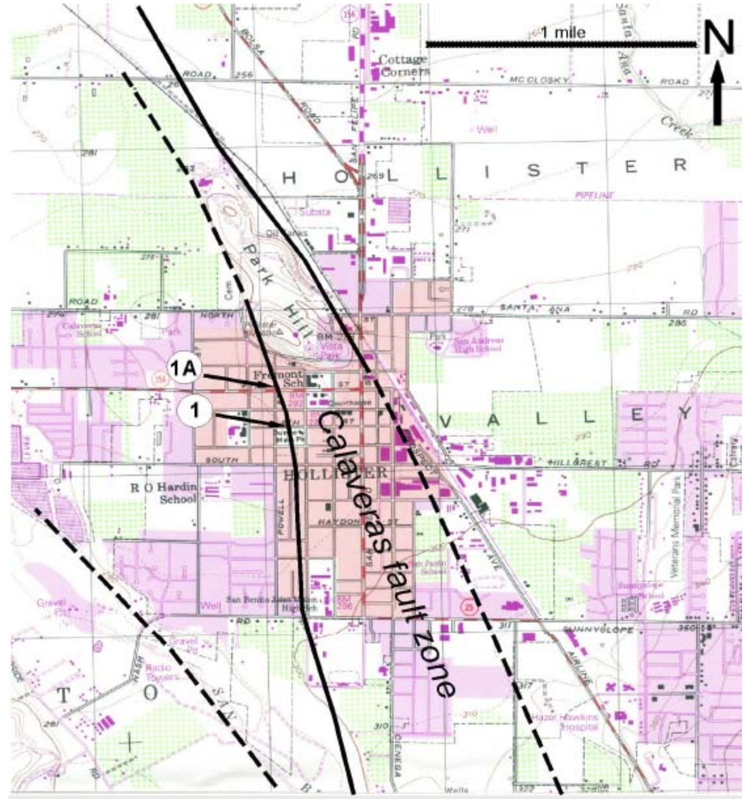


Figure 29 - Calaveras Fault Zone through Hollister. (USGS)

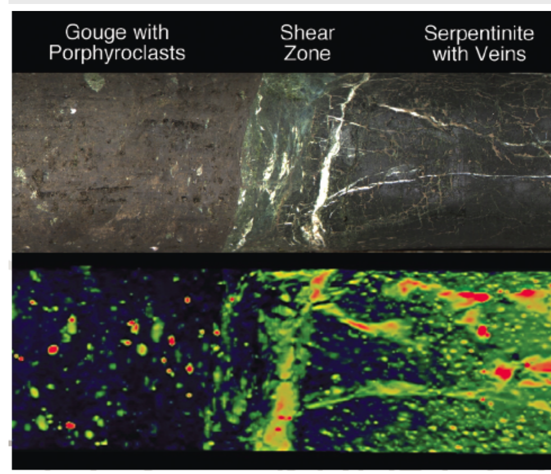


Figure 28 - Core sample from the active trace of the San Andreas Fault. Serpentinite and talc are thought to create a low friction environment allowing creep to occur. (*San Andreas Fault Observatory*)

histories that exceptional amounts of strain are building on the non-creeping segments of the fault, north of San Juan Bautista and south of Parkfield. Having no large rupture (>7.0) occur for over 100 years, seismologists working on the California Area Earthquake Probabilities forecast have shown the likelihood of experiencing a magnitude 6.7 earthquake somewhere on the fault in the next 30 years at 99%. Even more disturbing is that the same study concluded there was a 94% chance of a magnitude 7.0 and 46% chance of a magnitude 7.5 occurring within the same time frame. It is imperative that every Californian know the earthquake risks and hazards within their community so that they might be better prepared when a large quake strikes.

Figure 31 – Off kilter house spanning fault. (*Laura Hollister*)

Figure 32 - Offset street curb. (Laura Hollister)

Figure 30 - Offset retaining wall. (Laura Hollister)

		<u>To Stop #1-4 Franciscan Folds (37.064655°, -121.177773°)</u>
40.6	0.0	Head west on 6th St toward Powell St - go 269 ft
40.6	269 ft	Take the 1st right onto Powell St - go 0.1 mi
40.7	0.1	Turn right at 4th St/San Juan Rd - go 0.3 mi
41.0	0.3	Take the 3rd left onto San Benito St - go 0.3 mi
41.3	0.3	Continue onto CA-156 BUS E/San Felipe Rd - go 3.6 mi
44.9	3.6	Turn right at CA-156 E - go 5.1 mi
50.0	5.1	Continue onto CA-152 E/Pacheco Pass Hwy - go 12.3 mi
62.3	12.3	Turn right at Dinosaur Point Rd - go 0.5 mi
62.8	0.5	Continue onto Fifield Rd - go 2.1 mi
64.9	2.1	Arrive at Franciscan Folds
		Time allocated: 10 min.

The roadcut at this stop provides an excellent up-close and personal view of tightly folded ribbon cherts which were once siliceous ooze lying on the ocean bottom and are now associated with the smashed and tortured Franciscan Formation. It is also a great stop to collect samples of small folds that could be used in a classroom environment. The folds in this region of the Coast Ranges helped geologists in the 1970's gain a foothold while trying to solve the complex mess of rocks that is the California Coast Range. Prior to the development of Plate Tectonic Theory, the rocks of the Coast Range were so utterly discombobulated that they remained little more than an intriguing head-scratcher. However, with the advent of the Tectonic Theory, geologists quickly started to unravel the complexities as evidence for accreted terranes and ophiolite complexes associated with a previously convergent plate boundary started to surface (figure 9). With lots of research and geologic detective wizardry, we can now safely state that during the mid-Jurrasic something happened to cause the Sierran subduction zone (which we will see later today and tomorrow) to skip nearly sixty miles west, past the present day Great Valley. The Farallon oceanic plate was driven under the North American plate scraping off ocean floor rock sequences into a large accretionary wedge btween 140 and 28 million years ago. Some ophiolites survived intact, but most rocks were thrust into a mélange, part of which we are seeing today. Starting 28 million years ago, vast swaths of the Farallon Plate had been swallowed allowing the Pacific Plate to come into contact with the North American Plate. For reasons not yet fully understood, the transition caused a cessation of subduction and created the incipient transform boundary we now know as the San Andreas Fault. About three million years ago the Coast Ranges were uplifted by oblique strains on the San Andreas, exposing the old accretionary wedge and ophiolite complexes for nearly three hundred miles. The tiny folds at this stop are but one peephole into the exceptionally complex tectonic history of California's Coast Ranges

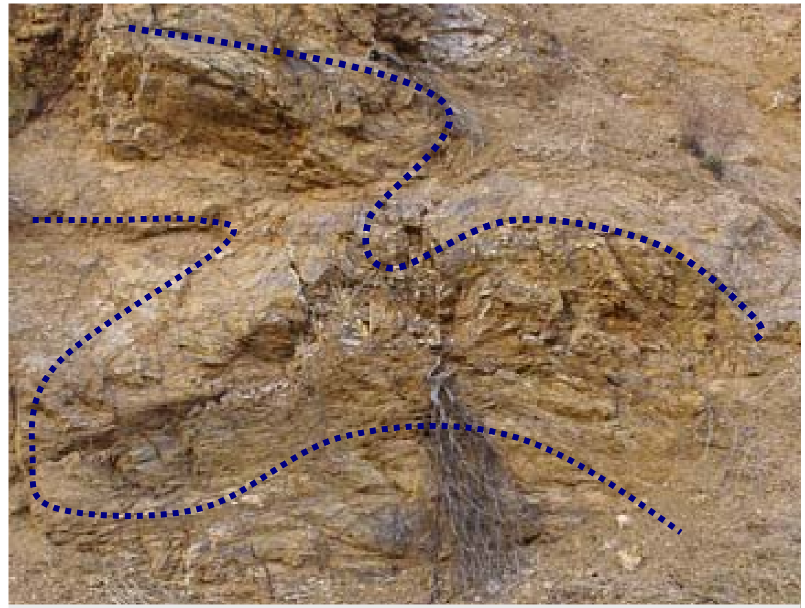


Figure 33 - Francisco Formation folds resulting from an accretionary wedge.

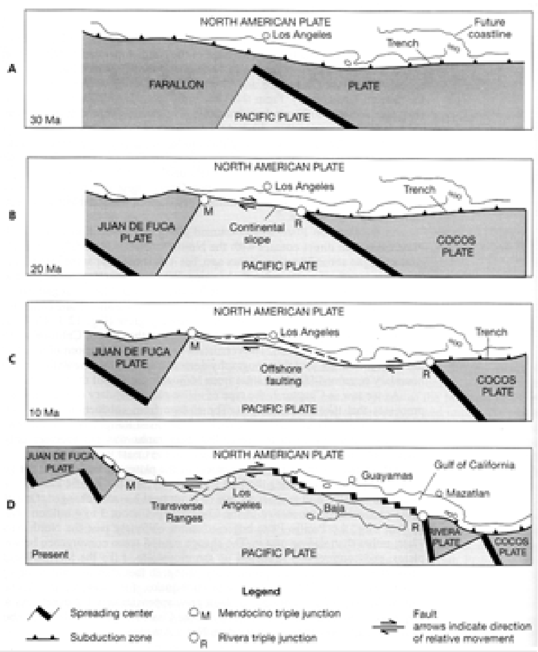


Figure 34 – "Plate tectonic setting of California at about 28 million years before present". (Harden, 1997)

To Stop #1-5 San Luis Overlook (37.081772°, -121.098358°)

64.9	0.0	Head west on Fifield Rd toward Dinosaur Point Rd - go 2.1 mi
67.0	2.1	Continue onto Dinosaur Point Rd - go 0.5 mi
67.5	0.5	Turn right at CA-152 E/Pacheco Pass Hwy - go 8.2 mi
75.7	8.2	Take the exit toward Romeros Visitors Center/San Louis Reservoir - go 0.1 mi
75.8	0.1	Continue straight - go 0.2 mi
76.0	0.2	Arrive at San Luis Overlook
		Time allocated: 35 min

This stop sheds light on the extreme measures taken to supply California's residents with a water supply. San Luis Reservoir was completed in 1967 to much fanfare as a means of creating valuable fresh water storage for California's burgeoning population. Unbelievably, the 2.04 million acre-ft capacity reservoir has no natural tributaries. Instead water is pumped into the dam from the O'neil Forebay, which is fed by the California Aqueduct. The aqueduct, which we will observe two stops ahead on this trip, is a series of canals run by the California Department of Water Resources which ferries water from the northern half of the state where precipitation is plentiful and the population sparse, to Los Angeles where the population is plentiful and the precipitation sparse.

Take several minutes to relax and enjoy the visitor center's movie and learn about the massive undertaking needed to complete the project.

To Stop #1-6 Los Banos Reservoir (36.989826°, -120.929977°)

76.0	0.0	Head northwest - go 0.2 mi
76.2	0.2	Slight right to merge onto CA-152 E - go 10.2 mi
86.4	10.2	Turn right at Volta Rd - go 1.0 mi
87.4	1.0	Turn left at Pioneer Rd - go 1.0 mi
88.4	1.0	Take the 3rd right onto Canyon Rd - go 3.2 mi
91.6	3.2	Slight left to stay on Canyon Rd - go 1.8 mi
93.4	1.8	Arrive at Los Banos Reservoir
		Time allocated: 15 min

Figure 35 - Mass wasting upstream of Los Banos Retention Dam.

This brief stop allows us an overview of several terraces of the Los Banos Creek floodplain. Prior to the Los Banos Retention dam, Los Banos Creek would occasionally flood and ravage the town of Los Banos. The 167' tall and 1370' wide dam was completed by the Bureau of Reclamation in 1965 to provide flood protection for the city that was severely damaged by the normally ephemeral stream during wetter periods. The terraces show amazing river channel and natural levee structures as one looks downstream from the dam towards the city of Los Banos. One must ponder what effect a flood on Los Banos Creek would have on modern day Los Banos, a town of over 34,000 residents?

Also noteworthy at this site is the four-foot thick fossiliferous member of the Upper Cretaceous marine Panoche formation and mass wasting in the hills upstream of the dam. Should time permit, a short but steep walk down to the right bank of the river will reward the curious with interesting marine fossils. Major slumping activity and the Ortigalita Fault scarp can be seen on the right bank of the reservoir upstream of the dam.

		To Stop #1-7 California Aqueduct Overlook (37.000431°, -120.908730°)
93.4	0.0	Head southeast on Canyon Rd - go 2.1 mi
95.5	2.1	Arrive at California Aqueduct Overlook
		Time allocated: 5 mi.

Having stopped at the San Luis Reservoir Visitor center earlier, you should be up to speed on the California Aqueduct. It was constructed in the early 1960's to convey water from Northern California to Southern California populations where water needs outpaced the available precipitation. The aqueduct snakes over seven hundred miles, delivering nearly 13,0000cfs of water at peak flows to residents of central and southern California. Without the flows, agriculture would be non-existent in the deserts of the south San Joaquin Valley, but diversions have wreaked havoc on native fish and riparian species in the north state. Maintaining a water balance satisfactory for both the environment and agriculture has been a tricky proposition throughout the years, especially during droughts when farmers in the far south of the valley, which used to be desert, are denied water in order to maintain minimal flows within rivers.

		To Stop #1-8 San Joaquin River (37.054722°, -120.549400°)
95.5	0.0	Head northeast on Canyon Rd - go 0.3 mi
95.8	0.3	Sharp right at Alvarado Trail - go 0.8 mi
96.6	0.8	Slight right to stay on Alvarado Trail - go 0.5 mi
97.1	0.5	Take the 1st right onto S Creek Rd - go 0.5 mi
97.6	0.5	Take the 1st left onto Almond Dr - go 3.0 mi
100.6	3.0	Turn left at CA-165 N/Mercey Springs Rd - go 4.0 mi
104.6	4.0	Turn right at CA-152 E/E Pacheco Blvd - go 15.6 mi
120.2	15.6	Turn right at Island Rd - go 135 ft
120.2	135 ft.	Take the 1st left onto Brazil Rd - go 0.3 mi
120.5	0.3	Arrive at San Joaquin River
		Time allocated: 25 min.

Figure 36 - Delta-Mendota Canal near Mendota, CA. Water in the canal was shipped from the delta to be put back into the San Joaquin River.

The San Joaquin River is a sad story full of follies but with a redemptive ending. The 330 mile long river begins its life as snowmelt in high country of Sequoia National Park. The river, being the second longest in California behind the Sacramento River, used to carry tremendous spring flows through this channel allowing steam ships to travel from the San Francisco Bay to Fresno. Chinook salmon were so thick residents used to report being able to cross the river on the backs of the huge fish. It's hard to imagine a steamship on the trickle that now drizzles in front of us. The demise of the river came in the form of Friant Dam, some forty miles upstream of this spot. The US Bureau of Reclamation finished the huge 299' tall concrete dam in 1942 creating the 520,000acre-ft Millerton Reservoir. The reservoir diverted nearly 95% of the rivers' original flow into the cotton and tomato fields of the south San Joaquin Valley, which are classified under the Köppen System as arid mid-latitude deserts and semi-arid steppes. With the large majority of the water diverted from the river channel, nearly sixty miles of the San Joaquin ran dry until tributaries further upstream brought the river to life for its last several miles to the Sac-Joaquin delta. The delta supplies nearly 22 million California residents their water supply, thus the decreasing freshwater flows from the San Joaquin impacted the water quality and salinity of the delta, and by extension, the San Francisco Bay. Salmon runs were also exterminated below the Tuolumne River. Most importantly, in terms of water deliverance, farmers downstream of the dam found their riverside water rights drying up. After several legal bouts, the Bureau of Reclamation came up with an idea to restore the river flow to the parched beds. In 1951, the B.R. decided to construct a peripheral canal from the delta, near the town of Tracy, back to the small town of Mendota, which sat on the banks of the old San Joaquin, nearly 117 miles to the south. Water from the delta was then pumped up the canal where it was returned to the rivers banks in Mendota. The idea was that any water flowing through the banks would be fine, even if it was brinier deltaic water. Ironically, today the river flows again from Mendota for about thirty miles before it is again diverted into peripheral irrigation canals, once again causing the river to go dry.

2010 was a historic year, however. Section 5937 of the California Fish and Game Code states : "the owner of any dam shall allow sufficient water to pass over, around, or through the dam, to keep in good condition any fish that may be planted or exist below the dam." In February 2010, after many years of litigation and political concessions to bring the Friant up to code, the river finally, and briefly, ran its entire channel for the first time in nearly seventy years when pulses of water were released from the Friant Dam. The new flows will be periodically released and studied until 2014 at which time, after several years of river channel restoration efforts, the river will again flow freely, hopefully allowing the return of salmon to a once majestic river.

To Stop #1-9 Fairmead Fossil Bed (37.061859°, -120.195503°)

120.5	0.0	Head southwest on Brazil Rd toward Island Rd - go 0.3 mi
120.8	0.3	Turn right at Island Rd - go 135 ft
120.8	135 ft	Take the 1st right onto CA-152 E - go 18.5 mi
139.3	18.5	Turn right at Rd 17 1/2 - go 476 ft
139.4	0.1	Turn left at Ave 23 - go 1.0 mi
140.4	1.0	Slight left at Rd 19 - go 1.8 mi
142.2	1.8	Turn left at Ave 21 1/2 - go 0.4 mi
142.6	0.4	Arrive at Fairmead Fossil Bed
		Time allocated: 1 hour.

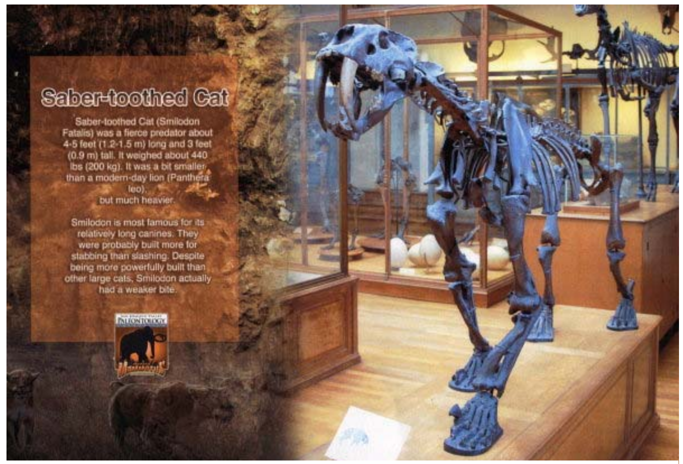


Figure 37 - Smilodon sabertooth fossil. Just one of the many species soon to be on display at the Fairmead Museum and landfill.
(*photo courtesy of maderamammoths.org*)

This important stop will transport us back to the mid-Pleistocene to view the flora and fauna of the Madera area during the last ice-age. The museum at this stop stands abreast the Madera County Landfill, where in 1993 excavations for a new garbage pit unearthed a large mammoth tusk. Following California Environmental Quality Act procedures, the industrial excavation was halted to extract what was thought to be a small assemblage of fossils within the sandstones and siltstones of the Turlock Lake Formation. What was supposed to be a short recovery has turned into the discovery of an immense 15-acre fossil bed that has since produced over 16,000 specimens of macro-fossils and over 500 specimens of microfossils.

The find represents the largest and most diverse bed of Irvingtonian fossils anywhere in North America. The 36-species of fauna is comprised mainly of Columbia Mammoths, smilodon sabertooths, mastodons, sloths, camels, horses, dire wolves and short-faced bears to name a few. The assemblage indicates that the area was a vast prairie 700,000+ years ago in what would have been a wetter, cooler climate. Paleontologists suspect that vast quantities of spring runoff from the Sierra glaciers (which we will detail tomorrow) periodically coated the savannah-like environment here with silt and sand, burying and preserving previously dead animals.

The museum is a first of its kind in the Central Valley and is scheduled to open in October 2010. The fossil excavations are expected to continue another twenty five years as a research site for students from nearby UC Merced, UC Berkeley and Fresno State University. The museum offers an extremely teachable moment for our Central Valley kids who only know the valley as flat, dull and boring.

To Stop #1-10 Snelling Dredge Tailings (37.520031°, -120.391182°)

142.6	0.0	Head east on Ave 21 1/2 toward Rd 19 1/2 - go 0.1 mi
142.7	0.1	Take the 1st right onto Rd 19 1/2 - go 1.5 mi
144.2	1.5	Turn left at Avenue 20 - go 2.0 mi
146.2	2.0	Turn left to merge onto CA-99 N - go 24.6 mi
170.8	24.6	Exit onto E 16th St - go 0.5 mi
171.3	0.5	Turn right at G St - go 6.6 mi
177.9	6.6	Continue onto Snelling Rd - go 9.4 mi
187.3	9.4	Turn right at CA-59 N - go 1.5 mi
188.8	1.5	Continue onto Co Rd J16/Merced Falls Rd - go 2.2 mi
191.0	2.2	Arrive at Snelling Dredge Tailings

Time allocated: 25 min.


Figure 38 - Snelling dredge tailings.

The piles of gravel before us come courtesy of gold dredges that operated from 1907 to 1951. Most of the tailings were, however, excavated between the early 1940's and early 1951. Its our first taste of the Gold Rush on this trip, and a subject that will be a recurring theme throughout the next seven days. Prospectors knew that there was gold in the river gravels of the Merced River floodplains, washed down from the quartz-bearing veins tens of miles upstream. In order to be transported such long distances, the gold was nearly microscopic. Such small quantities made regular recovery methods unfeasible. To economically sift through the gravels of the old flood plain and retrieve the gold, dredging had to be employed.

The dredges were essentially large barges emplaced on ponds that were created by digging into the Merced River's floodplain slightly lower than the surrounding water table (figure 40). The "ponds" flooded with groundwater allowing the dredges to float. The fronts of the dredges were equipped with a boom of rotating buckets that would continuously scoop the gravels off the leading edge of the pond and send the quarry over a sluicing device, all the while lengthening the pond. The sluicing device within the dredge separated the gold from the gravels and thusly expelled the gravels via conveyor belt along the back of the barge, back-filling the pond with heaps of gravel that had been pulled from the front. The dredge would continue the process by literally sailing across the land, digging its pond in the direction that it needed to go. The tailings in Snelling are immense and cover nearly 7,000 acres of land (figure 41). This tremendous habitat destruction occurred to obtain a mediocre sum of 500,000 oz of gold (Hayes, 2008); an amount that by one professor's calculations would merely fill two standard suitcases.

Figure 39 – Assortment of river gravels that piece together the Sierra's evolution.

Figure 40 - Gold dredge similar to those used near Snelling.
(*Photo: California Conservancy***)**

From the perspective of a geology student, the dredged gravels offer a unique view into the history of the mountains which were contributing to the sediments in the flood plain. At this stop we will spend several minutes trying to find as many different rock types as possible within the tailings. With any luck we should gather an assemblage of rocks that run the gamut from porphyritic volcanics to metamorphic mudstones and granites. For those knowledgeable in the ways of tectonic sequencing, these rocks will provide the canvas on which we will paint the geologic history of the area over the coming days. For now, a rudimentary hypothetical sequencing will suffice in planting a seed for our future discussions.

Figure 41 - Ariel view of dredging extent along Merced River.

To Stop #1-11 Downtown Hornitos (37.501759°, -120.237953°)

191.0	0.0	Head east on Co Rd J16/Merced Falls Rd - go 3.6 mi
194.6	3.6	Turn right at Co Rd J16/Hornitos Rd - go 0.4 mi
195	0.4	Slight right at Hornitos Rd - go 7.1 mi
202.1	7.1	Slight right to stay on Hornitos Rd - go 259 ft
202.1	259 ft	Take the 1st left onto High St - go 0.1 mi
202.2	0.1	Arrive at Downtown Hornitos
		Time allocated: 15 min

Figure 42 - Ghirardelli's original general store in Hornitos.

Hornitos was originally founded in the early years of the California Gold Rush by Mexican nationals, who several years previously had been occupying Mexican land. Anti-Mexican sentiment was still very prevalent after the Treaty of Guadalupe Hidalgo was signed ceding nearly 55% of Mexican territory to the United States in February of 1848 to end the Mexican-American War. Ironically, Sutter's discovery of gold at his mill site occurred just one week prior to the signing of the treaty, a fact that many scholars believe was hidden from the Mexican Government to expedite the transfer of land.

Most Mexican prospectors often found themselves subjugated to racism and were pushed off their rich claims by white settlers intent on claiming known easy pickings for themselves. The Mexican miners who founded Hornitos has been "asked" to leave the rich placer fields of nearby Quartzburg, and ultimately settled in Hornitos. Luckily for the Mexican miners, Hornitos turned out to be a fairly rich district and the town boomed for several years before being played out.

Fans of Ghirardelli might rejoice in knowing that Domenico Ghirardelli operated a general store (figure 42) in the area for three very successful years which allowed him to sell his store in 1858 and devote his full attention to his San Francisco chocolate confectionary company that is still very successful to this day. Hornitos' other famous resident was rumored to have been Joaquin Murrieta, the infamous outlaw known as the Mexican Robin Hood who apparently frequented the rough and tumble town knowing it was a safe-haven.

To Stop #1-11 Quartz Crystal Hunt (37.505009°, -120.234520°)

202.2 0.0 Head north on High St toward St Catherine St - go 367 ft
202.2 367 ft Take the 1st right onto St Catherine St - go 0.3 mi
202.5 0.3 Arrive at Quartz Crystal Hunt
Time allocated: 45 min.

Figure 43 - Overgrown tailings! Perfect for collecting quartz crystals.

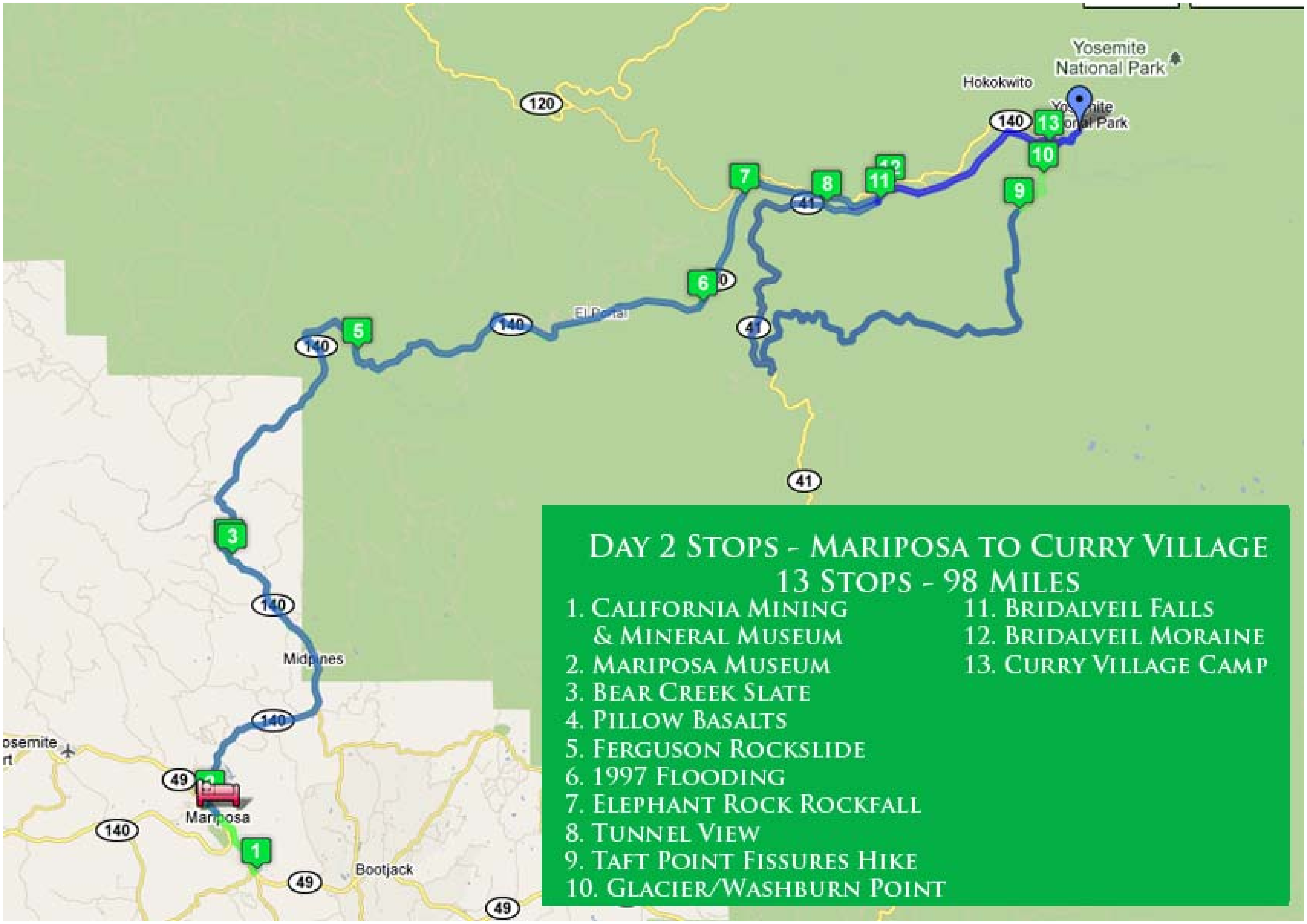
Our last stop on this first day of the trip should satiate the intrinsic rockhound in most. We'll be poking through the remnants of prospect tailings in what is now the Hornitos Transfer Station. Have no fear, no garbage is actually dumped here, just gathered and taken from here to other dumps at the site. The miners of Hornitos have done all the hard work for us, crushing many thousands of tons of quartz that once veined through the meta-sedimentary rocks of the Western Metamorphic Belt that we will discuss in much greater detail during tomorrow's journey to Yosemite. The veins in this area are particularly renowned for producing many small to medium sized quartz crystals, some attaining lengths of two inches and doubly terminated. The best way to hunt for the crystals is to find erosional areas within the tailings pile and let the low sun glimmer on crystalline faces. The glassy sparkle should catch your eye. Some light scraping of the clay-rich soil with a rock hammer or other utensil may be required if no rain has been present in the area within the past month. Good Luck. We will head to Mariposa for dinner and lodging after the hunt.

To Stop #1-12 Mariposa Lodge (37.486179°, -119.966522°)

202.5 0.0 1Head southwest on St Catherine St toward High St - go 0.3 mi
202.8 0.3 Turn left at High St - go 0.2 mi
203.0 0.2 Slight left at Hornitos Rd - go 5.9 mi
208.9 5.9 Slight left at Old Toll Rd - go 6.7 mi
215.6 6.7 Turn right at CA-49 S - go 4.7 mi
220.3 4.7 Turn right at CA-140 E/CA-49 S - go 0.6 mi
220.9 0.6 Arrive at Mariposa Lodge

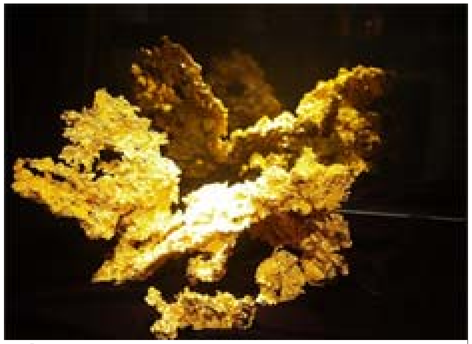
Day 2 – Mariposa to Curry Village: Gold with a Complex and Views not to Take for Granite.

Day two will give us glimpses of California's golden history, Cretaceous trench sediments, plutonic intrusions and the beautiful works of glaciers. Make sure your camera has several free gigs of space and that your water bottles are full. It's going to be an amazing ride today!

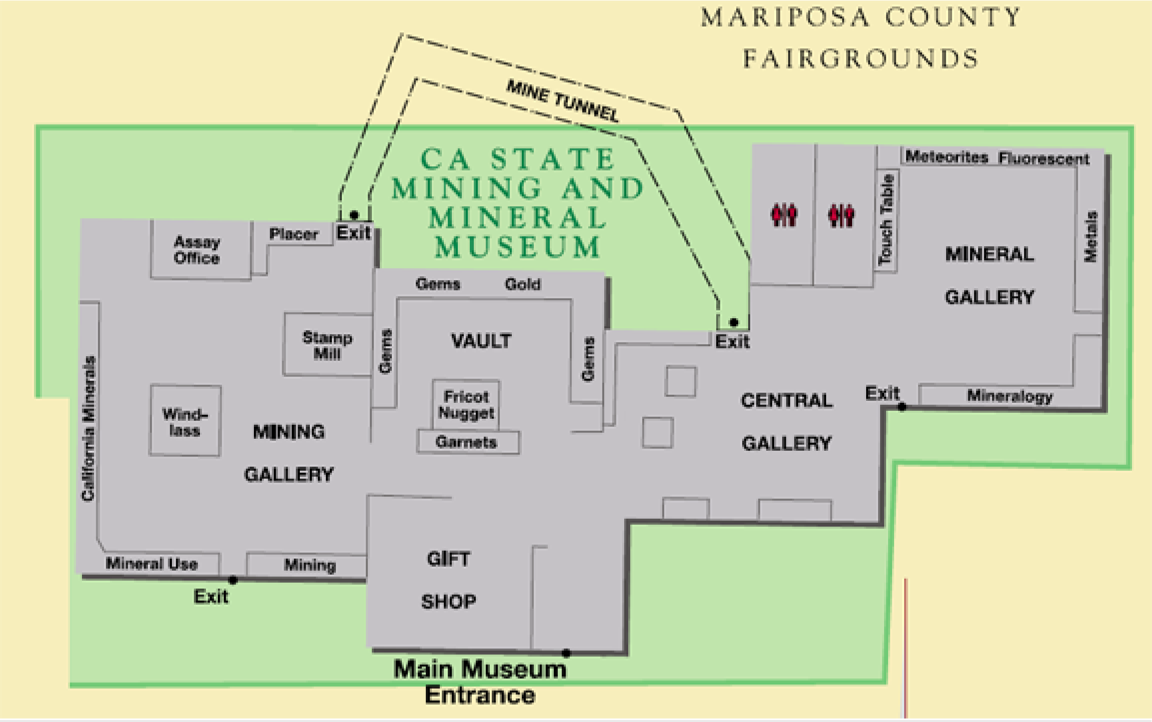


Mileage

Cum.	**Interval**	**To Stop #2-1 (37.463699°, -119.948952°) - Mining & Mineral Museum**
0.0	0.0	From the parking lot of the Mariposa Lodge, head SE on CA-140 E toward 7th St – go 0.3 mi
0.3	0.3	Turn left at HWY 49 South - go 1.7 mi
2.0	1.7	Arrive at Stop #1 – California State Mining & Mineral Museum
		Time allocated: 45min.


Fricot Nugget

The California State Mining & Mineral Museum houses a plethora of magnificent gold & mineral specimens from California and around the world. Much of the collection resided in a San Francisco museum until 1983 when it was moved to its current location within miles of John C Fremont & Kit Carson's mines and stamp mill that processed the rich Mariposa Vein and gave rise to the city of Mariposa. Mariposa lies on the Melones Fault Zone, separating the Jurassic-aged Foothills Terrane and the much older Paleozoic rocks of the Calaveras complex. The museum was finally designated a State Park in 1999 allowing for perpetual display of the 13.8 lb crystallized-gold Fricot Nugget which was found along the American River in 1864. At 2010 gold prices ($1235/troy oz.) the melted value of the gold would be in the neighborhood of $248,000. Since, however, the Fricot Nugget is the last remaining crystalline nugget from the Gold Rush Era, it is far more valuable as is. For those who are worried they might not be able to suppress their inner Jesse James, don't fret; the Fricot resides in a heavily surveilled & secure safe.



Mineral Museum Map

Points of interest to visit with our short time at the museum are the magnificent collections of native Californian minerals, including the brilliantly blue & bedazzling state gemstone, Benitoite, which is only found in the hills outside of Hollister in San Benito County. The antique stamp mill model, mine adit walk, gold rush era assay office and the exhibit of the many uses of California's non-glamorous rock & mineral wealth such as aggregates and borates are must see displays. By the end of the tour you should be able to name the California state rock, mineral, gemstone & fossil. When you're done, we'll meet at the vans and head back to downtown Mariposa for stop #2 at the Mariposa Museum.

To Stop #2-2 (37.489429°, -119.970711°) - Mariposa Museum & History Center

2.0	0.0	Return to Hwy 49
4.4	2.2	Turn right & head northwest on CA-49 N - go 2.2 mi
4.5	0.1	Turn left at 12th St - go 141 ft & Park in Mariposa County Museum Lot
Walk to POI		Arrive at Stop # 2 – Working stamp mill at Mariposa Museum.
		Time allocated: 30 min including bathroom break.

Figure 44 - Stamp mill at Mariposa Museum.

The Mariposa Museum & History Center has several well-preserved pieces of mining technology placed across the property along with many other Mariposa County artifacts in the museum proper. While the man-powered circular ore grinding mills of the first Mexican miners, and monitor nozzles used for hydraulic mining are fabulous artifacts, the star of this museum is the restored & fully functioning five-stamp mill. We have arranged for a special demonstration of the behemoth to provide a sense of what Mariposa and other towns home to stamp mills must have sounded like when operating 24/7 during the peak of the Gold Rush.

As in all mills, ore was fed through the stamps which were steam-powered. A large flywheel connected to a cam shaft, similar to that in your car, would rotate causing the vertical stamps of the mill to rise up and then drop after contact with the rotating cam was completed. Quartz ore under the stamps would be smashed to dust and flushed as a slurry over a copper chute coated in mercury using a continuous supply of water. The gold within the now-slurried ore would amalgamate over the copper chute. The amalgamation would periodically need to be scraped off the copper in order to free the gold in a later process that generally involved a cyanide bath. As you can see, the health risks involved in this type of endeavor were immense, but the allure of shiny gold and a decent wage made most "forget" about the danger.

Hopefully the running water has inspired you to use the facilities before we leave on our journey across an amazing complex of accreted terranes and wedges.

To Stop #2-3 (37.582600°, -119.960289°) -Bear Creek Canyon / Merced Canyon Overlook

4.5 0.0 Head southeast on Jessie St toward Coakley Cir - go 167 ft

4.6 0.1 Take the 1st right onto Coakley Cir - go 0.3 mi

4.9 9.7 Turn left onto HWY 140 E. Stay on 140 E at stop sign - go 9.7 mi - Be on the lookout for quartz veins and slate outcrops

14.6 Pullover on HWY Pullout to the right for Stop #3 – Bear Creek Slates

Time allocated: 10min.

Figure 45 - Slates of the Foothill Terrane next to Bear Creek.

Since leaving Mariposa, we've actually been travelling through time getting into ever older rocks as we head east. At this stop we're literally standing on the deposits once settled deeply and darkly on the bottom of a deep ocean trench. Exposed in the road cut across the road is a fabulous section of slate associated with the Western Metamorphic Belt and more specifically, the Foothill Terrane. It's the youngest (Triassic) in a series of accreted metamorphic rock belts that mark the ancient accumulations within a subduction zone trench between the North American plate and ancient oceanic plates. We'll see the oldest rocks in the belt (the Shoo Fly Complex) which represents the driving force of the Antler Orogeny in the mid-Devonian on the last day of our field study. While feet-thick "layers" of the slate's cleavage are amazing keep in mind that the cleavage of slate does not correlate to the original bedding planes of the deep ocean depositions. When one considers the entire canyon laid out before you is basically comprised of the same uplifted material, one can get a true sense of the immense amounts of time needed to accumulate such layers of mud.

The second point of interest at this stop is the short-lived but dramatic Bear Creek which occupies the canyon to the right of the road. While the eroded gradient of the creek is impressive at 1,000 ft in 2 miles, a more subtle observation might lead to a bit of a hydrologic conundrum. Bear Creek, like Mariposa Creek and others in the area, flow in a distinct north-south trend. How or why should this be with the east-west trending slope of the Sierra's? Even the Merced River canyon in the far distance follows the gradient of the Sierras from east to west. They answer is simple, the creeks predate the uplift of the Sierras and followed the north-south trends of the faulted remnants of metamorphic terranes discussed above. Once the Sierra's started uplifting between 9-10 Ma and the east-west gradient was established, down-cutting ceased on the n/s gradient. However, headward erosion from the ever deepening and widening Merced River Canyon is once again causing the Bear Creek bed to back cut deeper into its channel.

To Stop #2-4 (37.584194°, -119.961555°) - Pillow Basalts & Greenstone

WALK 0.13 Head downhill (North) along highway railing. Cross Road at .13 miles

Approach road cut with metamorphosed pillow basalts. Carefully cling to the side of the road cut.

Time allocated: 10 min.

In order to add to our evidence for a deep oceanic environment, this outcrop presents us with some amazing greenstones and metamorphosed pillow basalts that date to about 200 Ma. Look for the dark black arches reminiscent of the St. Luis Arch against the greenstone about six feet above road level. Recall that greenstones form from metamorphic mafic & ultramafic rocks like basalt. The pillow basalts are definitive proof that portions of this greenstone were actually erupted onto the surface of the seafloor. The pillow's current aerodynamic shape resulted after their bulbous former shape was metamorphosed by immense pressure.

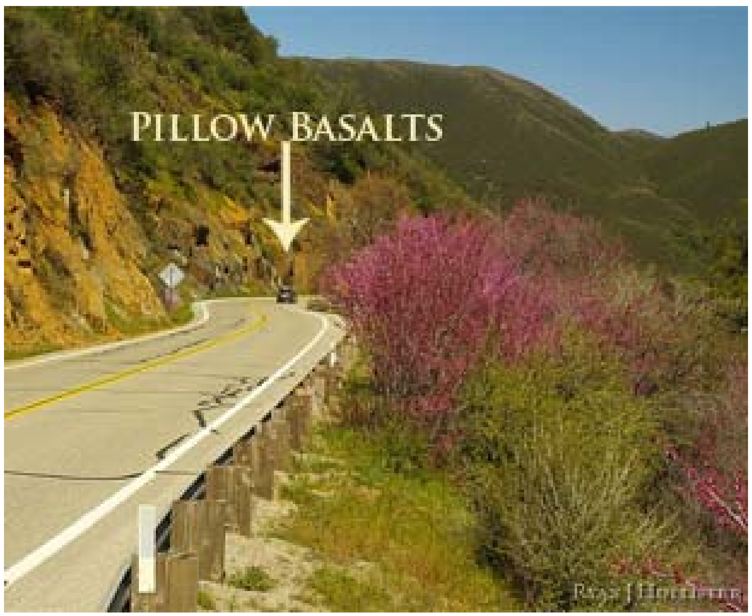


Figure 46 - Metamorphosed Pillow Basalt Outcrop

Figure 47 - Detail of 200Ma Pillow Basalts

To Stop #2-5 (37.660110°, -119.900978°) - Ferguson Rock Slide

14.6 0.0 Return to vans and proceed NE (downhill) on HWY 140 – go 10.1 mi

25.6 10.1 Pull through the stoplight for the one lane bridge and park in the cleared area near the fence.

Time allocated: 15 min

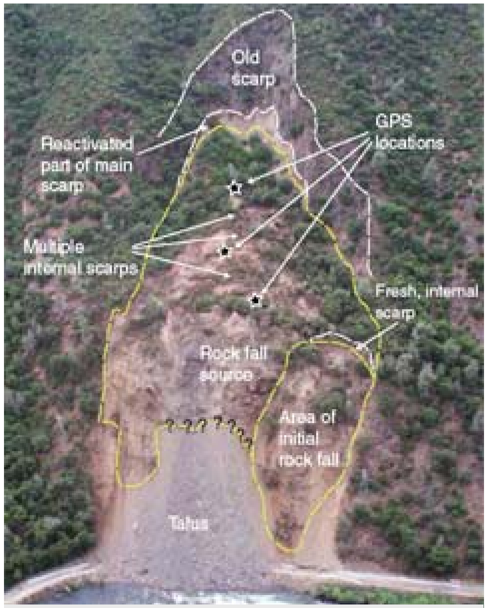


Figure 48 - Oblique aerial photograph of Ferguson Rock Slide. Dashed yellow lines indicate extent of the rock slide based on visual inspection. Rock-fall source area, talus, new scarps, and locations of GPS instruments are indicated. Photo taken on June 13th, 2006 – (Harp, et all).

Looking straight past the chain link fence you will see the remnants of the April 2006 Ferguson Rock Slide (figure 48). The 800,000 m^3 slide of slate and phyllite buried two hundred yards of HWY 140 shutting down the only snow-free route into Yosemite for 92 days (Harp, 2008). When looking at the extremely vertical nature of the rocks' cleavage, that is parallel to the canyon face, one can easily see how lubrication from an above average year of rain could help trigger the massive movements. The local tourism-based economies of Mariposa & El Portal are estimated to have lost nearly 4.8 million dollars during the 92 days without traffic while the USGS, USFS and CalTrans scrambled to find a suitable detour. Since the slope of the slide was too unstable and massive to clear, the road was routed via temporary bridges across the river and onto the old Yosemite Valley Railroad bed which was in operation from 1906 – 1945. The original detour bridges were replaced and re-angled in 2008 to allow tour buses to make the detour.

The Ferguson is now one of the most heavily monitored slide areas in the nation. Fearing a worst-case scenario that could cause the slide to dam the river canyon, three GPS spiders attached to geophones have been placed at various locations on the slide to monitor movement. Two stream gauges, one placed upstream of the slide, the other downstream, transmit hydrologic data every fifteen minutes via GOES satellite to monitor stream flow fluctuations. If the downstream gauge significantly differs from the upstream gauge alerts will be issued for possible blockage of the river channel.

Figure 49 - Ribbon chert near detour bridge.

After taking a look at the slide, walk downstream past the bridge about 150 yards. Looking across the river at this point affords us great views of truly tortured white and dark gray folded layers of ribbon chert (figure 49). Cherts are nearly chemically identical to quartz, however they are formed from the remnant silica-rich shells of microscopic animals that once lived in the deep Paleozoic seas off the ancient coast of North America. Had we been standing in the same spot over 200 million years ago we'd need a submersible capable of not getting mired in the siliceous ooze that coated the seafloor to depths of thousands of feet. Also of note, this specific chert demonstrates secondary folds – the first folds are horizontal, while the second episode of metamorphism folded them near vertical.

To Stop #2-6 (37.678017°, -119.736412°) - 1997 Flood Memorial

25.6 0.0 Return to vans, wait for stoplight at single lane bridge, then proceed on HWY 140 – go 11.1 mi.

26.3 0.7 Upon entering Yosemite, one might choose to use the restrooms just past the ranger kiosk.

36.7 11.1 Pull out and park at signed overlook of the Merced River.

Time allocated: 10 min

If you had tried to stand on this spot in early January of 1997, you would have been under 30 feet of water and the road underneath you would have been non-existent. The 1997 flood was an epic 200-300 year event that developed from a rapid melting of an above average snow pack. Usual winter weather patterns bring cold Alaskan low pressure centers tagging along on the jet stream and dump tremendous amounts of snow in elevations above 6000' feet. In the winter of 1996/97, an El Nino Southern Oscillation had established itself bringing in warmer storm systems from the tropical Pacific. The storms have a much higher water content than those normally dropping our of the Gulf of Alaska. The orographic cooling effects of the Sierra's allowed the warmer air to still be cooled below freezing and create a snowpack through December that had many ski resorts and farmers reliant on the water elated. On January 1-3 of 1997 a Pineapple Express consisting of even warmer and moister air than normal ENSO storms slammed into California resulting is severe orographic rains on the western slope of the Sierras above 11,000. The rain quickly melted the pre-existing large snowpack causing a deluge of water to rush out of the Sierras. Upstream in Yosemite Valley, river gauges measured river flow at 24,600 cfs with much of the Valley under six to ten feet of water. Due to the steep gradient here, all of that water funneled through the canyon with a vengeance, destroying the road and closing Yosemite Valley proper until March 14th 1997. Estimated infrastructure loss was $178 million, but all was not lost. Several hundred overused and abused campsites were removed and allowed to go back to their natural state. As we make our way through the valley during the rest of the day, keep an eye out for high water signage.

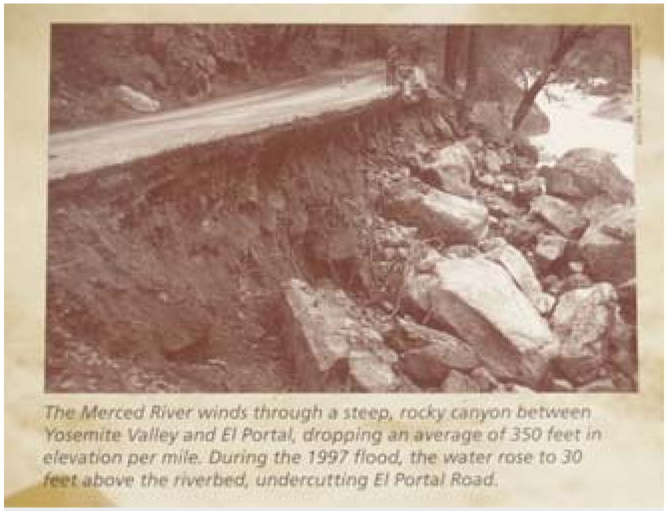


Figure 50 – Photo of Signage at stop # 2-6 depicting flood damage from 1997.

<u>To Stop #2-7(37.718082°, -119.716728°) - Elephant Rock Rock Fall</u>

36.7 0.0 Return to vans. Proceed on HWY 140 E – go 3.1 mi.

39.8 3.1 Pull out and park in the small pullout next to the remnants of a large rock fall.

Time allocate: 15 min.

The massive boulders of the 103 Ma El Capitan Granite that line this section of the highway are remnants from a massive 100,000 m^3 fall that originated from the cliffs on the north side of the highway opposite Elephant Rock, some 600 ft above our current vantage point in 1982. The road here was also closed for several months, and on a crappy note severed Yosemite's sewer line which runs under the road and terminates at a waste water treatment facility in El Portal.

After imagining the thunderous clap and cloud of pulverized rock dust the fall must have created, crawl on some of the rocks across the road and make some observations. The freshly exposed granite shows many great crystals of orthoclase, biotite and quartz along with dark splotches that seem a bit out of place. The dark splotches are thought to be xenoliths or enclaves. Xenoliths are chunks of country rock that were broken off and incorporated into the magmatic intrusions and subsequently altered by contact metamorphism. Several newer hypothesis suggest the blobs are enclaves, which are formed by contrasting magmas swirling past one another… something akin to a lava lamp.

Figure 52 - Remnants of 1982 rock fall that dumped over 100K tons of rock.

Figure 51 - Xenoliths (or enclaves) exposed in the El Capitan granite by the 1982 rock fall. Note the mechanical pencil for scale in the bottom left corner.

To Stop #2-8 (37.715511°, -119.677322°) - Tunnel View

39.8	0.0	Return to vans. Proceed into the park on HWY 140 – go 3.1 mi.
42.9	3.1	Keep right & cross bridge over Merced River & continue one-way – go 0.9mi.
43.8	0.9	Turn right onto HWY 41 towards Wawona/Fresno – go 1.6 mi.
45.4	1.6	Arrive at Tunnel View. Park in either lot.
		Time allocated: 20 min.

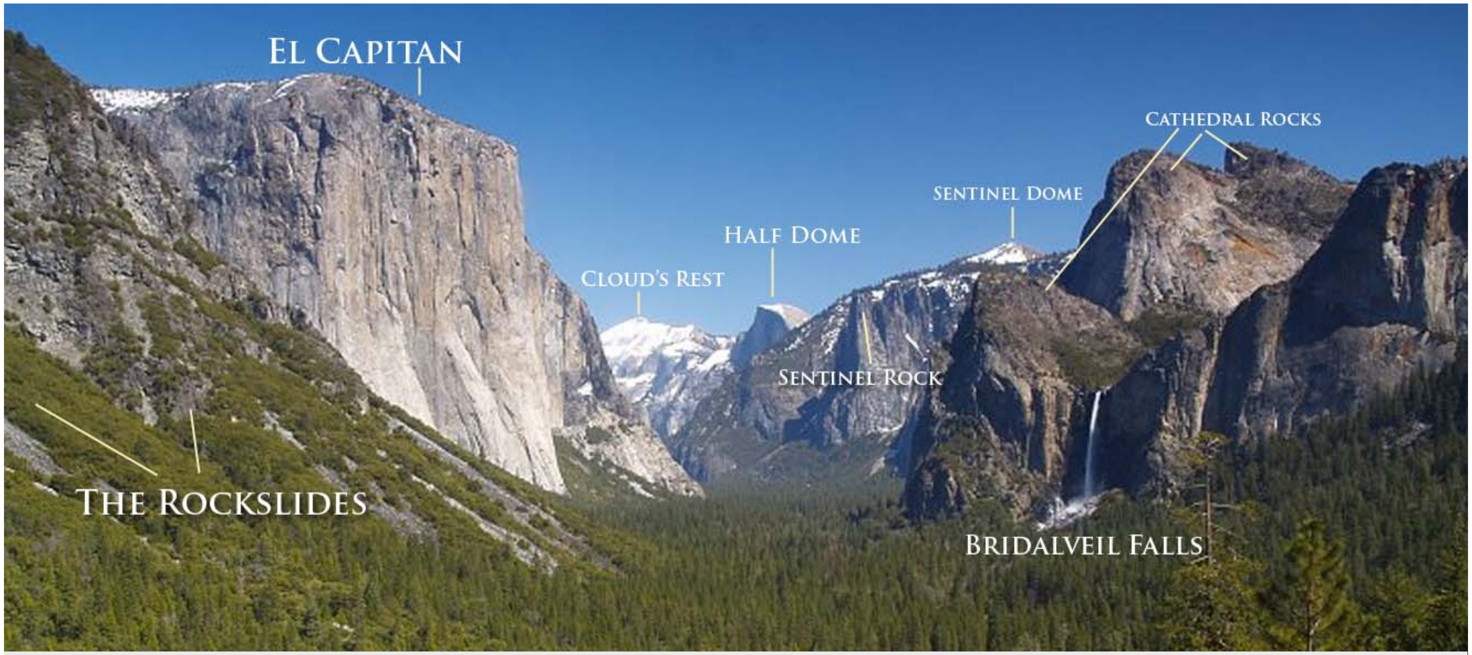


Figure 53 - Description of landmarks seen from Tunnel View.

Welcome to Yosemite. This is the classic view made eternally famous by Ansel Adams. From the recently refurbished parking lot vantage point take several minutes to soak-in the amazing overview before contemplating the geology of the area. Referring to Figure 53 lets work from the left of the view to the right identifying some major landmarks and points of interest. On the very left in the foreground of El Capitan are the "Rockslides", slopes consisting of Jurassic diorite (Batemen, 2002). Note how futile its resistance to jointing has been as evidenced by the huge talus slopes. The large vertical cliff behind the talus is El Capitan (2,330 m; 7569 ft) which is the largest shear granite wall in the entire world with a drop of almost 950 meters (3,000 ft). The El Capitan granites are about 103 Ma. In the far center distance is the arête known as Cloud's Rest (3,027m, 9930 ft) which is composed of Half Dome granodiorite. Next to Cloud's Rest closer to the foreground is the unmistakable Half Dome (2,720 m; 8,842 ft), also comprised of Half Dome Granodiorite. Shifting our view again to the right we spy the craggy Sentinel Rock (2,165 m; 7,038 ft) composed of 94 Ma Sentinel Granodiorite, and the higher rounded

Sentinel Dome (2,498 m; 8,117 ft) composed of the less-jointed 103 Ma El Capitan Granite. Swinging our view to the right once again, the three Cathedral Rocks also made up of El Capitan Granite (1,726 m, 5,610 ft; 2,015m, 6551 ft; and 2,042m, 6,638 ft) line the eastern extent of Bridalveil Fall's hanging valley. The falls plunge over 620 ft, the mist of which often creates very photogenic springtime rainbows.

Now that you're hopefully familiar with the lay of the land, we'll get into specifics at more appropriate stops, but you should start asking yourself if you see any "classic" glacial features.

To Stop #2-9 (37.712383°, -119.586189°) - Taft Point Fissures Hike

45.4	0.0	Return to vans. Proceed up HWY 41 towards Wawona – go 7.6mi.
53.0	7.6	Turn LEFT onto Glacier Point Road – go 13.4 mi.
66.4	13.4	Arrive at parking for Taft Point Fissures Trail on left.

May require parking on right shoulder during busy season.

Time allocated: 2 hrs.

HIKE: 2 miles out & back. 250' Elevation loss & gain.

Figure 54- The view from Taft Point obtained while young and brazen (crazy). El Capitan in distance.

Fill your water bottles, put on your hiking shoes and bring your camera with an extra set of nerves. This short hike will take you across three different igneous bodies and bring you face to face with amazing joints that allow you to peer nearly 2000' below. The hike is relatively flat most of the way and will take you over the 94 Ma Sentinel Dome Granodiorite, the 96+Ma Taft Granite and terminates at Taft Point on the 103 Ma El Capitan Granite. The fissures occur near the end of the trail within the vertically jointed Taft Granites. Granites tend to develop joints from unloading that will parallel nearby canyon walls, hence the verticality here. Carefully look at the slim grooves that one could literally jump over. Continue on to the barred Taft Point for a lofty view of Yosemite Valley. You'll notice El Capitan to the left and Yosemite Falls to the right center across the valley. The falls are the some of the tallest composite falls in the world falling a combined 2,425 ft. In most years the falls run dry by September until the next rains and snows. You might also ponder why the falls take the path in which they do. Just to the left of the falls is the Yosemite Falls Trail that looks like a much better candidate for a stream bed. It turns out that a moraine from one of the most recent ice-ages diverted Yosemite to its current position. Speaking of ice, the Sherwin Glaciation of 760,000 years ago filled Yosemite Valley to the brim. It's hard to imagine the scene before us covered in ice.

If you're really brave and want to feel the ill-effects of your stomach twisting, lie flat on your belly and creep your nose over the edge of the precipice. Like a scene from a panicked dream, you'll feel your body press into the rock beneath you as if gravity somehow increased five-fold. The spectacle is dizzying, but exhilarating. Return to the van to take the wobble out of your knees.

To Stop # 2-10 (37.727211°, -119.574483°) - Glacier Point Overlook

66.4 0.0 Return to Vans. Proceed to the terminus of Glacier Point Road – go 1.9 mi

68.3 1.9 Arrive at Glacier Point Parking Lot. Park & rendezvous at gift shop.

Time allocated: 40 min, including restrooms.

The views form Glacier Point are truly world-class and offer a great vantage point for discussing the geologic history of the park. From here we can see the magnificent extent of the park's granites and subsequent work of various glaciations. The granites were emplaced in many small episodes during the Mesozoic form a subduction process analogous to today's Cascadia and Nazca subduction zones in North and South America, respectively. Sinking oceanic slabs were heated and melted, and, as their mafic magmas rose towards the surface, accumulated silica-based minerals from partial melting and other processes. Not surprisingly there is much evidence (which we will see tomorrow) of tremendous amounts of volcanism during this time. The magma that was still many miles beneath the surface eventually would cool and crystallize into granites that comprise the Sierra Nevada batholith.

Figure 55 - Little Yosemite Valley as seen from Glacier Point. Vernal Falls in foreground shadow, Nevada Falls in center next to Liberty Cap.

As stated earlier, the uplift of the current Sierras didn't commence until 9-10 million years ago. As the overlying rocks atop the granites were eroded away by means of rivers glaciation the granites became exposed. With the external pressures of overlying rock now absent, the granites began expanding, which produced jointing in sheet-like slabs known as exfoliation (a term I have to point out that my dad, a PE teacher, taught me when I was three). When looking at Half Dome, North Dome and Liberty Cap Dome from this vantage point one can see the awesome domed appearance created by such exfoliation. The sheeting, jointing and exfoliation expectedly create geologically frequent rockfalls. You're standing very near the site of detachment of the July 1996 Happy Isle rockfall that killed one person and created an airblast that shattered 300 trees over a 10 acre swath. The fresh scar of the largest rock fall of the past fifteen years can be seen just to the left Half Dome's base on Ahwiyah Point. The freed slab of granite fell 1,800 feet before shattering with a force that registered as magnitude 2.5 on local seismographs. The remnants of the rockfall are easily accessible via the Mirror Lake Trailhead, but the area is still very dangerous and should not be approached.

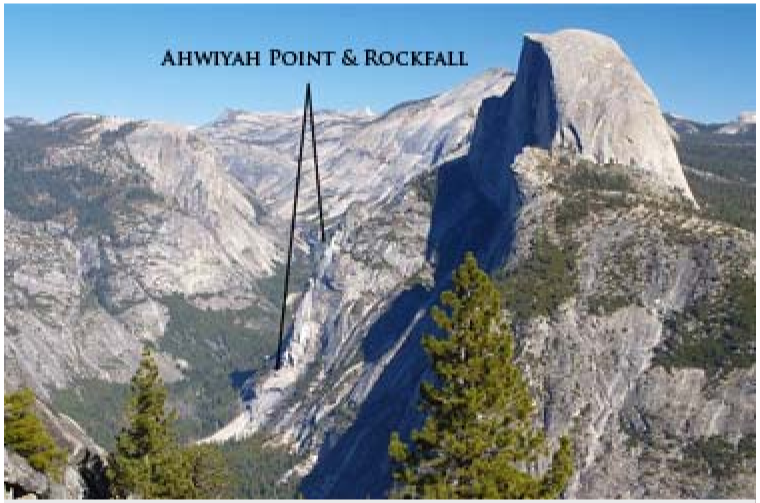


Figure 56 - Not so Half Dome & Ahwiyah Point Rockfall as seen from Glacier Point area.

Glaciation within Yosemite There are three distinct periods of glaciation recognized within Yosemite Valley, as seen in the table below, and Glacier Point is as good of a place to view the features as anywhere else in the park.

Glacial Stage	Approximate Age *years before present*
Tioga	9,900 – 25,500
Tahoe	56,000 – 118,000
Sherwin AKA Pre Tahoe	> 760,000

The Sherwin glaciation was by far the largest and was responsible for the majority of the sculpting of Yosemite Valley and Little Yosemite Valley. Only the tops of the highest peaks above 7,000' in the valley were immune to carving by the icy bulldozer. Vertical jointing in Half Dome weakened the rock sufficiently to have a quarter of its face removed by the Sherwin glaciation leaving behind the iconic monolith we see to today. Jointing and mass wasting have since obscured much of the evidence of the glaciers from the valley walls (Huber, 1987). Subsequent glaciations (Tahoe & Tioga) reworked the jointing within Little Yosemite Valley, plucking and removing vulnerable rocks to create the stair steps that produce the amazing Vernal (318') & Nevada (594') Falls. During tomorrow's trip to the high country we'll see first hand evidence of glaciation as well an actual glacier for those willing to accept the challenge.

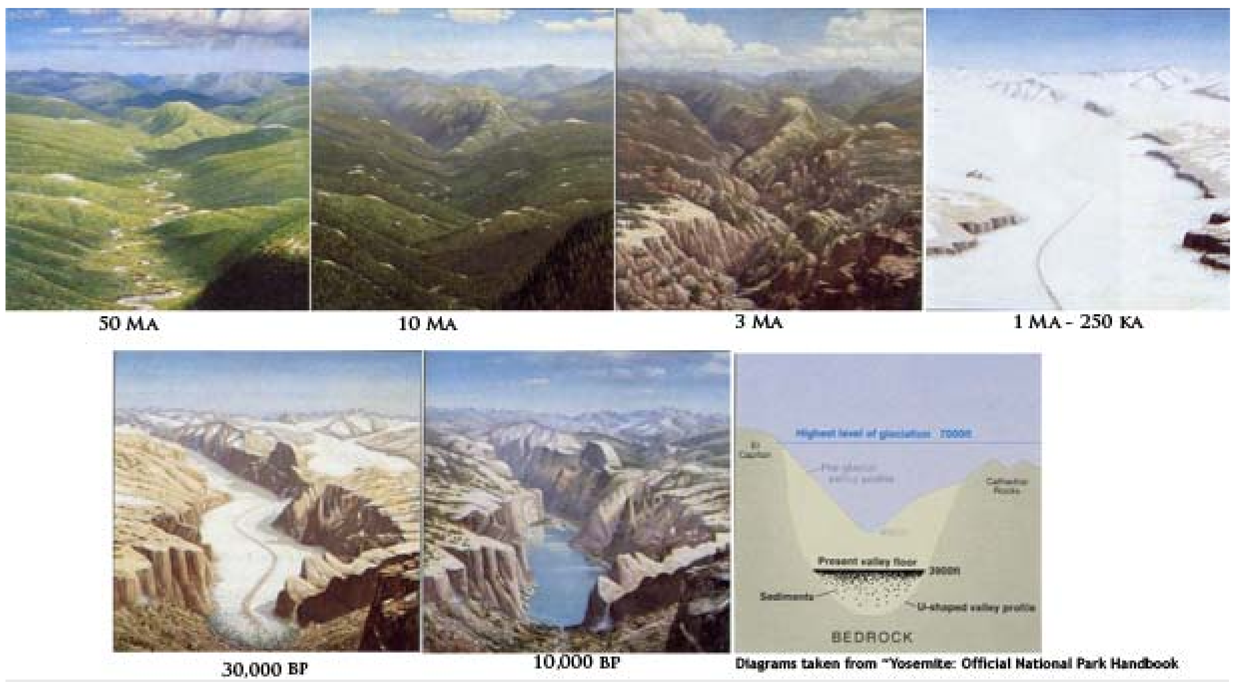


Figure 57 - Evolution of Yosemite Valley and its glaciations.

Figure 58 - Bridalveil Falls

<u>To Stop # 2-11 (37.716576°, -119.652267°) -Bridalveil Falls Visit</u>

68.3 0.0 Return to vans. Take Glacier Point Road back towards valley floor – go 15.3 mi

83.6 15.3 Turn RIGHT onto HWY 41 – go 9.2 mi.

92.8 9.2 Arrive at Bridalveil Falls parking lot. Park & meet at trailhead.

Time allocated: 20min

This is an easy chance to actually feel the spray and experience the forces associated with Bridalveil's 620ft dive off of the hanging valley. Take the quick quarter mile hike to the falls, gawk, snap some photos and return to the vans.

<u>To Stop # 2-12 (37.721046°, -119.647217°) - Bridalveil Moraine & Ribbon Falls</u>

92.8 0.0 Return to vans. Turn RIGHT out or parking lot and head into Yosemite Valley – go 0.1mi

92.9 0.1 Keep right and merge onto HWY 140 – go 0.3 mi.

93.2 0.3 Arrive at moraine. Park on right side of road next to meadow.

Time allocated: 10 min

Figure 59 - Bridalveil meadow moraine, the dam responsible for Lake Yosemite's formation over 10,000 years ago.

Figure 60 - Ribbon Falls. 1612 feet of free fall is the most in Yosemite.

Walk east along the side of the road until coming across a road cut containing a large jumble of unsorted and relatively angular rocks. This is the recessional moraine left behind by the most recent Tioga Glaciation. The moraine dammed the Merced River creating Yosemite Lake for several thousand years as evidenced by lake-bottom sediments. The sediments also hide the fact that Yosemite is indeed a U-shaped glacially carved valley. The bottom of the "U" in this valley has been filled to create the flat amazing valley we presently see.

If you look to north wall across the meadow, you will also see in normal years the sinuous Ribbon Falls, which is in fact the highest free-falling waterfall in the park at 1612 ft.

To Stop #2-13 (37.738312°, -119.571671°) - End of Guided Day at Curry Village

93.2	0.0	Return to Vans. Continue into valley – go 4.8mi
98.0	4.8	Turn RIGHT into Curry Village – go 0.1mi
98.1	0.0	Park in Curry Village Parking Lot.
		Be ready to hit the road tomorrow at 8am to head for the high country.

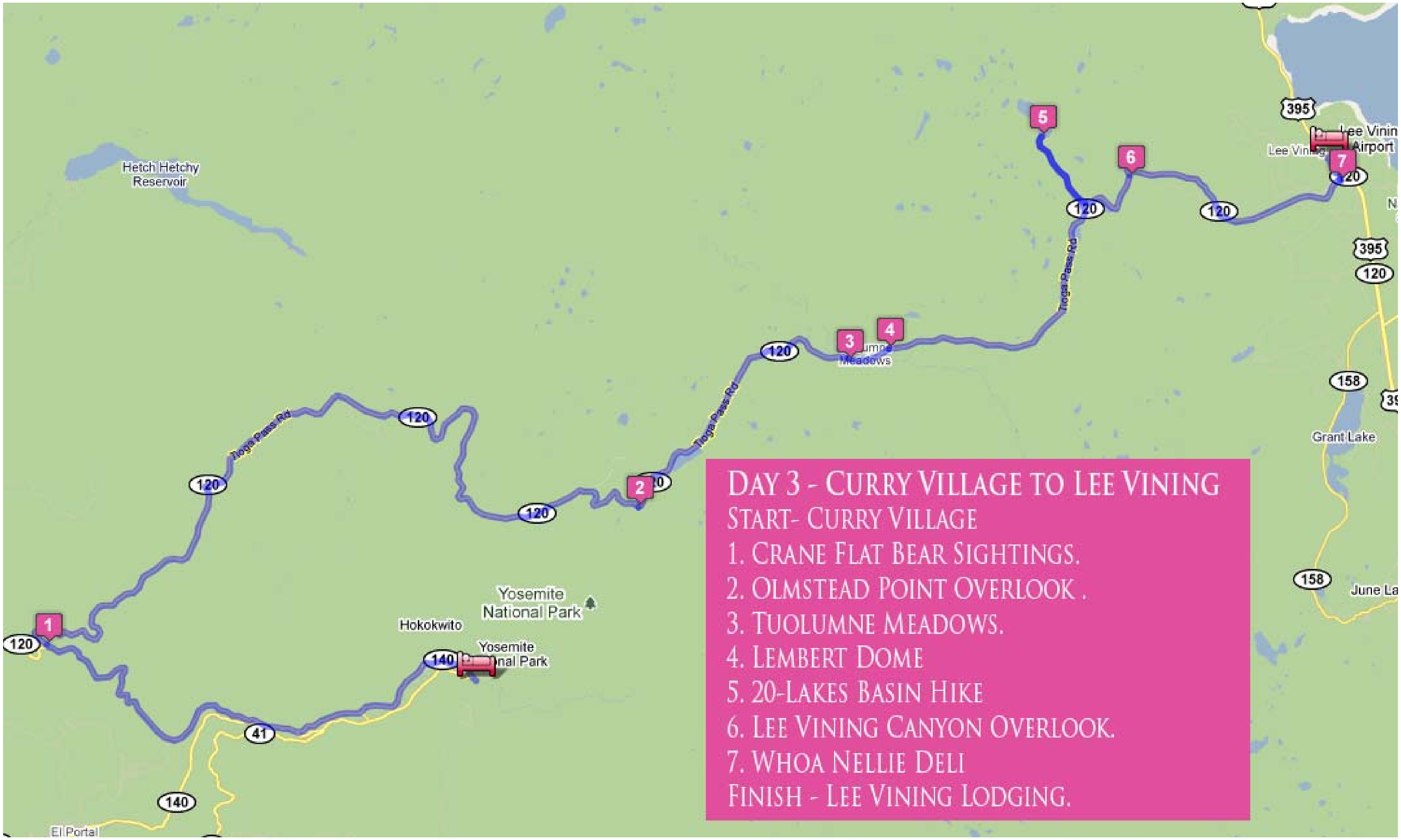
Check into tent cabins at Curry Village. Don't be too afraid of rocks falling off Glacier Point into your tent. Canvas stops everything. But if you do hear a thunder in the middle of the night, make like a track star and sprint for the valley meadows away from the cliff. After enjoying a meal at one of the many fine eateries in the Village feel free to take the free shuttles to stops around the valley. If you're up for more easy hiking, I'd head for Mirror Lake to check out the most recent large rockfall at Ahwiyah Point beneath Half Dome. The stroll to Lower Yosemite Falls is a great flat and short choice to aide in digestion. Movies in the visitor center and ranger talks are also generally available in the evenings. For the photographers at heart, I recommend hiking a short half-mile to the nearby meadows to catch the sunset on Half Dome and Cloud's Rest. If you're lucky you might even catch a hint of blazing orange alpenglow.

Figure 62 - Curry Village tent cabins. Our home for the evening and a black bear highway.

Figure 61 - Meadow across from Yosemite Falls. A great evening stroll to help you dinner digest.

Day 3 – Curry Village to Lee Vining: We're on Top of the World.

Day three has us up and exploring the very highest reaches of the Central Sierra. Alpine scenery out of a calendar awaits around every corner… along with the story of how it formed. Make sure your memory card is empty, because you're going to burn through images like nobody's business today.



Mileage

Cum.	**Interval**	**To Stop #3-1 Crane Flat and Bear Sightings (37.753548°, -119.798653°)**
0.0	0.0	Head west on Yosemite National Park Rd toward Southside Dr - go 0.1 mi
0.1	0.1	Continue onto CA-140 W/Northside Dr - go 7.3 mi
7.4	7.3	Turn right at Big Oak Rd (signs for CA-120/Tioga Rd/Manteca) - go 9.4 mi
16.8	9.4	Slight left at Old Yosemite Coulterville Rd - go 404 ft
16.9	0.1	Take the 1st right onto CA-120 E/Ireland Lake - go 0.1 mi
17.0	0.1	Arrive at Crane flat Road intersection and bear sightings
		Time allocated: 10min

Crane Flat, at an elevation near 6,200', is a fair-sized meadow that has gathered detritus and pond sediments since last retreat of the glaciers. The soils provide for a marsh-like environment during the late spring and early summer snow melts. The abundance of vegetation and insects has in recent years become a large attractant for several black bears (the only species of bear remaining in California) and thousands of visitors who have found easy viewing of the bears from the Crane Flat roadside. Perhaps we'll get lucky today and see one of the bears. If not, we'll head up the mountain where we'll have bigger fish to fry.

		To Stop #3-2 Olmstead Point (37.810867°, -119.485069°)
17.0	0.0	Head northwest on CA-120 E/Big Oak Rd/Tioga Pass Rd toward Big Oak Rd - go 29.2 mi
46.2	29.2	Arrive at Olmstead Point
		Time allocated: 15min

Olmstead Point provides one of the classic "reverse" views of Yosemite Valley. To the right of center of the view is Half Dome, which from this angle looks rather fin-like and not so dome-ish. To the left of center is the looming peak of Cloud's Rest which we first spied in the far background during yesterday's stop at tunnel view. To the far left, almost directly behind us, the vantage point allows views down to Tenaya Lake, the largest natural lake in Yosemite and a popular summer rafting stop. This stop is of significant for several reasons. First, we'll take a short stroll to the right of the parking lot to the top of glacially-polished knobs. Reaching down and feeling smoothness most only know on their kitchen countertops provides a visceral connection to the massive glaciers that several times poured down the valley with rocks and grit grinding over the surface of where we now stand. The

Figure 63 - Example of a large erratic at Olmstead Point.

knob also affords a close-up look at several small glacial erratics, once trapped in the ice but left where they are now by the receding and melting glaciers. The erratics are in fact key pieces of evidence that help geologists determine the path the glaciers took. Many of the erratics at this point are made of granodiorites that originated in Tuolumne Meadows and beyond. By tracing the path back to where the erratics originated one can reconstruct exactly how the glaciers traveled. The height of the glaciers can also be determined from this stop with a quick glance over to Cloud's Rest. One will note the very distinct elevation where polished & smooth canyonside transitions into jagged, exfoliated exposures about half-way up the canyon. The transition point is known as the trim line (figure 64). Also of note at this stop are the great exposures of exfoliation (sheet jointing) in the road cut behind the observation parking lot. Recall that the sheeting is formed as pressure is released from the tightly crystallized rocks.

Figure 64 - Glacial trim line on Cloud's Rest showing maximum thickness of glaciers in canyon.

		To Stop #3-3 Tuolumne Meadows (37.872051°, -119.374062°)
46.2	0.0	Head east on CA-120 E/Tioga Pass Rd - go 9.1 mi
55.3	9.1	Arrive at Tuolumne Meadows
		Time allocated: 20 min

This is a brief rest stop to use the last flush-facilities until Lee Vining at the end of the day. Spend se veral minutes to use the facilities and check out the visitor's center which will provide a small bit of background for our next stops today. After that we'll head to our next stop, Lembert Dome.

Figure 65 - Tuolumne Meadows in late fall with some awesome lenticular clouds to boot.

At an elevation of 8,600', Tuolumne Meadows holds the distinction of being the largest subalpine meadow in the Sierra Nevada. This area is typically under fifteen feet or more of snow in normal winters, and the road over this pass rarely opens before June due to the large amounts of snow and avalanche concerns on the road. The meadow is also the point of confluence for the Dana & Lyell Forks of the Tuolumne (too-all-um-nee) River, which originate on the flanks of Mt Dana and Mt Lyell, respectively. The river that flows through this meadow actually ends up in an odd location… the taps of 1.7 million San Franciscans via Hetch Hetchy Reservoir. Nearly 208 million gallons per day flow from the impoundment via hundreds of miles of pipes to the Bay Area. The remainder of the Tuolumne is impounded again at Don Pedro Reservoir which provides the majority of agricultural water for the Turlock Irrigation District. Currently, only 39% of the Tuolumne's flows ever reach the ocean.

Just beyond Tuolumne Meadows, the river drops sharply into the Grand Canyon of the Tuolumne, one of the more popular and spectacular backpacking destinations in the park.

To Stop #3-4 Lembert Dome (37.877056°, -119.353043°)

55.3	0.0	Head southeast on CA-120 - go 1.3 mi
56.6	1.3	Arrive at Lembert Dome trailhead
		Time allocated: 15 min

Figure 66 - Lembert Dome. A roche moutanee (sheep rock) that had its lee side plucked as glaciers flowed over the rock.

Close observation of the nearly 500' tall Lembert Dome reveals an odd shape. The dome itself is made of the 88 Ma Cathedral Peak Granodiorite, much like the surrounding mountains of Tuolumne Meadows. However, instead of being completely rounded on all sides like the domes near Tenaya Lake, Lembert "dome" actually exhibits an inclined ramp from the east with its western face steeply dropping into jointed jumbles. Lermbert is in fact no dome at all, rather a roche moutonnee (sheep shaped rocks). Roche moutonnees are formed when glaciers completely overrun basement rocks, smoothing a polished slope in the direction of the glacier's travel and plucking joined pieces on the leeward side of the rock. The plucking is responsible for the precipitous drop. Evidence points to the fact that Lembert Dome was in fact drowned by nearly 1,500' of ice during the most extensive periods of glaciation. Fairview Dome, at the far end of Tuolumne Meadows stands nearly 1,000' above the meadow, but it too is a roche moutonnee, once completely overtopped by glaciers 500' higher than the dome itself. Try to find the glacial trim lines on the sides of Cathedral Peak to provide you with a hint of just how encompassing the glaciers were in this area until 10,000 years ago.

To Stop #3-5 Saddlebag Lake Resort (37.965855°, -119.271873°)

56.6	0.0	Head east on HWY 120 and exit park - go 9.1 mi
65.7	9.1	Sharp left at Saddlebag Lake Rd - go 2.5 mi
68.2	2.5	Arrive at Saddlebag Lake Resort
		Time allocated: Until 6pm

REFER TO TOPO & GEOLOGIC MAPS IN APPENDIX

Welcome to one of the most breathtaking areas in the entire nation. If the 10,060' elevation at Saddlebag Lake doesn't purloin your pulmonary response, the vistas most certainly will. This is where we will spend the majority of the day hiking into the amazing Twenty Lakes Basin of the Hoover Wilderness. We'll take the water taxi across Saddlebag Lake to shave-off nearly four miles of hiking and dump us off into the land where "awesome" was invented. During your

Figure 67 - Shamrock Lake, one of twenty in the basin.

allotted time in the wilderness you'll have free reign to explore the entire basin that exhibits a wonderfully glaciated landscape consisting of both the Sierra Nevada batholith as well as amazingly metamorphosed roof pendants that range in age from Paleozoic (360-240 Ma) to the unconformably overlain rocks representing upper Jurassic (185 Ma). In some cases you'll even get to walk the actual contact between the batholith metamorphics. For the really brave and in-shape, views of Conness Glacier can also be attained. Your only task on this hike is to identify as many glacial and intrusive features as possible while also being mindful of the many steeply dipping metamorphic formations that you'll cross. Referencing the included geologic map should be of tremendous value for this exercise. I would highly recommend a camera for this hike as the flowers, water features and mountains are truly amazing and only rarely get in the way of the rocks. Digital pictures are also easily shared at the hotel in the evening for further discussion.

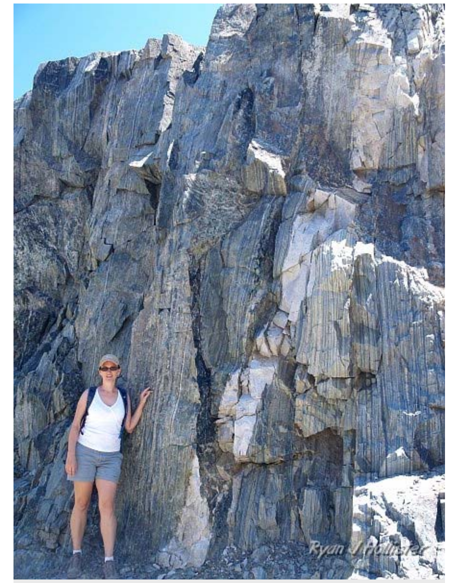


Figure 68 - Jurassic aged volcanic lake sediments now uplifted and vertically dipping.

Now for the hike's logistics. Be sure to load your daypack with your lunch and snacks, as well as at least two liters of water. The elevation tends to dehydrate hikers at a higher rate. Also make sure the DEET is in your case as the mosquitos can at times be hellish, depending on how much time has elapsed between the snow melt and our hike. The loop trail around the Twenty Lakes Basin is a mere 4.5 miles with a rolling 572' of elevation gain. For those who stroll at a leisurely pace and pause frequently, staying on the trail will most likely allow you to finish the hike in less than four hours. That gives lots of time to relax, explore, photograph and fish the area. The loop hike will take you by most of the different outcrops of rock, from strongly metamorphosed continental sediments to vertically dipping volcanic ash layers from Triassic Lakes. Towards the end of Steelhead Lake one can view the remnants of the Hess Tungsten Mine that operated from the early 1940's into the early 1960's along the contact between the pluton and metamorphics. If you venture far off trail keep a sharp eye out for other prospect pits along the contact.

For those who are more adventurous and adept at cross-country hiking, zig-zagging across the interior of the trail loop past Z-Lake and Twin Lakes is very fun. Along with the many lakes that filled-in the depressions gouged by the glacial retreat, those traversing the interior will find tons of chatter marks, gouging and erratics ten feet in diameter that originated off the high faces near North Peak.

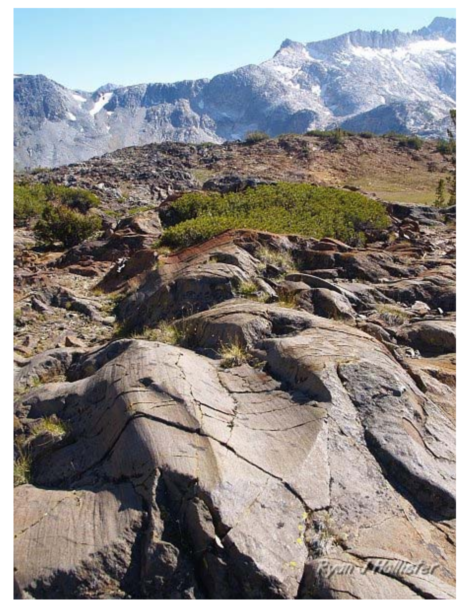


Figure 69 - Paleozoic metasedimentary rocks with deep glacial gouging.

The uber-hike in the area is to Conness Lakes and, if global warming hasn't yet run its course, Conness Glacier. The hike is only 2.5 miles one way but gains nearly 800'. The trail is also mostly cross-country, and the lakes are most easily reached after walking in the southwest portion of the loop trail and peeling-off to the west/southwest at an unnamed lake between Greenstonte & Wasco Lakes. From here you'll be within the Harvery

Monroe Hall Research Area which studies many biological processes in an undisturbed, natural setting. Now all that's needed is to skirt to the right of the 100' waterfall whose waters originate from the Conness Lakes. Following the use trail you find once above the bare rock will lead you to the Conness Lakes nestled at the base of Mount Conness. A quick glance up the hill will reveal the receding remnants of Conness Glacier, not expected to last more than fifty years at current recessional rates. Fishing enthusiasts will find fine golden trout in the Conness Lakes for a bit of catch and release fun.

After the hike we'll meet back at the boat dock at a predetermined time to meet the water taxi for our journey back across the lake.

To Stop #3-6 Lee Vining Canyon and Lateral Morraines (37.949306°, -119.224747°)

68.2	0.0	Head west on In04/Saddlebag Lake Rd toward Junction Campground Rd - go 2.6 mi
70.8	2.6	Continue onto CA-120 E/Tioga Pass Rd - go 2.1 mi
72.9	2.1	Arrive at Tioga Pass Moraine
		Time allocated: 10 mi.

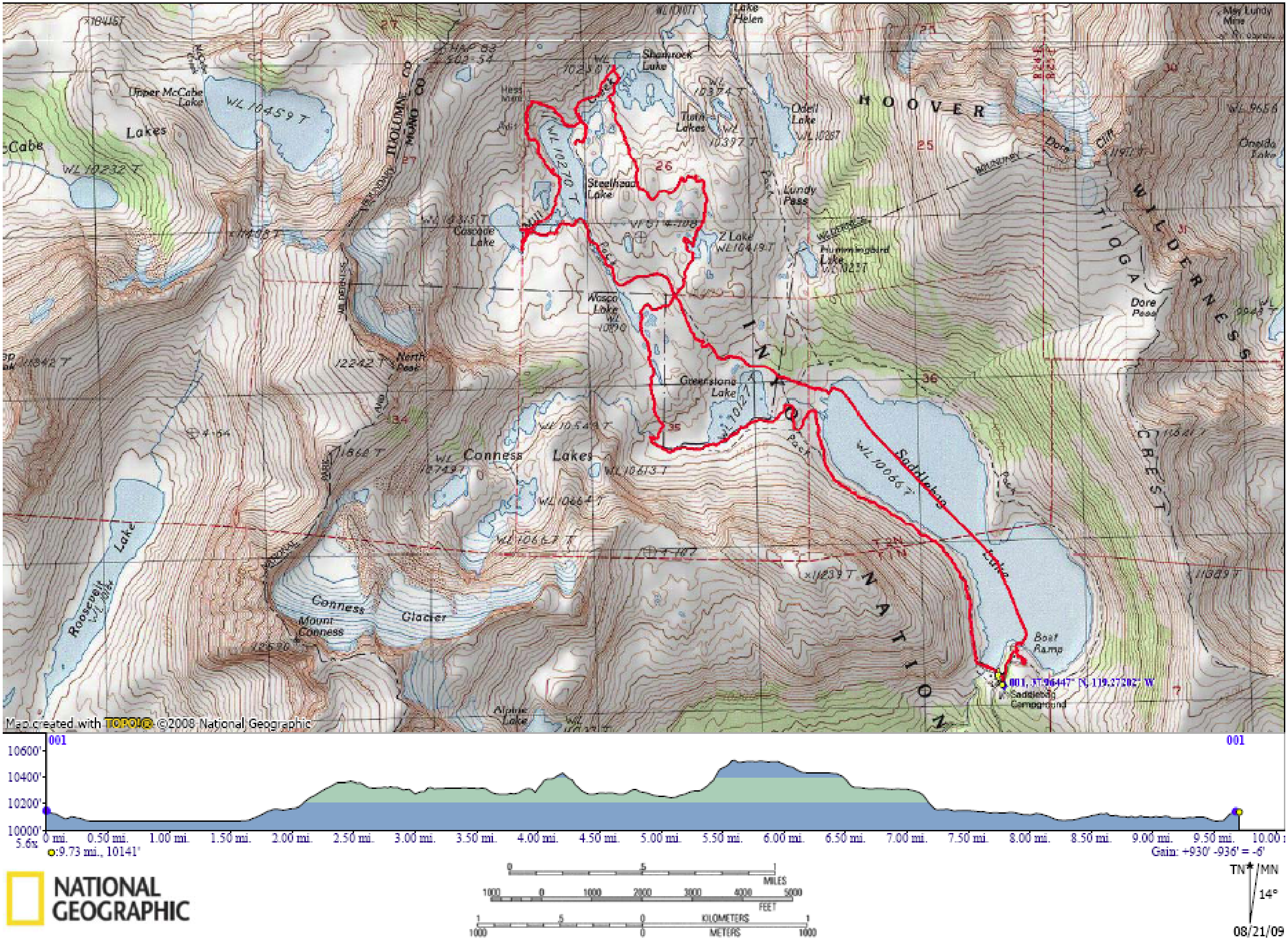
This stop is part engineering marvel and also gives us our first good look down the Eastern Sierra Escarpment which has risen quite rapidly due in part to what is now assumed to be lower crust delamination. The Tioga Road up Lee Vining Canyon was first constructed for automobile use in 1915 and remained a dirt road into 1937. The Lee Vining Grade was again re-engineered and paved from 1965-1970. The precariousness of the road along Lee Vining Canyon can give acrophobics a fit and a second thought to drivers who stop to enjoy the view.

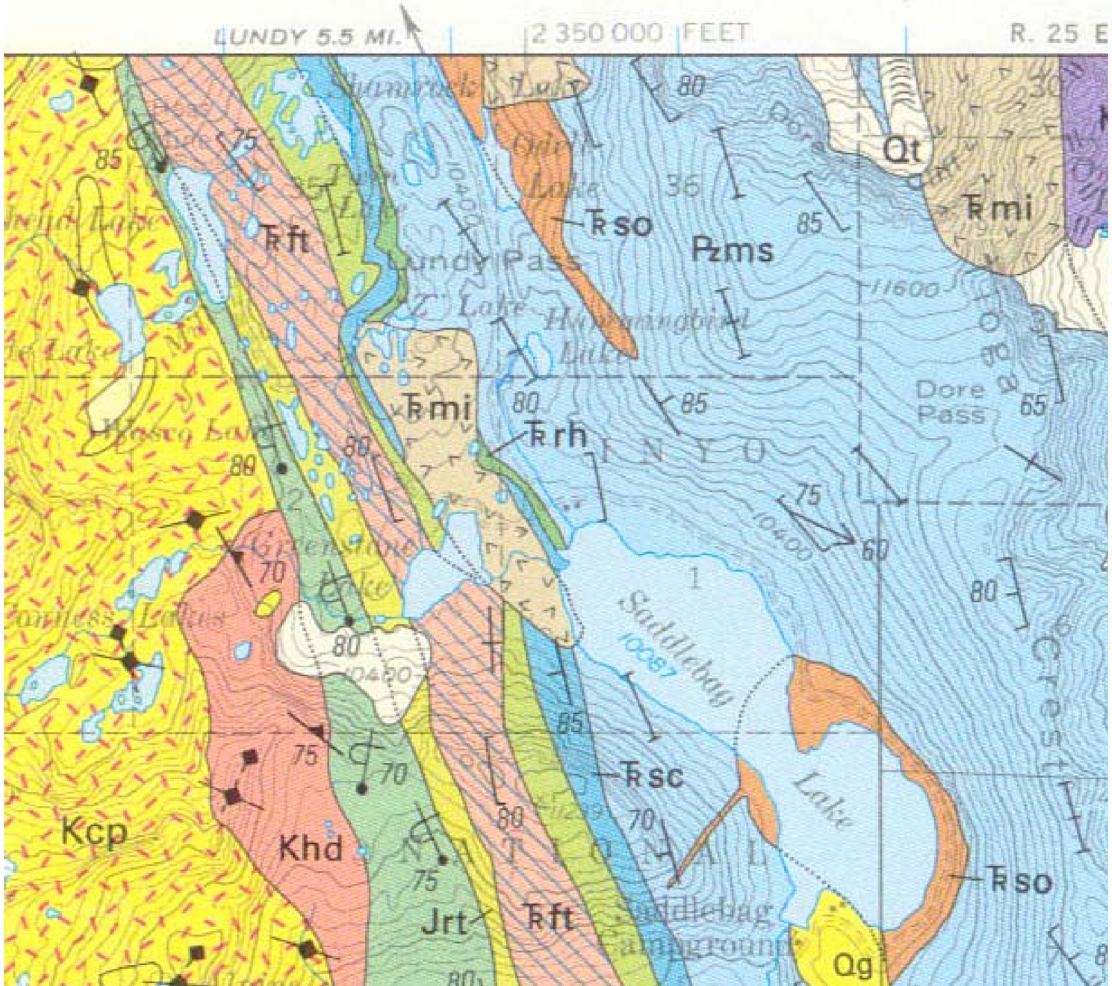
Lateral moraines are visible at the far end of the canyon. Close inspection of satellite images actually show a series of lateral moraines pressed against one another, a testament to the several different episodes of glaciation that spilled out of this canyon. Several miles down the road, just before we turn off for the Whoa Nellie Deli, you will be able to fully appreciate the 500' tall moraines. The view from the road provides an easy look at the jumbled and unconsolidated till within the moraine.

One last tidbit is that the steep gradient of Lee Vining Creek is utilized by electric companies to produce small-scale hydroelectric power. The creek may be small, but the energy generated by the long fall has been more than enough to keep the Poole power plant at the base of the falls in operation since 1923. The damming of Saddlebag Lake, Ellery Lake and Tioga lake provides a fairly consistent flow throughout the year.

Figure 70 - Lee Vining Canyon

Saddlebag Lake to 20 Lakes Basin





marginal to the central mass

- Kcp — CATHEDRAL PEAK GRANODIORITE—Medium-grained hornblende-biotite granodiorite that contains conspicuous blocky megacrysts of K-feldspar 2 to 5 cm across. Megacrysts are largest and most abundant in the margins of the body and are progressively less abundant and smaller inward. Foliation is generally weak. U-Pb zircon age: 88±2 m.y.

HALF DOME GRANODIORITE—Two facies recognized:

- Khdp — Porphyritic facies—Medium-grained porphyritic hornblende-biotite granodiorite with a seriate texture. Biotite and hornblende commonly in euhedra. Abundance of K-feldspar megacrysts increases inward toward contact with Cathedral Peak Granodiorite. Megacrysts are generally smaller than those in the Cathedral Peak Granodiorite, are tabular rather than equant, and commonly are a little more than 1 cm across and 2 to 3 cm long
- Khd — Equigranular facies—Medium-grained equigranular granodiorite. Characterized by euhedral hornblende prisms 1 to 3 cm long, biotite books as much as 1 cm across, and conspicuous sphene
- Kga — TONALITE OF GLEN AULIN—Dark-colored rock of variable composition ranging from fine-grained quartz diorite in the west to medium-grained granodiorite

ferent ages

METAMORPHOSED SEDIMENTARY AND VOLCANIC ROCKS AND HYPABYSSAL INTRUSIVE ROCKS

Saddlebag lake area

- Kdp — DACITE PORPHYRY—Fine-grained gray rock composed of plagioclase phenocrysts in a matrix of plagioclase, quartz, and opaque minerals
- Kft — FELSIC TUFF—Quartz and feldspar crystals abundant, and collapsed pumice fragments present locally. Includes thinly laminated calc-silicate rock composed of quartz, feldspar, epidote, and opaque minerals
- Kph — PELITIC HORNFELS—Thin-bedded fine-grained metasiltstone composed of tiny grains of plagioclase, muscovite, quartz, and opaque minerals. Larger plagioclase grains are present locally. Crossbeds occur in some places
- Kmft — INTERSTRATIFIED MAFIC AND FELSIC TUFFS—Includes a lens of pebble conglomerate. Tuffs are composed chiefly of quartz, biotite, plagioclase, and opaque minerals
- Jlb — TUFFACEOUS LAKE BEDS—Thinly bedded and fine grained; composed chiefly of volcanogenic sediment. Common minerals include plagioclase, quartz, biotite, hornblende, and opaque minerals. Calcareous layers contain calcite, diopside, hornblende, epidote, and trace amounts of scheelite
- Jrt — RHYOLITE ASH-FLOW TUFF—Light-gray tuff with a few flattened pumice fragments. Phenocrysts of quartz and plagioclase are in a fine-grained matrix. Rb-Sr whole-rock age about 185 m.y.
- Ŧrmi — MAFIC HYPABYSSAL INTRUSIVE ROCK—Probably of andesitic composition. Mass northeast of Dore Cliff is porphyritic
- Ŧrso — MONZONITE OF SADDLEBAG AND ODELL LAKES—Altered biotite-hornblende monzonite. Probably hypabyssal and cogenetic with Triassic volcanic rocks. Rb-Sr whole-rock age: about 220 m.y.
- Ŧrft — MAFIC FLOWS AND TUFF—Pebble conglomerate at base of unit is overlain by tuffaceous beds of intermediate composition. Mafic flows at top of unit. Rb-Sr whole-rock age: 224±14 m.y.
- Ŧrrt — RHYOLITE ASH-FLOW TUFF—Light-gray tuff with many flattened pumice fragments generally 1 to 5 cm long. Phenocrysts of quartz and plagioclase are embedded in a fine-grained matrix
- Ŧrsc — TUFFACEOUS SANDSTONE, SILTSTONE, AND CONGLOMERATE—Lenses of rhyolite tuff are present in a few places. Conglomerate lenses apparently were deposited in stream channels. Flattened pebbles are identical with rock in Paleozoic strata down section to the east
- Ŧrrh — RHYOLITE TUFF—Mostly bedded
- Pzms — METASEDIMENTARY STRATA, UNDIFFERENTIATED—Quartzofeldspathic hornfels, calc-silicate hornfels, and carbonaceous marble in the northeast corner of the quadrangle

Northwest and southeast parts of quadrangle

- Jmgd — MICROGRANODIORITE—Hypabyssal intrusive rock east of Vogelsang Lake. Ranges in composition and texture from microgranodiorite to granite porphyry and intrusive rhyolite
- Jmv — METAVOLCANIC ROCKS SOUTH OF IRELAND LAKE—Also includes septum 2 km northwest of Hooper Peak in the northwest corner of the quadrangle and a small mass 2½ km west of Babcock Lake in the south-central part. Predominantly tuff-breccia of intermediate composition containing angular to rounded fragments that average 2 to 10 cm across but are as large as 75 cm
- Jms — METASEDIMENTARY ROCKS WEST OF IRELAND LAKE—Thinly laminated calc-silicate hornfels and quartz-biotite schist with epidote layers and "eyes." Locally interbedded with volcanic conglomerate
- Jm — UNDIFFERENTIATED METASEDIMENTARY AND METAVOLCANIC ROCKS NORTH OF HOOPER PEAK—Pattern indicates abundant dikes of the adjacent plutonic rocks

West side of quadrangle

- pKcs — CALC-SILICATE HORNFELS, QUARTZITE, AND SCHIST—In pendants and septa between Glen Aulin and May Lake
- pKq — MASSIVE QUARTZITE—Associated with other metasedimentary rocks in metamorphic remnants between Glen Aulin and May Lake

To Stop #3-7 Whoa Nellie Deli (37.947647°, -119.113342°)

72.9	0.0	Head northwest on CA-120 E/Tioga Pass Rd toward In21/Poole Power Plant Rd - go 7.5 mi
80.4	7.5	Turn right - go 226 ft
80.4	226 ft	Arrive at Mobile Gas Station – Deli inside!
		Time allocated: Enjoy a leisurely dinner. You've earned it.

Parked at the end of the lateral moraine and housed within a Mobil gas station, the Whoa Nellie Deli is the best gourmet fast food you will encounter, especially after a hard day's hike. The menus is eclectic ranging from Kansas City Steak Salad and Jambalaya to Lobster Tacos and Buffalo Burgers. If we hit the night just right, one might also be able to partake in the live music that often plays as the sun goes down over the hills and casts an amazing hue of peach onto Mono Lake.

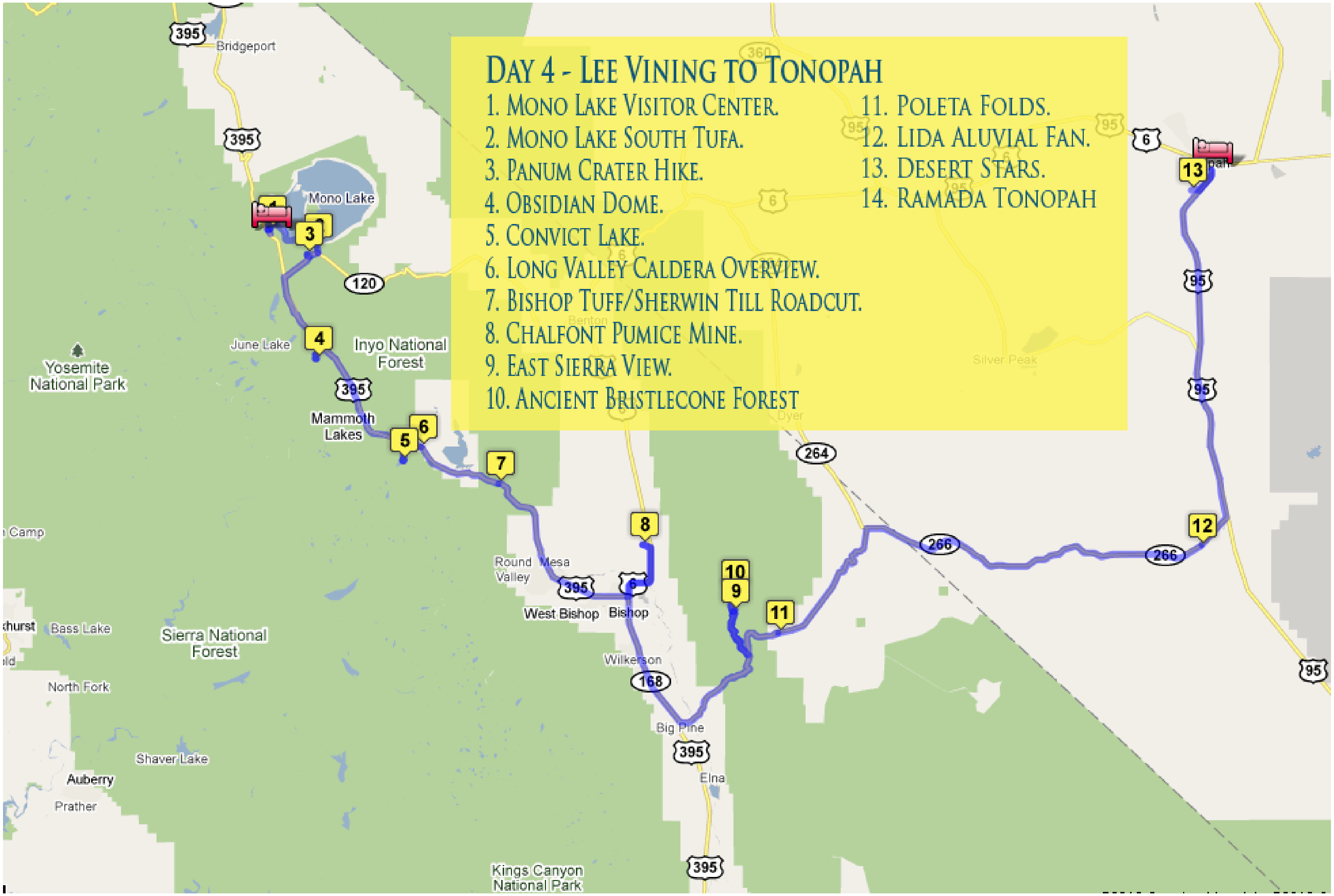
To Stop #3-8 Lee Vining Lodge (37.957058°, -119.120102°)

80.4	0.0	Head northwest toward CA-120 W/Tioga Pass Rd - go 226 ft
80.4	226 ft	Turn right at CA-120 E/Tioga Pass Rd - go 0.2 mi
80.6	0.2	Continue onto Pumice Rd - go 0.2 mi
80.8	0.2	Make a U-turn - go 0.2 mi
81.0	0.2	Take the 1st right onto US-395 N - go 0.6 mi
81.6	0.6	Turn left at 3rd St - go 266 ft
81.6	266 ft	Take the 1st right onto Lee Vining Ave - go 144 ft
81.6	144 ft	Arrive at Lee Vining Lodge
		Be ready to go tomorrow morning by 8:00am

As lodging in the area is consistently undergoing management changes, the exact hotel of choice will remain unlisted until the actual dates of the trip are announced. There are, as of this writing, several small motels that could accommodate our group.

Day 4 -Lee Vining to Tonopah: An Explosive Journey to the Edge of the World.

Today's journey will lead us past the amazing Eastern Sierra Escarpment and gives us a peek at Mt Whitney's Peak. We'll skirt the boundary between the Sierra Nevada and the Basin & Range province and along the way come across some great volcanic features as well desert erosional features.



Mileage

Cum.	Interval	To Stop #4-1 Mono Lake Visitor Center (37.965973°, -119.120033°)
0.0	0.0	Head to HWY 395 and turn LEFT – go 0.5mi.
0.5	0.5	Take the 2nd right at signed Entrance to Mono Lake Visitor Center - go 0.3 mi
0.8	0.3	Arrive at Mono Lake Visitor Center.
		Allocated Time: 20min

The Mono Lake Scenic Area Visitor center is our first stop of the day after gassing-up in Lee Vining. The museum showcases the wonderful human, natural, and geologic history of the Mono Basin and will provide some background information for our next stop at the South Tufa Preserve. Take several minutes to wander the museum, use the clean restroom facilities and maybe pick-up a few items at the museum's store. We'll meet back in the van in 20min.

		To Stop #4-2 Mono Lake South Tufa & LA Water Rights (37.938782°, -119.027084°)
0.8	0.0	Return to Vans. Head back out the Visitor Center Drive - go 0.2 mi
1.0	0.2	Before reaching HWY 395 turn RIGHT at Mattly Ave - go 0.2 mi
1.2	0.2	Veer right toward Picnic Grounds Rd - go 0.3 mi
1.5	0.3	Turn right at Picnic Grounds Rd - go 3.3 mi crossing Lee Vining Creek along the way
4.8	3.3	Veer left at Test Station Rd - go 3.8 mi crossing Rush Creek
8.6	3.8	Turn left to stay on Test Station Rd - go 0.2 mi
8.8	0.2	Arrive at South Tuffa Preserve.
		Allocated Time: 35 min

Figure 71- South Tufa stands. Remnants from when the lake was higher.

The lake basin is a relatively new feature on the landscape, as it is the down dropped block on the eastern side of the Sierra Nevada escarpment. Most age estimates place the basins origins at around four million years. Due to the stark Sierra Nevada rain shadow, Mono Lake is fed almost entirely by the Eastern Sierra snow runoff. The Sierra crest averages nearly 45 inches of precipitation annually, yet a mere 5 inches fall on the Mono Basin. Since the lake has no outlet, water accumulating in the basin has nowhere to go but up in this arid environment, which has an evaporation rate of nearly 45 inches per year. The evaporated water leaves behind its once dissolved salts to give the lake a salinity nearly twice that of ocean water.

During the Tioga and Tahoe Glaciations, Mono Lake was at least 600' deeper than present and was the starting point for a large series of Pleistocene lakes that were connected by rivers and eventually terminated at Lake Manly, in Death Valley NP. The lake was also actually higher than present prior to the early 1940's when the City of Los Angeles used its water rights to divert the many tributaries of Mono Lake into the Los Angeles aqueduct which leads to the thirsty LA basin. This caused a drastic drop in Mono Lake's levels, exposing Tufa Towers we are about to explore. Thanks to a few trout that re-established themselves in Rush Creek down stream of Grant Lake after the spillways were breached gave in 1983, Los Angeles Water and Power (LAWP) was required to maintain flows in the creek to protect the population. Those flows the fed back into Mono Lake causing the lake's surface to rise once again. Later court rulings in the 1990's mandated that Mono Lake's surface levels be maintained at 6,392'… 10' higher than present levels. Had we visited during the Pleistocene, Mono Lake would have been hundreds of feet deeper and would have been the start of a large chain of lakes that eventually drained into Lake Manly, known today as Death Valley.

Figure 72 - Sign marking 1963 water levels which is now the level State Law has mandated for the lake to maintain by the middle of this decade. Obviously the mandate is a work in progress.

The stars of this stop are the tufa towers, an amazing calcium carbonate precipitate that forms from the reaction of fresh spring water injected into the salty lake along sub lake fault systems. Calcium ions from the fresh water springs react with carbonate-rich lake water through a complex process utilizing the lake's algae to form the calcite and aragonite towers we see today. It should be noted that towers only form in an underwater environment and their verticality is due to the density differences in spring and lake water. The tufas that you will be exploring are only a few hundred years old, exposed after the LAWP diversions mentioned above.

Take several minutes to browse the area and hopefully take some memorable photos. Be sure to look for brine shrimp and algae, the only things that can actually live in the lake water, but which make a great primary food sources for many hundreds of species of birds.

Return to the van when done.

Figure 73 - Mono Lake as seen from HWY 395

To Stop #4-3 Panum Crater Hike & Volcanic History (37.924770°, -119.044029°)

8.8	0.0	Return to vans. Leave the parking lot Head east on Test Station Rd toward HWY 120 - go 0.6 m
9.4	0.6	Veer slight right to stay on Test Station Rd - go 0.4 mi
9.8	0.4	Turn right toward CA-120 W - go 325 ft
9.9	0.1	Turn RIGHT onto CA-120 W - go 1.0 mi
10.9	1.0	Turn RIGHT onto unmarked dirt road - go 0.4 mi
11.3	0.4	Turn RIGHT - go 0.2 mi
11.5	0.2	Arrive at Panum Crater Hike
		Allocated time: 45 Minutes

Figure 74 - Trail around Panum Crater

Panum Crater is the youngest volcanic feature of the Mono-Inyo Craters at a mere 600 years old. The majority of the craters, the oldest of which dates to 35,000 yrs, can be seen immediately to the southeast of us. The purpose of this stop is to hike to the rim of the Panum Crater in an effort to discern the eruptive sequence. At the crest, Panum's distinct plug dome will become much more obvious and afford marvelous views of Mono Lake.

Since there is no trail to top, participants are encouraged to find and gather as many different rock types as possible on their switch-backing journey to the crest of the crater. Once at the crater's rim we'll use the rock evidence to piece together the exact sequence of the eruption and influences that may have affected the eruption style. Hikers should find rounded granite cobbles along with sands and obsidian shards, which are a strong indicator of a phreatic eruption occurred here as magma intruded into groundwater provided by a nearby creek that once existed on the site. The explosion, which accounts for the crater walls, was followed by a series of cinder and pumice eruptions that were followed by the final plug domes which turned into "crumble breccias"; pressures from newer lavas extruded in the plug dome literally crumbling the existing dome and incorporating the chunks into the new flows.

Figure 75 - Panum Crater as viewed from above. (Google Earth)

To Stop #4-4 Obsidian Dome Obsidian Flow (37.757179°, -119.025749°)

11.5	0.0	Return to vans and return the way you came to HWY 120 junction. - go 0.6 mi
12.1	0.6	Turn RIGHT onto HWY120 W - go 3.7 mi
15.8	3.7	Turn LEFT onto US-395 S - go 9.3 mi
25.1	9.3	Turn right at Obsidian Dome Rd - go 0.3 mi
25.4	0.3	Continue onto Glass Flow Rd - go 0.6 mi
26.0	0.6	Continue onto Obsidian Dome Rd - go 0.6 mi
26.6	0.6	Slight left at Forest road 2S10 - go 0.2 mi
26.8	0.2	Arrive at Obsidian Dome.
		Allocated Time: 20 min

This interesting glass flow erupted in the late summer of 1,350 AD based on the dendrochronology of the trees caught in the flow. The series of three flows exhibit north to south orientation, which those studying the area have suggested resulted from a dike intruding the remnant boundary of the Long Valley Caldera, which we see in overview several miles down the road. This is a great stop to view flow banding and vesicular obsidian as well as phreatic craters that preceded the massive flows. Have fun exploring the area for several minutes but don't stray too far up the hill as we have many more sites to visit.

To Stop #4-5 Convict Lake Moraine, Metamorphic Roof Pendant(37.593559°, -118.851646°)

26.8	0.0	Retrace our route back to HWY 395 S – go 1.7 mi
28.5	1.7	Turn **right** at **US-395 S** - go **15.4 mi**
43.9	15.4	Turn **right** at **Convict Lake Rd** - go **2.3 mi**
46.2	2.3	Arrive at Convict Lake (additional parking above shoreline)
		Allocated time: 20 min

Figure 76 - Mount Morrison roof pendant.

Our Convict Lake stop is one of the prettiest bathroom breaks we'll have on the trip, not to mention it offers some stunning geologic vistas and glacial features previously unseen on this trip. The area is also uber-western since the lake got it's name by way of a shootout that occurred here in 1871 between escaped prisoners who murdered a Pony Express rider and the posse intent on rectifying a wrong. Convict Lake is a tremendously large glacial tarn that reaches a depth of 140 ft thanks in part to a huge terminal moraine just beyond the lake's outlet. Several lateral moraines from the different stages of glaciation can also be seen along the canyon walls downstream of the lake. The looming Mt. Morrison at the back of the lake deserves an entire's day exploration into its confines, but during this brief stop we will only mention that it is a remarkably well-preserved metamorphic roof pendant consisting of Paleozoic sandstones and marbles. The tight folds and colors of the mountain attest to the metamorphism and contrast nicely against the azure waters of Convict Lake.

<u>To Stop #4-6 Long Valley Caldera Overview (37.615864°, -118.814568°)</u>

46.2 0.0 Return vans and head back out to HWY 395 – go 2.3 mi

48.5 2.3 Turn right at US-395 S - go 1.5 mi

50.0 1.5 Pull over & Park up Mt Morrison road a few yard to gain view of Long Valley Caldera. *Allocated time 5-10min.*

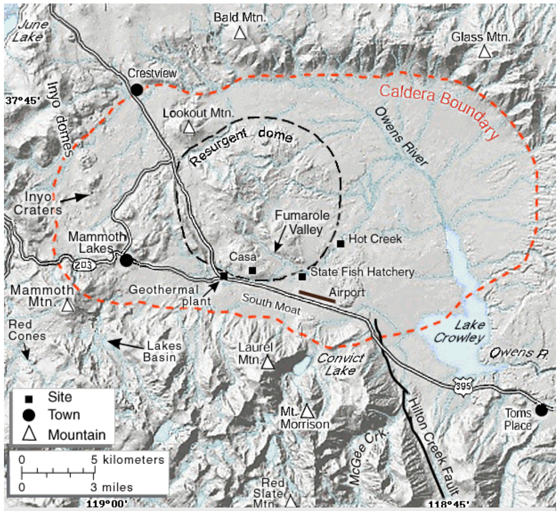


Figure 77 - Long Valley Caldera Outline (*USGS*)

By consulting your maps, you can see that we are on the southwestern edge of the second largest volcano in North America. 760,000 years ago this spot was the site of large, caldera style eruption that ejected some 150 cubic miles of magma which, when compared with Mt St Helens' 1980 0.67 cubic miles eruption, should give a good idea of just how massive the volcano was. Estimates assume that the eruption lasted nearly six days, and when it was over the empty magma chamber collapsed approixmatley 2-3 km! The collapse left a large depression in the ground that measures nine miles by eighteen miles, and is still easily recognizable from the air today. The eruption was truly cataclysmic as layers of ash several inches thick can be found as far away as central Nebraska (figure 78).

Locally, the collapsing column of ash and pumice created the Bishop Tuff, the high, visible, pink tablelands we are about to descend through on our way into Bishop. Closer to Bishop the thickness of these ash layers is nearly 600' deep. We will take a closer look at some of the layers at our Chalfont Stop.

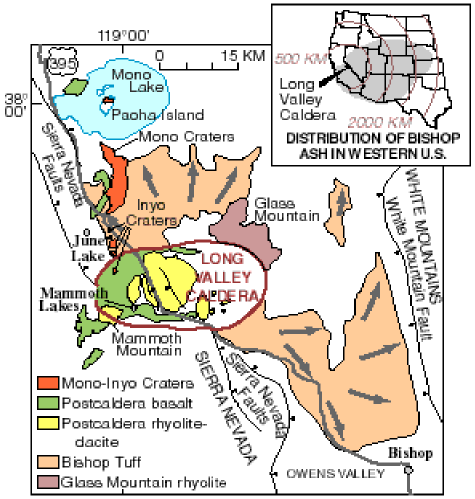


Figure 78 - Simplified geologic map of Long Valley Caldera and ejecta distribution. (*USGS*)

To Stop #4-7 Sherwin Till & Bishop Tuff Roadcut (37.557644°, -118.657196°)

50.0 0.0 Return to Vans. Continue SOUTH on US-395 S toward Crowley Lake Dr - go 10.1 mi

60.1 10.1 Pull over across from large road cut and park.

Allocated time: 10 min.

Welcome to one of the most famous road cuts in the entire world. Carefull observation of the hillside shows that the bottom left portion of the cut is comprised of unsorted glacial till that has enough nutrients to support plant life in the form of sagebrush. The overlying, right side of the cut is fairly fine-grained and supports very little plant life. As luck would have it, this road cut shows the stratigraphic relationship between Sherwin Till and Bishop Tuff ash fall. The 760 Ka ash lies on top of the till, therefore the till must be older (Law of Superposition). Geologists in the early 1980's found soil on top of the till which means several millennia had to have passed in order for the soil to develop, thus most geologists put the actual development of the till at just about 1.0 Ma. Gotta love geology! One last interesting tidbit are the clastic dikes made of sediments that seem to jut out of the ash. Their origins are a mystery, but some have speculated that they are tension cracks from earthquakes that have been filled from above.

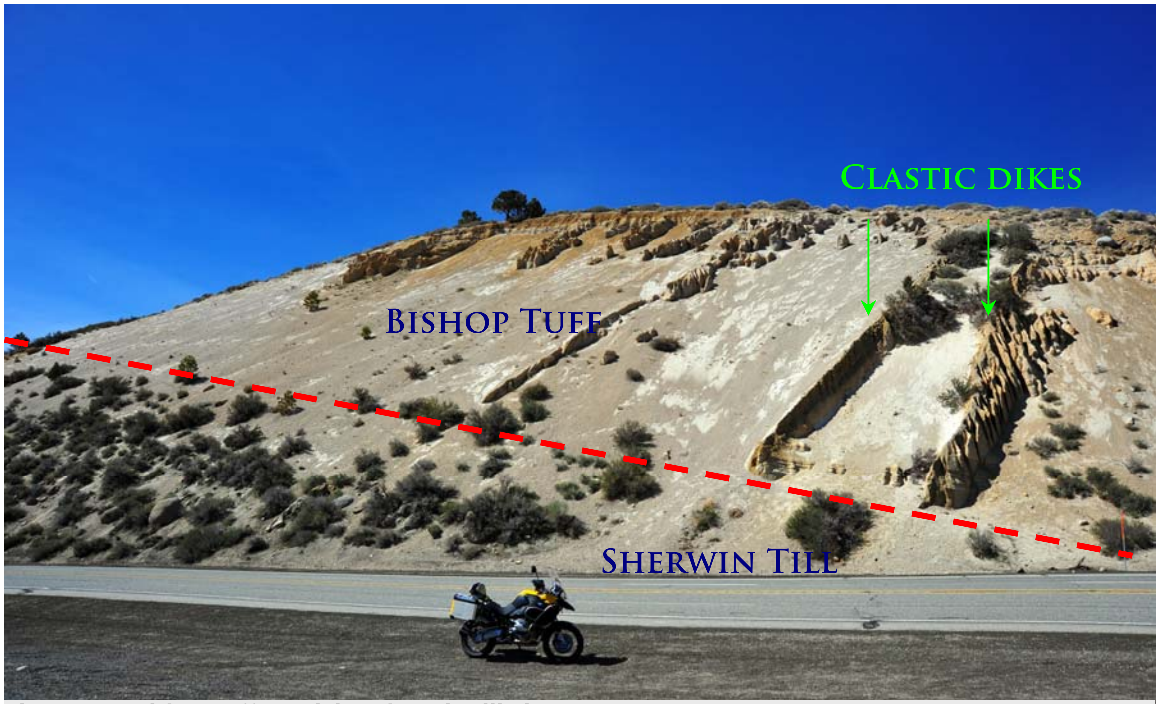


Figure 79 - Bishop tuff overlying Sherwin till along HWY 395.

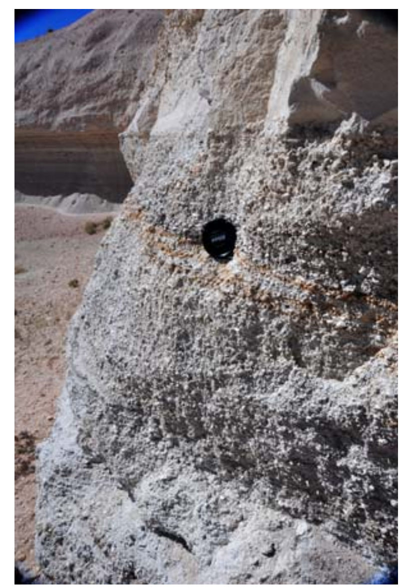
To Stop #4-8 Chalfont Pumice Mines & samples! (37.459930°, -118.366150°)

60.1	0.0	Return to Vans. Continue south on US-395 S - go 21.9 mi
82.0	21.9	Stay STRAIGHT at fairgrounds & Continue onto Wye Rd - go 0.2 mi
82.2	0.2	Turn left at US-6 E - go 7.6 mi
89.8	7.6	Turn left at Rudolph Rd - go 0.8 mi
90.6	0.8	Slight right - go 367 ft
90.67	0.07	Turn left - go 449 ft
90.7	0.08	Arrive at Chalfont Pumice Mine
		Allocated time: 20min

Figure 80 - Chalfont pumice quarry: the remnants of a large pyroclastic flow and secret ingredient in stone washed jeans.

Looking to stockpile some pumice samples for you class? Look no further than the Chalfont Pumice Mine. Here we can see two distinct episodes of the Bishop Tuff's formation. The lower unit of the tuff is a poorly sorted air fall tuff, while the upper layer is nicely sorted pyroclastic flow. The sorting is most likely caused by the fact that the flow had traveled over 22 miles to reach this point (22 miles!!). The funky brown and reddish "layers" are actually a manganese-oxide stain from groundwater that was once present in this locale. Cal Poly Pomona has taken samples of the upper and lower layers of the quarry walls and has concluded that each layer is practically indistinguishable from one another indicating a quick succession of deposition (Jessey, 2007). This fact leads most to conclude the Long Valley eruption occurred rapidly. Also of note, several field trips I have been on in the area have stated the preferred use of the quarried pumice was as an abrasive in the making of "stone washed" jeans.

Grab some ziplock baggies and fill the to your heart's content with the pumice. You'll never know when you might need a pumice stone to chuck at an unsuspecting knucklehead in class.



To Stop #4-10 Eastern Sierra Overlook (37.352146°, -118.183189°)

90.7	0.0	Return to HWY 6 the way you came in – go 1.0 mi
91.7	1.0	Turn right at US-6 W - go 7.6 mi
99.3	7.6	Turn right at Wye Rd - go 0.2 mi
99.5	0.2	Sharp left at US-395 S - go 15.6 mi
115.1	15.6	Turn left at CA-168 E - go 12.9 mi
128.0	12.9	Turn left at White Mountain Rd - go 5.4 mi
132.4	5.4	Turn right to stay on White Mountain Rd - go 1.5 mi
133.9	1.5	Pull-out at overlook (presumed here via Google Earth)
		Allocated Time: 5-10min for photos.

We've already seen much of the distant view in person. To the left (north) is Bishop and to the south Owen's Valley and the High Sierra. From this point it is easy to see just how sharp and jagged the Eastern Sierra escarpment is. Our current position officially welcomes us into the Basin & Range geologic province, where extensional faulting and thinning lithosphere is the rule. 2.3 Ma, this area was still attached to the Sierra Nevada Mountains in one large unbroken block, as evidenced in 2.3 Ma lakebed sediments now tilted some 6 degrees just below us. The tilting, caused by down dropping of the Owens Valley floor (essentially a huge grabben), is responsible for nearly 7,550' of relative uplift in the last 2.3 Ma (about 1mm/yr). These mountains are still young, and their faults have been very active in recent geologic time.

Enjoy the view and take some photos before we head to a great hike into the world's oldest living things. If we're lucky we might even be privy to lenticular clouds forming in the waves of air blowing over the Sierra crest.

To Stop # 4-11 Ancient Bristlecone Forest (37.383118°, -118.181480°)

133.9	0.0	Return to vans. Head northwest on White Mountain Rd - go 3.0 mi
136.9	3.0	Park at Schulman Grove visitor center (if open)
		Allocated Time: 1+ hrs to Hike 1mi Discovery Trail.

The Ancient Bristlecone Pines are some of the oldest trees in the world, with some living trees having survived 4,840 years and counting! The trees mostly grow on the Precambrian-aged Reed Dolomite, which is, ironically, some of the oldest rock in California. The rocks attest to at time between 850 Ma and 400 Ma when this area was a continental

Figure 81 - Patriarch Grove of Bristlecone Pines. The oldest living trees on Earth.

shelf under a warm tropical sea much nearer the equator. The interplay between tropical rocks and the current bristlecone trees actually make for an interesting study in climate change. The dendrochronologic record for these mountains reach back nearly 10,000 years… far enough to reconstruct the ice age climate and subsequent climate changes to the present day. Interestingly, in the Patriarch grove further up the road at the 11,000' elevation, one can view ancient treelines of the past forests in situ where they died much higher upslope 2,000 years ago. The trees apparently grew vigorously during the Holocene Climactic Optimum 5,000+ years ago when warmer temperatures would have allowed for longer growing seasons even at elevations over 12,000 feet. As the climate cooled, the treeline dropped to present levels. New bristlecones, however, are once again advancing into the higher slopes suggesting a warming climate. Dendroclimatologists consider the bristlecone an exceptional indicator of past climate.

Figure 82 - Geologically controlled habitats are obvious. Bristlecones grow on white dolomite behind the author, yet nothing grows on the red quartzite in the foreground.

As you hike through the easy guided loop trail, consider what it must be like having lived in the same harsh spot for more than 3,000 years. You can also ponder the fact that bristlecone pine tree rings were used to calibrate Carbon-14 dating, the reliable process used to (now) accurately date once-living organisms up to 40,000+ years old.

Several notes of caution: Take your time hiking, as walking at 10,000 ft. in elevation is a task for those not accustomed to the altitude. Also, as a survivor of a severe lighting storm in this exact spot several years ago, I must caution that you immediately head for the cars at the first sign of thunder or lighting. The storm I was watching from afar as young, risk-taking man snuck up on my hiking group in a hurry leaving us stranded in the highlands with camera tripods (lightning rods) and no raingear. We ditched our tripods and ran the two miles back to the cars dodging flash/bangs after no safe low spots on the Methuselah Trail presented themselves. Several times the flash-bangs of lighting/thunder were instantaneous, and we even saw one bristlecone branch in the gully below get torched. There is no greater motivator to learn about lightning safety than having almost been zapped. It's quite an experience to have one's arm hair come to army-like vertical attention due to static charge.

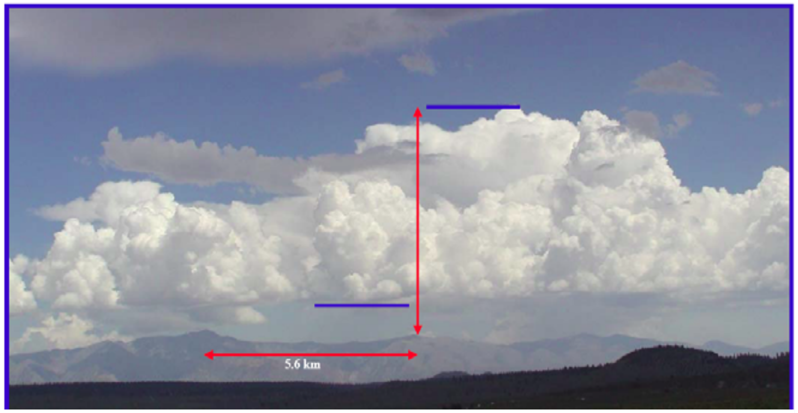


Figure 83 – Unstable and moist parcels of air rise aloft creating cumulonimbus clouds over White Mountains. Daytime heating of mountain slopes and valley breezes contribute to parcel uplift.

Figure 84 - Several thousand years of harsh weather sculpted this tree.

To Stop # 4-12 Poleta Folds - Deep Springs (37.318024°, -118.091866°)

136.9	0.0	Return to cars, return down White Mountain Road to HWY 168 – go 9.9 mi
146.8	9.9	Turn LEFT at CA-168 E - go 6.5 mi
153.3	6.5	Turn right – onto dirt road - go 207 ft- Arrive at Poleta Folds.
		Allocated Time: 30 min

A quick glance at the outcrop in front of us helps us to understand why this area has been home to so many structural geology mapping classes. These are the tortured Poleta Folds, containing late Devonian rocks from the eroded remnants of an island arc associated with the Antler Orogeny. It wasn't until the Nevadan Orogoeny that these rocks were folded and faulted, with subsequent Basin & Range faulting exposing the folds to the world.

Figure 85 - Poleta Folds viewed from afar. The majority of California geology students use this site as their first mapping experience.

To Stop # 4-14 Aluvial Fan & Desert Features near Lidia (37.458176°, -117.237038°)

153.3 0.0 Head northeast on CA-168 E toward CA-266 S - go 0.1 mi2Continue onto CA-266 S - go 4.4 mi

157.7 4.4 Entering Nevada

193.6 35.9 3Continue onto NV-266 E - go 35.9 mi Pull out on shoulder.

Allocated time: 10 min.

Our last daylight stop, we'll pull over to enjoy the massive alluvial fan that dominates the horizon. The fan consists of the eroded bits of mountains from which the fan emanates. While it might seem odd in a desert, water is the main erosional agent responsible for the fan. Summer monsoonal deluges send raging torrents down the mountains plucking any loose rocks as it goes. The more load in the stream, the faster erosion occurs. Once the raging streams reach the flat basin floor their velocity slows, competence drops, and the load is deposited. With little plant life to root together topsoil and rocks, what little rain that falls in the desert sculpts masterpieces of solitaire beauty. Look around the stop to find other pieces of evidence that water sculpts the land.

To Ramada Hotel Tonopah (38.057968°, -117.217171°)

193.6 0.0 Head northeast on NV-266 E - go 4.1 mi

197.7 4.1 Turn left at US-95 N - go 40.8 mi

238.5 40.8 Arrive at Ramada.

We'll check in, eat and then get cleaned-up. Meet back at the vans by 9:30 to drive to the outskirts of town for some great constellation star gazing with our naked eyes or binoculars. Be ready to leave tomorrow morning by 7:30 am!

TO Stop # 4-15 Star Gazing outside Tonopah (38.025986°, -117.257507°).

238.5 0.0 Head south on US-95 S/Erie St - go 2.7 mi

241.2 2.7 Turn right - go 1.0 mi

242.2 1.0 Slight right - go 354 ft or possibly up mountain depending on conditions.

Even though Tonopah is only several miles away, its light pollution is minimal and will still allow for spectacular naked-eye observations of the night sky. Below are several sky guides from Starry Night for 10pm at Tonopah. They will help you pick out common constellations. Further information about planets and moons and can be obtained from any astronomy website or smartphone app prior to leaving for the evening. The Milky Way will be the star of the show. For historic constellation names refer to the Turlock Sky Charts in the Astronomy Section of the introduction to this guide.

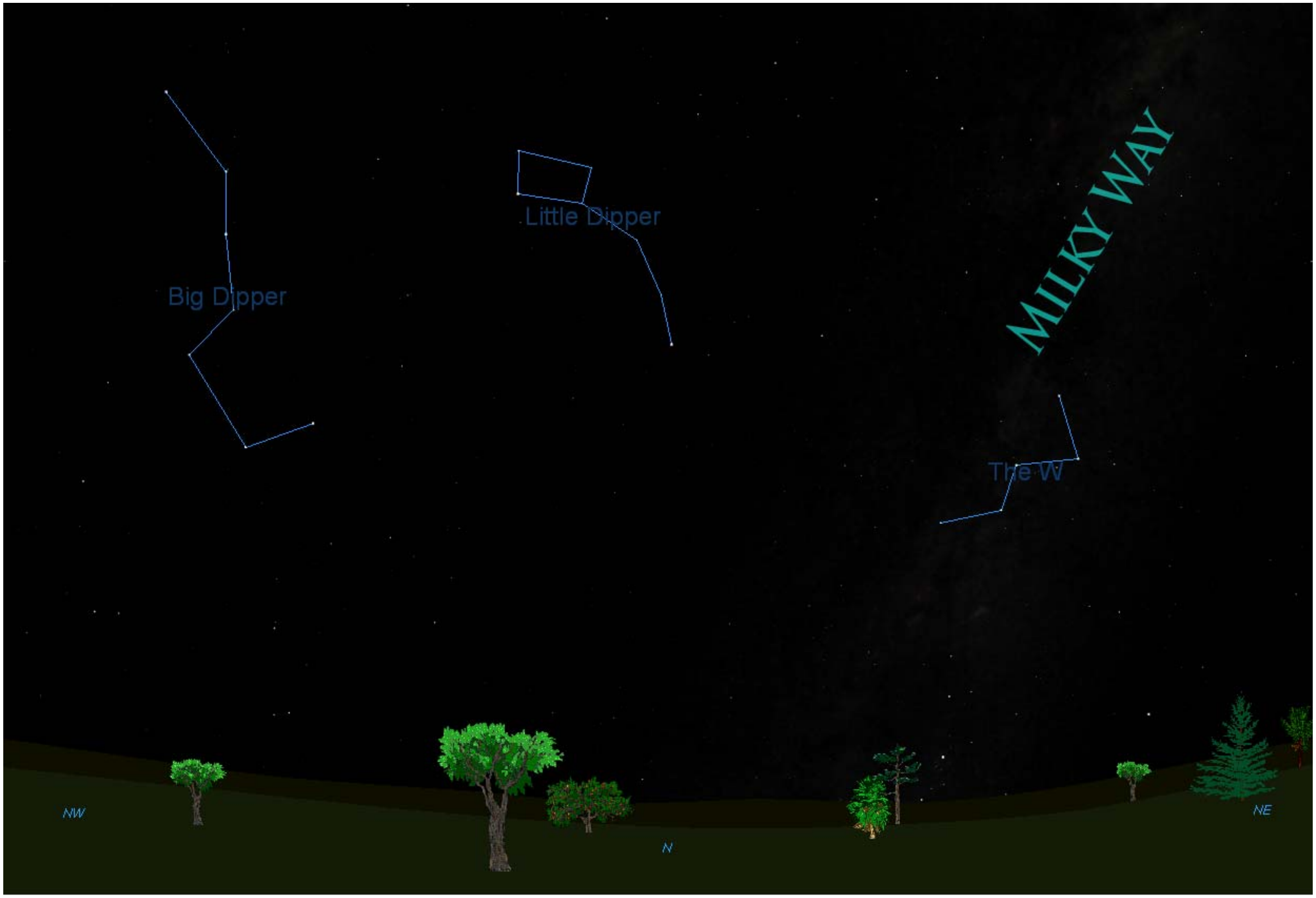


Figure 86 - View to the North sky outside of Tonopah

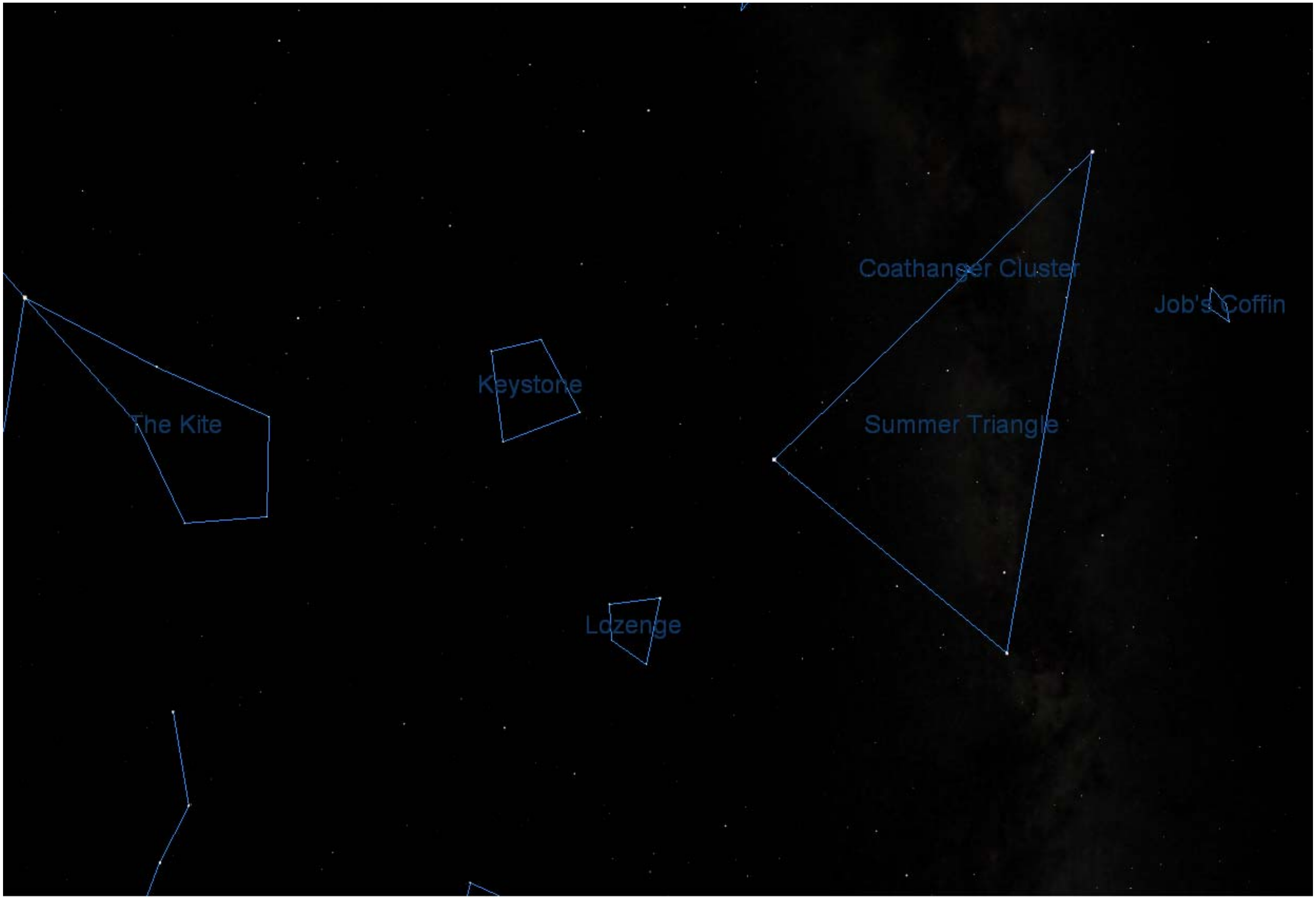


Figure 87 - View to the North directly overhead outside of Tonopah.

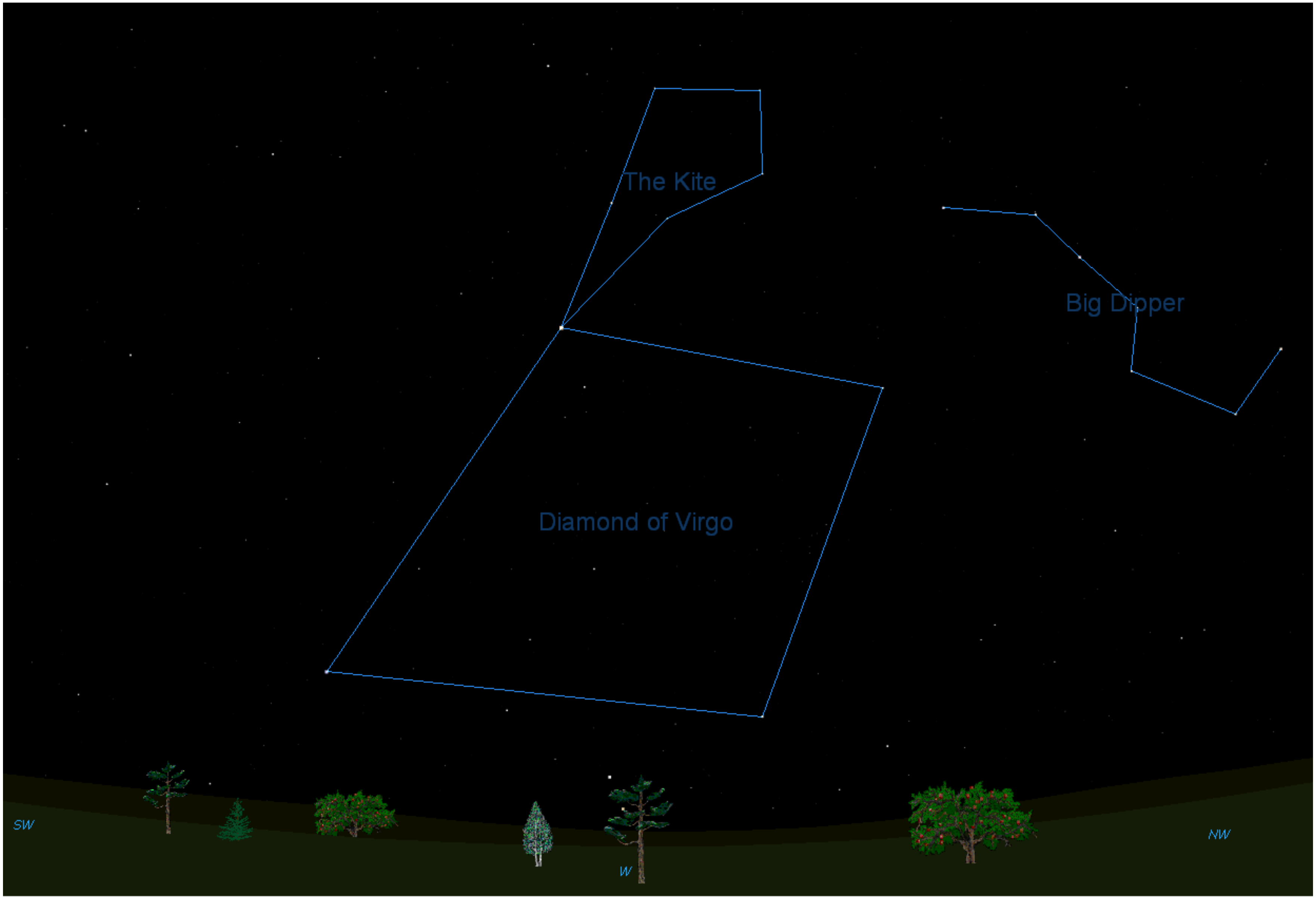


Figure 88 - View to the West outside of Tonopah.

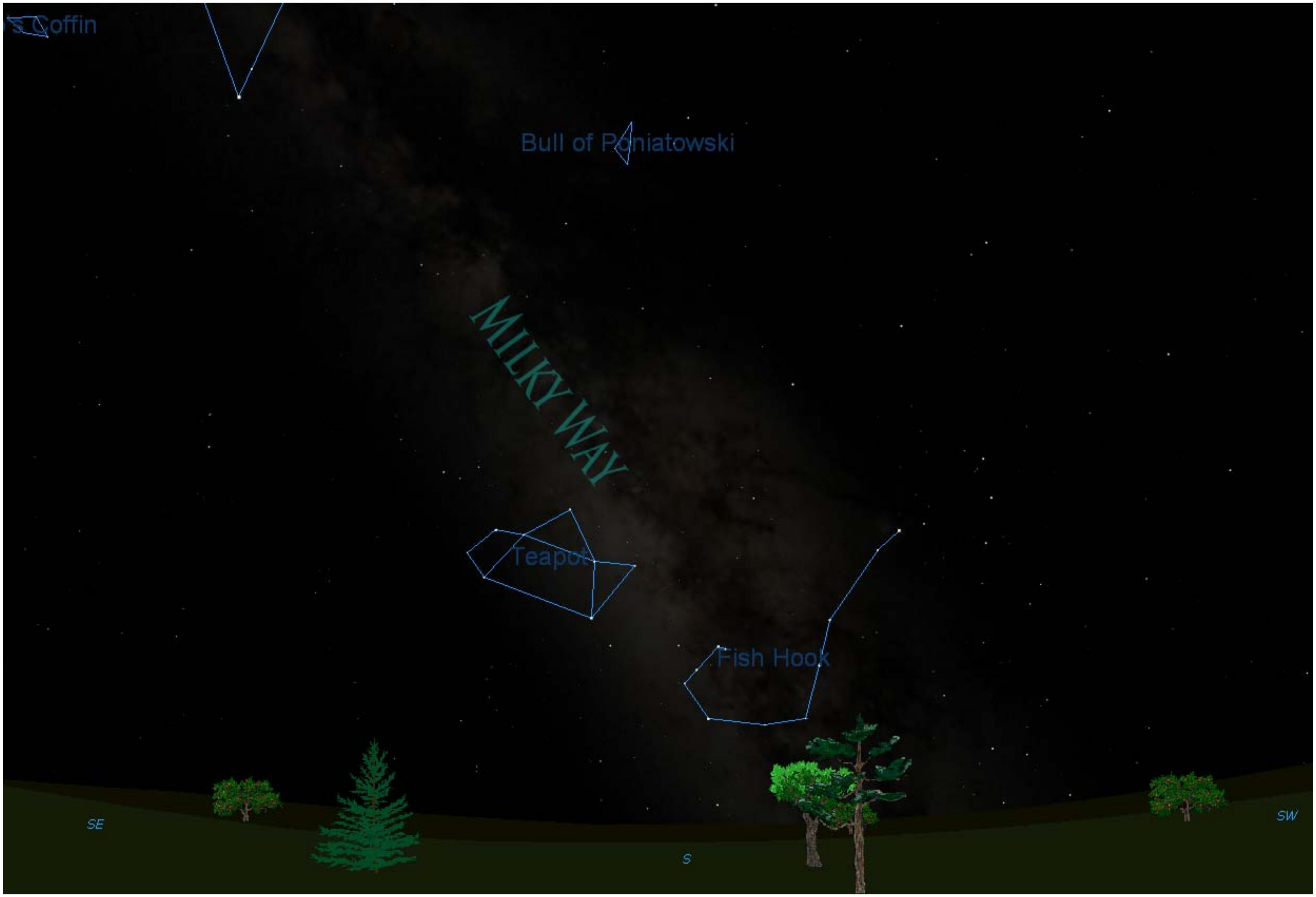


Figure 89 - View to the SOUTH outside of Tonopah.

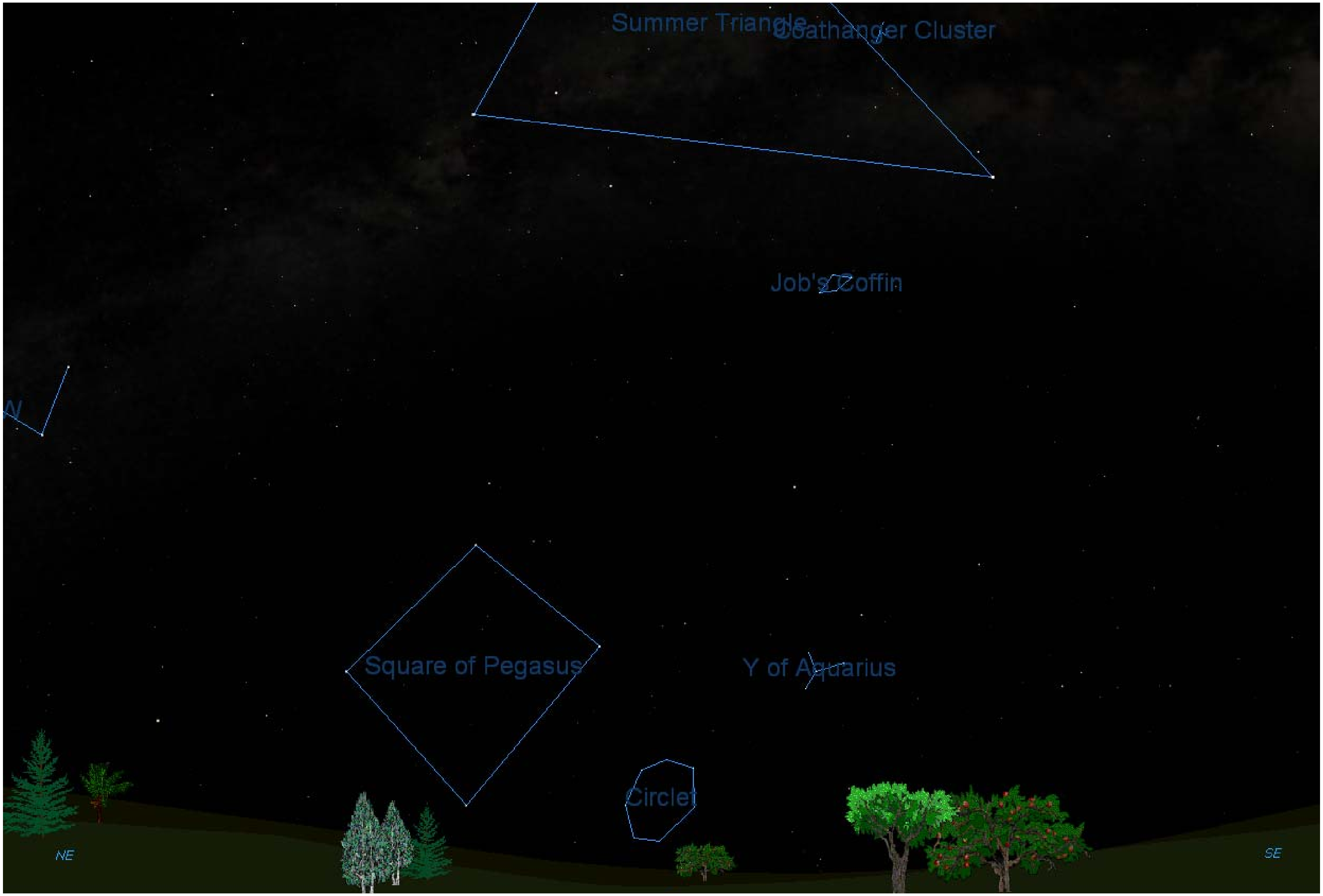


Figure 90 - View to the East ouside of Tonopah

Day 5 – Tonopah to Fallon via Big Smoky Valley: Time to Stretch our Riches.

IF your sense of adventure still hasn't been piqued thus far on the trip, today's the day for an ultimate adventure through the Basin and Range, some of the thinnest and most rapidly extending crust on the planet. The distance between Reno and Salt Lake City has doubled in the past 80 million years allowing lots of volcanism to infiltrate the area and emplace some of the richest gold deposits in the country. Lets get to some explorin'!

Mileage

Cum.	**Interval**	**To Stop #5-1 Manhattan Mining District (38.539574°, -117.075294°)**
0.0	0.0	Head southeast on Erie St toward Air Force Rd - go 279 ft
0.0	279 ft	Take the 1st left onto Air Force Rd - go 52 ft
0.0	52 ft	Turn left at US-95 N/Erie St - go 0.3 mi
0.3	0.3	Turn right at US-6 E (signs for Ely) - go 5.4 mi
5.7	5.4	Turn left at NV-376 N - go 36.9 mi
42.6	36.9	Turn right at NV-377 E - go 6.6 mi
49.2	6.6	Turn left at Gold St - go 138 ft
49.2	138 ft	Turn left - go 240 ft
49.2	240 ft	Arrive at Manhattan Mining District
		Time allocated: 1 hour

Figure 91 - Manhattan used to be filled with sweet rides. (*Dolores Steele, ghosttowns.com***)**

This is the first of several ghost towns that we'll be exploring today. It is the author's hope that experiencing "The Old West" will help the participants better understand the geologic lure of such an isolated land. We'll have some time to wander the town of Manhattan and will then head east to East Manhattan several miles down the road.

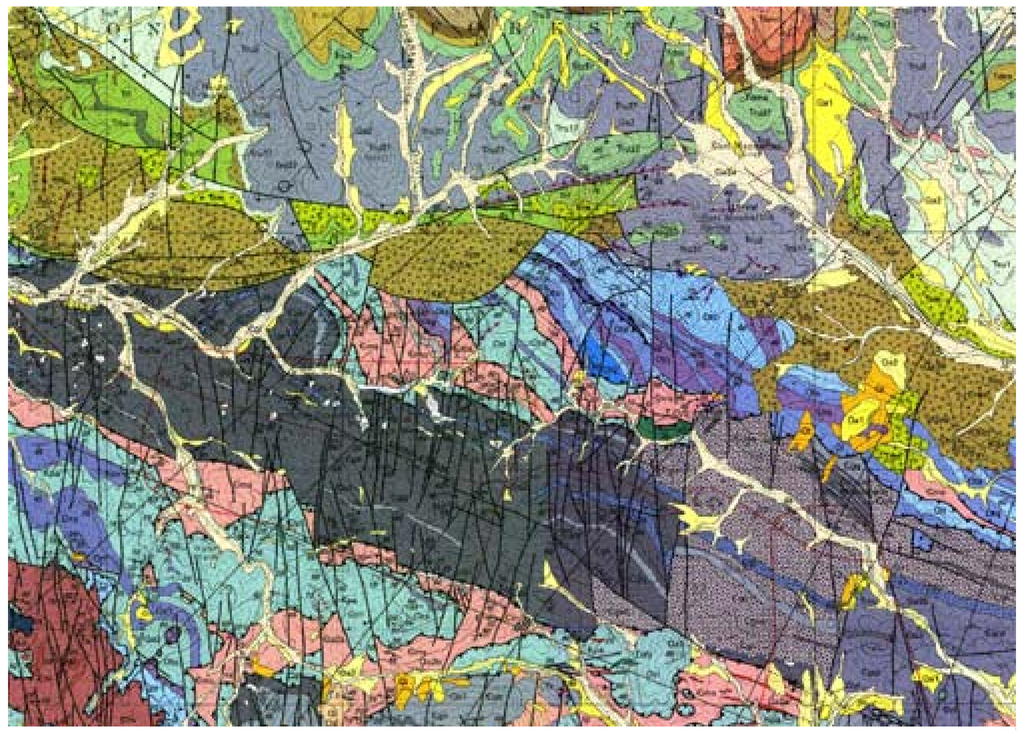


Figure 92 - A convoluted sampling of the complex geology surrounding Manhattan, NV.

Manhattan owes its existence to a hodge-podge of local geology. By referring to the included geologic map of the area one can come to appreciate the jumbled, complexly faulted and volcanic nature of the region. The majority of the oldest rocks in the area are remnants of clastic sedimentary and metamorphic rocks which speak to a non-sea environment. These rocks were subsequently subjected to intense magmatism nearly 16 Ma as caldera flare-ups coincided the extension of the Basin & Range. The ranges that encapsulate the Big Smoky valley contain the remnants of three major caldera episodes which no doubt contributed to the emplacement of the gold and silver ores found throughout the hills. The hills in Manhattan proper are composed of sediments and metamorphics from the Cambrian and Ordovician transgressions and regressions. Estimates put the thickness of the Ordovician rocks at nearly 5000' and, according to geologic maps, graptolite fossils are very abundant.

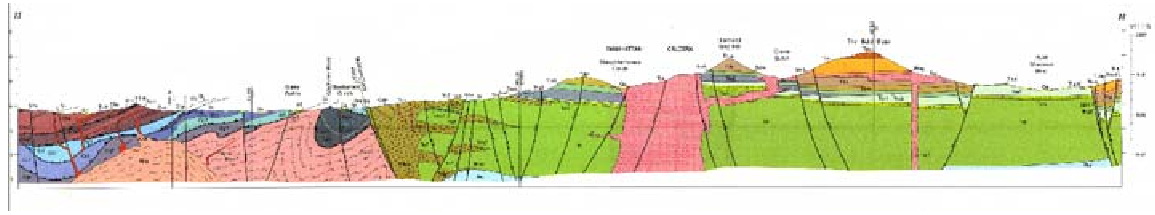


Figure 93 - A fun cross-section to figure out.

Manhattan had several stages of development that waxed and waned along with mining production. The town was first established when silver ore was discovered in 1866. From 1869 until the discovery of gold in 1905, the town sat in municipal hibernation. When assays returned ore values at over $10,000 per ton (close to $250,000 in 2009 dollars!) the town again boomed to life (ghostowns.com, 2006). Interestingly, most of the capital for the operations within the town was being bankrolled by institutions and individuals in San Francisco. The arrangement would have worked out well had not the 1906 earthquake devastated Manhattan's investors. With little money left to support the industry, the town again dwindled until placer deposits were discovered in alluvium at the base of the canyon that produced over 150,000 oz. You may have noticed the dredge tailings that worked the area. The town again petered out until the current "small" pit mine was opened in 1974 and operated into the early 90's (although new production may again soon start). In all, the Manhattan district has thus far produced nearly one million ounces of gold.

Take your time to wander the ghostly remnants of what once was and what is once again.

To Stop #5-2 East Manhattan (38.545311°, -117.026878°)

49.2	0.0	Head southeast toward Gold St - go 249 ft
49.2	249 ft	Turn right at Gold St - go 138 ft
49.2	138 ft	Turn left at NV-377 E/Main St - go 0.7 mi
49.9	0.7	Slight left toward E Manhattan Rd - go 0.4 mi
50.3	0.4	Continue straight onto E Manhattan Rd - go 1.9 mi
52.2	1.9	Turn right - go 0.1 mi
52.3	0.1	Arrive at East Manhattan
		Time allocated: 30 min.

We arrive at this stop to further explore both the past and future gold production within the area. MAX resource corporation has purchased over 133 claims in this 2,660 acre wash. Recent assays from 2009 in the surrounding rhyolite tuffs have produced 4.9 grams of gold per ton of bulk rock and 1.2 grams/ton silver. With the high prices of gold, what little remains of the historic East Manhattan District will most likely be chewed-up for another large scale open-pit mine. This is also a good area to see many tuffs and breccias associated with the caldera flare-ups of the region. We'll spend a few minutes poking around the hills, but be cognizant that this area is claimed and you'd most likely be shot trying to take samples.

While we make our way back to Hwy 378, we may find time to pull over and do a cursory fossil hunt.

To Stop #5-3 Round Mountain Mine (38.706947°, -117.096748°)

52.3	0.0	Head north toward E Manhattan Rd/Natl Forest Develop Road 014 Rd - go 0.1 mi
52.4	0.1	Turn left at E Manhattan Rd/Natl Forest Develop Road 014 Rd - go 2.3 mi
54.7	2.3	Continue onto NV-377 W/Main St - go 7.2 mi
61.9	7.2	Turn right at NV-376 N - go 10.2 mi
72.1	10.2	Turn right at Jett Canyon Rd - go 1.2 mi
73.3	1.2	Arrive at Round Mountain Mine
		Time allocated: 2 hours

Thanks to a few prior arrangements we'll get to take a behind the scenes tour of the Round Mountain Mine. We should get to see the equipment used in all stages of production, and if we're lucky we may even get to see some of the end-product as well.

Round Mountain is somewhat of an ironic name considering the circular nature of this 1 x 1.5 mile wide open pit gold mine. Round Hole seems more apt a name for the tremendously modern and huge heap-leach facility. The mine has recently become one of Nevada's top gold and silver producers, shoveling out more than 14,000,000 ounces of gold during its operation. Its ore also contains high amounts of electrum, a 2/3 gold- 1/3 silver amalgamation. The mine has gained notoriety with specimen collectors for amazing crystalline specimens it routinely turns out.

Figure 94 - Round Mountain Mine oblique arial view. **(***Google Earth)*

Figure 95 - Electrum from Round Mountain Mine. A 60-40 gold-silver amalgamation (minedat.org)

To Stop #5-4 To Kingston Canyon Camp (39.225273°, -117.140182°)

73.3	0.0	Head west on Jett Canyon Rd toward NV-376 N - go 1.2 mi
74.5	1.2	Take the 1st right onto NV-376 N - go 37.1 mi
111.6	37.1	Turn left toward Kingston Canyon Rd - go 2.2 mi
113.8	2.2	Continue straight onto Kingston Canyon Rd - go 3.3 mi
117.1	3.3	Turn left - go 384 ft
117.2	384ft	Arrive at Kingston Canyon Camp
		Time allocated: 30 min

This scenic detour will bring us past the small town of Kingston, an old stamp milling and mining town that hasn't seen much action since the early 1900's. The town is built on a relatively large alluvial fan that originates from Kingston Canyon. We'll use the canyon to traverse the Toiyabe Range into the Reese River Valley. Along the way we'll climb from the sweltering 6,000' elevation up to 8,400' feet at the base of Edith, Arhcie and Bunker Hills. The creek runs year round and actually holds a remnant population of Lahontan Cutthroat trout that once swam freely in the Pleistocene Lake Lahontan (their ancestors grew to over 35 lbs even 120 years ago in Pyramid Lake). It's amazing to think a vibrant cold water fish species has eked out an existence in only several miles of a stream whose waters are destined to dry up in a desert sink.

Should the conditions permit we'll stop at the Kingston Canyon Camp to get out and observe the effects of the climactic shift due to elevation on the local flora and fauna.

To Stop #5-5 Reese River Plain (39.378365°, -117.166100°)

117.7	0.0	Head west toward Kingston Canyon Rd/Natl Forest Develop Road 012 Rd - go 384 ft
117.3	0.1	Turn left at Kingston Canyon Rd/Natl Forest Develop Road 012 Rd - go 11.9 mi
129.2	11.9	Continue onto Big Creek Rd - go 1.9 mi
131.1	1.9	Turn left - go 262 ft
131.1	262 ft	Turn right - go 0.8 mi
131.9	0.8	Arrive at Reese River Plain
		Time allocated: 5 min

Here we have a look at the Reese River Valley and the Mighty Reese River. This is a brief stop to show what wild effect gold speculation can have on those with deep pockets and who are naïve to the actual topography and geology of the area. While observing the characteristics of this river, which rarely runs higher than a "muddy trickle", consider that stories abound of the Reese River Navigation Company that sprang into existence during the 1860's. The idea, as the story goes, was to ship ore from mills in the Toiyabe range via river barge to Battle Mountain, the nearest railroad depot. The appeal of the efficiency of such an operation lured many east coast elite to invest in the boondoggle, not knowing that the river rarely ran deeper than several inches near its confluence with the Humboldt River. Guy Rocha, a former State Archivist for Nevada, has found no evidence to support such a story, which first appeared in area newspapers and advertising brochures in 1951. True or not, the story is worth pondering while overlooking such a vast valley from above. How much would you be willing to invest with a "guaranteed" 500% return?

To Stop #5-6 Iron Mountain Vantage (39.359783°, -117.401962°)

131.9 0.0 Head northwest toward State Route 21 - go 2.9 mi
134.8 2.9 Turn right at State Route 21 - go 4.9 mi
139.7 4.9 Turn left at NV-722 W/State Hwy 2 - go 11.7 mi
151.4 11.7 Arrive at Iron Mountain Vantage
Time allocated: none

Passing view - no stop. The large dark mountain to the left of the road is Iron Mountain, a great example of a plug dome that has intruded older tuff.

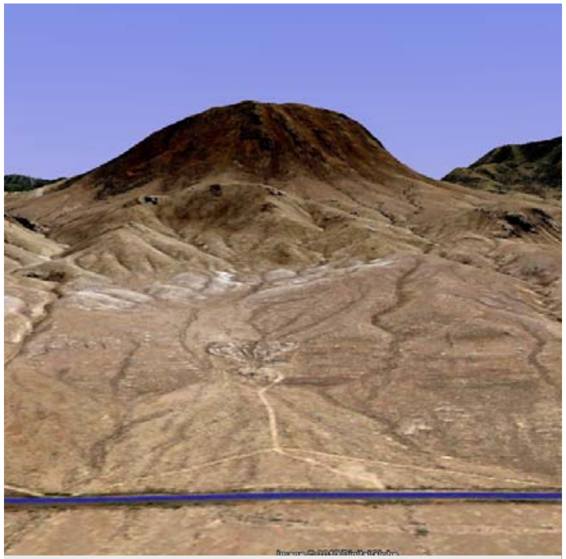


Figure 96 - Iron Mountain Plug Dome (Google Earth)

To Stop #5-7 Carrolls Summit Area (39.262363°, -117.718163°)

151.4 0.0 Head west on NV-722 W/State Hwy 2 - go 22.8 mi
174.2 22.8 Turn right - go 223 ft
174.2 223 ft Arrive at Carrolls Summit Area
Time allocated: 35 min between summit & Buffalo Creek.

The Desatoya Mountains are another example of a Miocene caldera that formed nearly 25 Ma and has since been deformed and faulted due to basin & range extension. Behind us is a rather large cliff of columnar-jointed rhyolitic ash-flow tuff. The jointing occurs as minerals cool and arrange themselves into an efficiently compact hexagonal (usually) shape. The Tuff of Desatoya Peak has been measured to 3,500' thick, which must give one pause to imagine the catastrophic impact of such an eruption.

As we exit the Desatoya Hills we'll also take a quick stop at Buffalo Creek where the modern creek has cut through older stream deposits. This occurred due to the relative uplift of the Desatoyas after the old stream beds had been deposited. The new dowcutting resulted in a steeper gradient as a result of what must have been a series of earthquakes.

<u>To Stop #5-8 Sand Hills (39.271069°, -118.404984°)</u>

174.2	0.0	Head southeast toward NV-722 E/State Hwy 2 - go 223 ft
174.2	223 ft	Turn right at NV-722 W/State Hwy 2 - go 1.5 mi
175.7	1.5	Turn left to stay on NV-722 W/State Hwy 2 - go 15.7 mi
191.4	15.7	Turn left at US-50 W/Austin Hwy - go 23.8 mi
215.2	23.8	Arrive at Sand Hills
		Time allocated: 20 min.

Figure 97 - Sand Hills. One can hear it boom if there are no vehicles nearby. *(www.rte50.com)*

Sand Mountain, situated immediately north of HWY 395, is one of the most popular off road vehicle sites in Nevada, and is a reminder of the remarkable influence the wind has on surface geology. The "mountain" is 2 miles long and averages 600 feet high and is surrounded by smaller, shifting dunes, all of which sit in a small basin at the southern edge of the Stillwater Range. The dune is made up of quartz sand, and studies have indicated that some of the sand comes from as far away as 40 miles south at the location of the Pleistocene Walker River Delta. During the Pleistocene, the Walker River flowed out of the Sierra Nevada Mountains, as it does today, and carried the ground up grains of quartz, depositing them in a delta that was formed when the river emptied into Lake Lahontan. Today, those quartz grains have been carried by the prevailing southwesterly wind during dust storms until the wind is forced up and over the Stillwater Range. As the wind climbs, it drops the sand and the dunes are created.

Sand Mountain is also interesting as it is a booming sand dune. When the dune sand is disturbed it can emit a low acoustical noise that has variously been described as a bass violin, a kettle drum, a foghorn and low flying aircraft. It has been observed that the dune generates is best noise during the summer, when the sand is dry, however it is likely that the noise is over shadowed today the by the hundreds of OHV's that swarm the dune in the summer months.

<u>To Stop #5-9 Grimes Point Petroglyphs and Wonderstone (39.401581°, -118.648224°)</u>

215.2	0.0	Head northwest on US-50 W/Austin Hwy - go 16.3 mi
231.5	16.3	Turn right - go 210 ft
231.5	210 ft	Turn right - go 495 ft
231.6	495 ft	Arrive at Grimes Point Petroglyphs and Wonderstone
		Time allocated:1hour

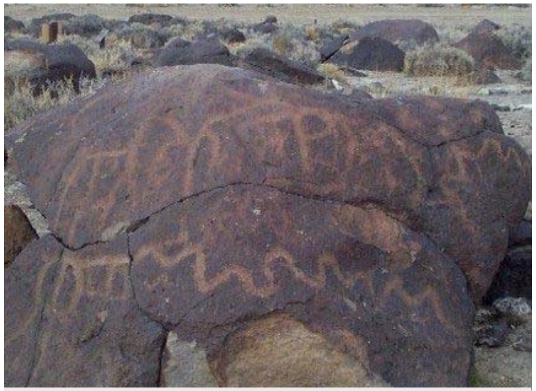


Figure 98 - Grimes Point Petroglyphs *(BLM.gov)*

Grimes Point provides us with an opportunity to look back into the Pleistocene and imagine the skill and ingenuity that must have been utilized by prehistoric natives to survive. The point is the site of a large collection of Native American petroglyphs that date from 5,000 B.C. and 1,500 A.D. Petroglyphs of many styles are visible here, including "Pit and Groove", the oldest style found in the Great Basin. There are also curvilinear and rectilinear abstract geometric designs. The petroglyphs are carved into approximately 150 large basalt boulders at and around the point. There is also evidence of a drift fence along the top of the ridge that may have been constructed by natives in order to drive game that came to the point to drink from Pleistocene Lake Lahontan, which would have surrounded the point during the ice ages.

Please take some time to walk along the interpretive trail and take advantage of the signs that further explain the petroglyphs, early native culture and the local geology. Photography of the petroglyphs is allowed, but remember, you should never touch on or near the petroglyphs as this contact can damage them. We will end the day just up the road to collect lakeshore-tumbled specimens of "wonderstone"; a volcanic tuff that has been hydrothermally altered.

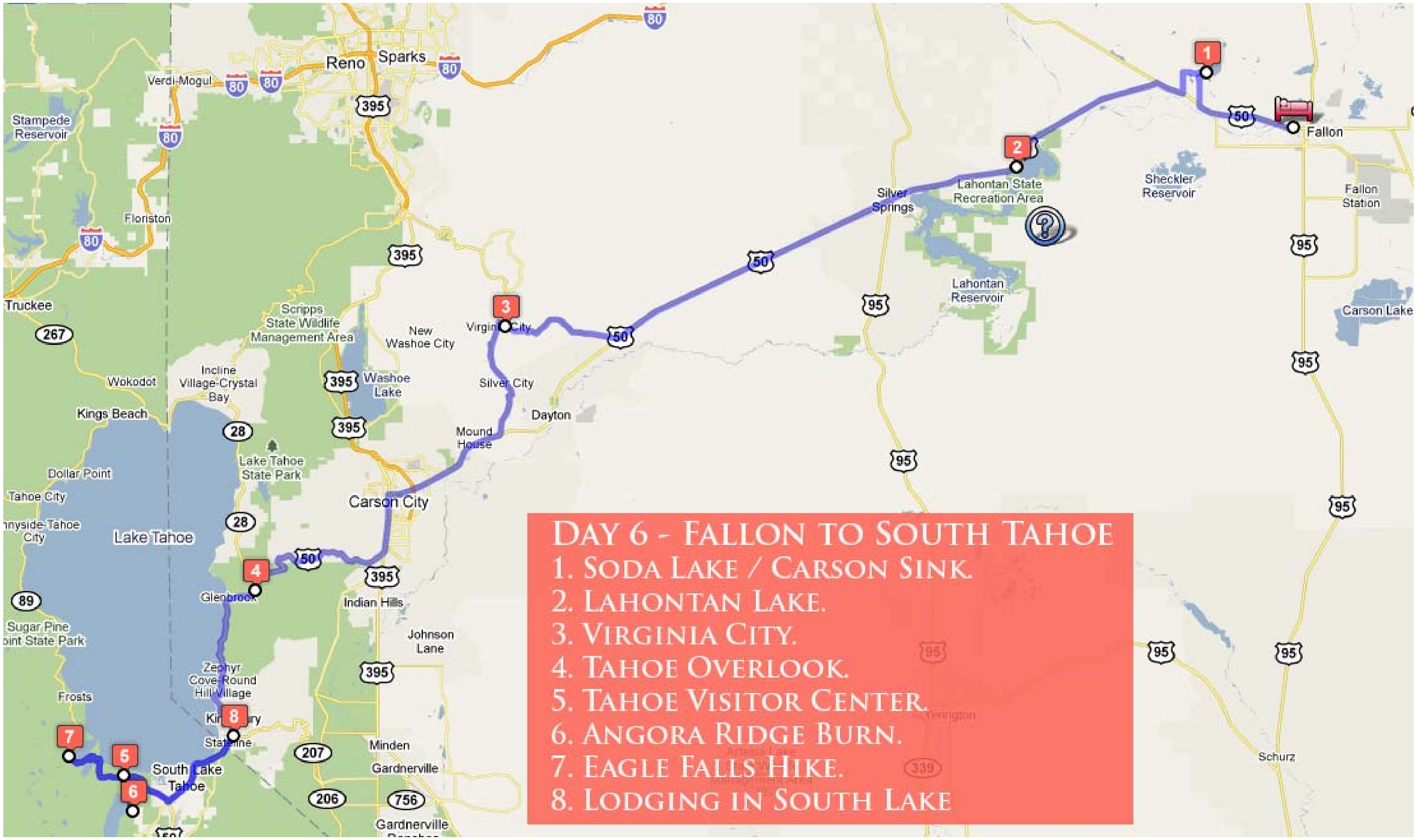
Figure 99 - Wonderstones near Grimes Point
(nbmg.unr.edu)

<u>To Stop #5-10 Holiday Inn, Fallon, NV (39.464600°, -118.777184°)</u>

231.6	0.0	Head west - go 495 ft
231.7	495 ft	Turn left toward US-50 W/Austin Hwy - go 210 ft
231.7	210 ft	Take the 1st right onto US-50 W/Austin Hwy - go 2.7 mi
234.4	2.7	Turn left at NV-118 W/Wildes Rd - go 6.5 mi
240.9	6.5	Turn right at S Maine St - go 0.4 mi
241.3	0.4	Arrive Holliday Inn
		Be ready to leave by 7:30 am tomorrow!

Day 6 – Fallon to South Lake Tahoe: Silver, Glaciers, Several Lakes and a Tsunamis.

Our travels today bring us back out of the desert as turn towards home. We'll drive through a lake (sort of), see the richest silver lode in US history, and then end the day exploring the largest sub alpine lake in the U.S. Make sure the cameras are handy!



Mileage

Cum.	Interval	To Stop #6-1 Soda Lake (39.522053°, -118.887009°)
0.0	0.0	Head south on Commercial Way toward W Williams Ave - go 0.1 mi
0.1	0.1	Turn right at US-50 W/W Williams Ave - go 5.6 mi
5.7	5.6	Slight right at Lucas Rd - go 1.4 mi
7.1	1.4	Turn left toward Lucas Rd - go 0.1 mi
7.2	0.1	Continue straight onto Lucas Rd - go 0.1 mi
7.3	0.1	Turn right - go 0.6 mi
7.9	0.6	Arrive at Soda Lake
		Time allocated 25 min

Figure 100 - Bombs and cinders erupted out of Soda Lakes. (http://www.nbmg.unr.edu)

This stop offers a look at two unique volcanoes and a large desert sink.

The Soda Lakes are interesting maars that, getting a bit ahead of ourselves, are younger than the Pleistocene sediments of Ancient Lake Lahontan. The craters were blasted out via strong phreatic eruptions when magma interacted with groundwater and flash boiled the water to make huge steam explosions. The most recent dating of the lakes places the eruption date within the past 1,500 years. Basalt bombs and cinders are abundant around the lakes and many contain clear crystals of plagioclase feldspar * and small crystals of green olivine. The debris from the maar trends southwest, which has helped geologists studying the area determine the eruptions happened in the winter when typical northwesterly winds predominate. The lakes themselves are fairly basic (alkali) with a pH ranging around 9.7. The lakes are also chemically stratified with nearly twenty five times the amount of dissolved sodium and sulfates in the lower half of the lake (37-64m). The majority of the lakes chemical composition results from evaporation of incoming ground and mineral waters.

Soda Lakes sit to the extreme southwest end of the Carson Desert and Carson Sink, where the Carson and Humboldt rivers come to die. The twenty-mile wide Carson Sink playa is the low point for the 26,000 square miles of river basins that drain into it. In wet years several feet of water can accumulate over the playa surface, but quickly evaporates once the warmth of spring and summer increase evaporation rates. As Tingley & Pizarro put it, the climate of the Carson Desert is "continental in the extreme, with warm summers, cold winters, and wide fluctuations of diurnal temperatures. Summer daytime temperatures may reach 100° F and winter minimums can dive to below -5° F". Fallon averages a whopping 5.3 inches of rain per year and seven inches of snow. The data lens to the question of how Fallon maintains such a large agricultural existence in such an arid environment. The following stop will answer that question.

To Stop #6-2 Lahontan Reservoir Overlook (39.443882°, -119.091713°)

7.9	0.0	Head west - go 0.5 mi
8.4	0.5	Turn right toward Kamibo Dr - go 0.5 mi
8.9	0.5	Slight left at Kamibo Dr - go 0.5 mi
9.4	0.5	Take the 2nd left onto Trento Ln - go 1.2 mi
10.6	1.2	Turn right at US-50 W/Reno Hwy - go 1.6 mi
12.2	1.6	Turn left at US-50 W/Carson Hwy - go 9.6 mi
21.8	9.6	Turn left - go 0.1 mi
21.9	0.1	Arrive at Lahontan Reservoir Overlook
		Time allocation: 25 min

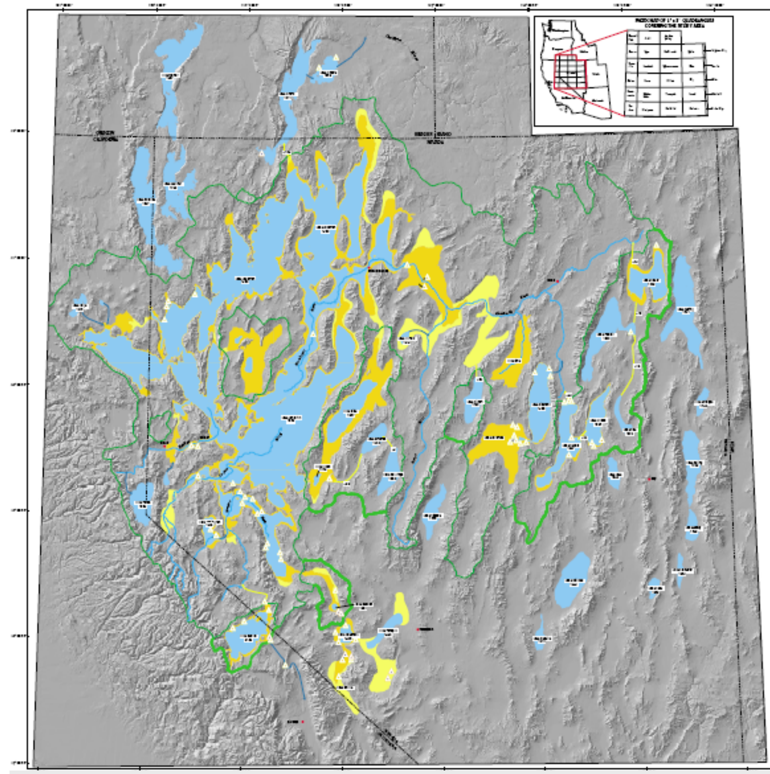


Figure 101- Extent of Pleistocene Lake Lahontan. (Reheis, 1999)

The reservoir before us today dams the Carson River and provides fifteen square miles of irrigation water for the farmers near Fallon. The lake's water contains relatively high amounts of mercury from the mining along the banks of the Carson River upstream in the Sierran mining districts, a reminder of just how polluting past mineral extraction has been and how long the effects linger.

While the irrigation aspect of the reservoir is intriguing, had the farmers lived in Fallon during the Pleistocene they would have needed submersibles to farm fish. Why? The reservoir is a puny remnant of its Pleistocene self. During the Pleistocene the Basin & Range had a much cooler climate that resulted in less evaporation and slightly more precipitation. The excess water ponded in the low lying basins that had, millions of years earlier, started downdropping due to crustal extension. At the lake's last maximum stand, some point before 12,070 years ago, it covered nearly 8,500 mi^2 and reached depths to 920 feet. Here the water would have been over 400 feet above our heads (Tingley and Pizarro, 2000). The evidence for such a large lake lies on the slopes of the mountains in the form of wave-action shorelines as well as massive deposits of clay and silt that preserve an abundant fossil record. Scan the hill sides for the incised shorelines and try to make an inference on why some are larger than others. The scale of the lake was huge and provided an abundant fauna for early human inhabitants to the area in its recessional stages.

Figure 102 - Lahaontan Cutthroat Trout: Nevada's state fish. *(netstate.com)*

To Stop #6-3 Virginia City (39.310925°, -119.642487°)

21.9	0.0	Head southwest toward US-50 E/Carson Hwy - go 0.2 mi
22.1	0.2	Turn left at US-50 W/Carson Hwy - go 25.1 mi
47.2	25.1	Turn right at Six Mile Canyon Rd - go 7.6 mi
54.8	7.6	Turn left at P St - go 289 ft
54.8	289 ft	Arrive at Virginia City
		Time allocation: 1.5 hrs.

Having experienced real ghost towns yesterday, we'll now get to explore a town that has maintained its mining vibrancy by quarrying the pockets of tourists. The city sits at the base of the Comstock Fault, which contained the incredibly rich Comstock Silver Lode. The discovery of the silver in the Comstock waited nearly ten years to be discovered after the 1849 California Gold Rush. Those who had no luck in California began prospecting sites in Nevada for gold, and occasionally found small amounts of gold in the exposed headwall of the Comstock Fault near what is now Gold Hill. The exposed fault also contained large amounts of weathered, mud-like, blue-black material that tended to stick to unsuspecting prospectors' shoes. It wasn't until 1859 that more experienced prospectors recognized the sticky mess as nearly pure silver sulfide. Many stories abound of double-crossing and back-stabbing deals that occurred to acquire claim rights and by 1860 a full-blown silver rush was in bloom.

Virginia City was the first silver rush boomtown in the United States. Nearly $500,000 million dollars of ore were extracted from the three-mile long Comstock Vein during peak production from 1860-1880. Ironically, very few people made money on the operation due to immense litigation and infrastructure investment. Tingley and Pizzaro point out that "during its main production period, the Comstock produced more precious metals than all of the rest of the United States".

As the Comstock mines dug deeper, following the dipping lode vein, new engineering feats had to be achieved, making Virginia City a hotbed for mining technology advancements. The most renowned engineering achievement, and one which you can observe while in Virginia City, is the Sutro Tunnel. The four mile long tunnel was driven into the side of the mountain 1,650' below the Comstock vein's outcropping on the surface to provided drainage of the hydrothermal springs seeping into the mines. The shafts had previously needed constant pumping at a cost of millions of dollars to keep the shafts free of water and, therefore, workable. Adolph Sutro's tunnel design was passed by the U.S. Congress in 1866 (which understood value of precious metals to the freshly rebuilding country and wanted a safer industry) granting Sutro royalties to ores mined above his tunnel. Due to financial and mine owner pressures, the tunnel was not completed until 1878, at the end of the boom. The nearly straight four mile long tunnel gained a mere ten feet in elevation over its course, making it a true engineering marvel, even if it had come too late to be of use in Virginia City. Water still flows out of the tunnel today and the Sutro Tunnel and Drainage Company is still in existence, expecting to collect royalties in the event mining ever resumes in the area.

Take some time wandering the sites of downtown Virginia City and experience time travel by entering the many preserved buildings and amazing history of the city. You might also care to ponder the power of mineral influence on society.

To Stop #6-4 Tahoe Overlook (39.090836°, -119.911736°)

54.8	0.0	Head north on P St toward Mill St/State Route 79 - go 289 ft
54.9	289 ft	Turn left at Mill St/State Route 79 - go 0.3 mi
55.2	0.3	Turn left at NV-341 E/C St - go 1.5 mi
56.7	1.5	Continue onto NV-342 S/N Main St - go 3.0 mi
59.7	3.0	Continue onto NV-341 E - go 2.8 mi
62.5	2.8	Turn right at US-50 W - go 7.7 mi
70.2	7.7	Turn left at N Carson St - go 3.3 mi
73.5	3.3	Slight right toward US-50 W - go 0.2 mi
73.7	0.2	Continue straight onto US-50 W - go 10.4 mi
84.1	10.4	Arrive at Tahoe Overlook
		Time allocation: 15 min

Figure 103 - Geologic map of Tahoe basin showing faults and bathymytry. (Saucedo, 2005)

Here we'll pause to take our first peak at the magnificent Lake Tahoe Basin. The lake sits in what is essentially a large grabben comprised of the Sierra Nevada Mountains to the west and the Carson Range to the east. Subsequent volcanism, which intensified in the Pliocene 5 million years ago, created large lava, tuff and mud flows that dammed the northern perimeter of the down-dropped block and allowed for filling of the basin. The lake has stupendous dimensions: 22 miles deep, 12 miles long and 1,645' deep at its deepest point. The volume contained within the lake would be enough to fill an area equal to the size of California to a depth of 14 inches!

The deep azure color is owed to the absorbtion of red wavelengths at shallow depths and a deeper scattering blues. The lake is still renowned for its clarity, with Secchi visibility measurements averaging a depth of nearly seventy feet during the past ten years. When measurements were first recorded in 1968, the average visible depth was 102 feet. Studies are ongoing, but most research is pointing towards siltation and residential runoff as the main culprit for the declining clarity. Strict building codes now exist in the lake's watershed in both California and Nevada and have been attributed with the recent stability of the Tahoe's clarity.

Under the surface of the water, directly across from our view, lies the West Tahoe Fault, which we will cross later in the day. The fault's estimated 7.3 maximum magnitude could wreak havoc on the lake, creating tsunamis in the ten to thirty foot range. At least two paleo-tsunamis have been documented, as well as a large turbidite formation off the coast of Tahoe city that occurred sometime between 15,000 and 7,000 years ago. The geohazards within the lake's basin should not be taken lightly, and ongoing research is being conducted to fully understand the threats.

A small dam on the lake's outlet regulates the flow of the Truckee River which provides municipal water for Reno and many other smaller towns along its path to Pyramid Lake. Tahoe and Pyramid (along with Walker) lakes once held gargantuan Lahontan cutthroat trout, a remnant species of the Pleistocene Lake Lahontan. The fish, generally 24-48 inches long, and sometimes well over sixty pounds, were over harvested at a rate of 73,000 lbs per year to satiate the palettes of hungry miners in Virginia City as well as the wealthy from San Francisco. The over harvesting, logging and mining run-off, along with several dams built on the Truckee River between Tahoe and Pyramid lakes, spelled demise for the river-spawning species. Currently, a healthy population resides within Tahoe, but now come nowhere near attaining their past size. The modern California record Lahontan caught with tackle and pole is a mere 31.5 pounds.

		<u>To Stop #6-5 Taylor Creek Visitor Center (38.935646°, -120.053101°)</u>
84.1	0.0	Head south on US-50 W toward Kelly Cir - go 16.6 mi
100.7	16.6	Turn right at CA-89 N/Emerald Bay Rd - go 3.2 mi
103.9	3.2	Turn right at Visitor Center Rd - go 0.2 mi
104.1	0.2	Arrive at Tahoe Research Center
		Time allocation: 40 min

This stop is meant to give you about thirty minutes to peruse the great displays within the museum, and most importantly allow you to walk the special half-mile loop through a well-signed explanation of a Tahoe riparian ecosystem. The trail passes streams and marshes and actually goes underground for several yards so that visitors can view an active stream profile of Taylor Creek. The aquarium-like view is quite mesmerizing and makes this stop very worthwhile. While our visit will likely allow viewing of full-time Taylor Creek residents, the fall brings spawning trout and Kokanee salmon upcreek in an amazing display of frothy, red biomass.

Figure 104 - Taylor Creek Stream Profile.

Figure 105 - Taylor Creek marsh: filters water and helps keep Tahoe blue.

To Stop #6-6 Angora Ridge Overlook (38.906330°, -120.044090°)

104.1	0.0	Head northeast on Visitor Center Rd toward Baldwin Beach Rd - go 0.2 mi
104.3	0.2	Turn left at CA-89 S/Emerald Bay Rd - go 466 ft
104.4	466 ft	Take the 1st right onto Fallen Leaf Rd - go 0.1 mi
104.5	0.1	Slight left to stay on Fallen Leaf Rd - go 1.9 mi
106.4	1.9	Turn left at Tahoe Mountain Rd - go 69 ft
106.4	69 ft	Arrive at Angora Ridge Overlook
		Time allocation: 10 min

Figure 106 - Angora Ridge Fire at full force. Drought and katabatic winds fueled the fire. *(US Forest Service Photo)*

This stop ties together two seemingly unrelated views. Surrounding us are the remnant burns from the Angora Ridge Fire from June 2007, and to our north is Fallen Leaf Lake, an obvious glacial valley bounded by lateral moraines and dammed by a terminal moraine as the last glaciers retreated nearly 12,000 years ago. The fire burned 3,072 acres, 250 structures amd displaced over 1,000 residents thanks to a careless, illegal campfire. The Angora fire is the largest wildlands fire of modern times within the Tahoe Basin and occurred during the beginning of the three year drought. High westerly katabatic winds (descending air warming at the dry adiabatic rate as it fell off the Sierran crest) within the region at the time of ignition rapidly pushed the flames three miles in four hours. Luckily many neighborhoods in the area had been cleared of underbrush in the years preceding the fire, preventing a full-blown crown fire from ravaging surrounding forest lands.

Fires in the Sierra are a great reminder of just how unstable the environment can be during drought years, which leads us to a discussion of Fallen Leaf Lake to our north. Recent and ongoing studies have found vertically standing tree snags rooted along the shelf of the modern lake. Carbon 14 and dendrochronologic dating shows that several trees were over two hundred years old at the time of their death circa 1,240. The working hypothesis to explain the trees is a severe, 200-plus year drought, which caused the lake levels to plunge and allowed for tree germination on what would have been a shoreline of the shallower lake. Even scarier than the prospect of a 200+ year drought is the fact that preliminary findings have also found stumps dating from 300 BC and 1525 BC. The older stumps suggest a cyclical pattern to mega-droughts, the like of which would be crippling to California and the United States. Research to fully document the entire lake bed of Fallen Leaf Lake via state-of-the-art sonar was commenced in July of 2010 by Scripps Institute. The findings will undoubtedly be extremely interesting, especially if a drought cycle is established. The ramifications for California's water storage infrastructure could be profound.

To Stop #6-7 Eagle Falls and Lake Hike (38.951466°, -120.111679°)

106.4	0.0	Head northwest on Tahoe Mountain Rd toward Fallen Leaf Rd - go 69 ft
106.4	69 ft	Turn right at Fallen Leaf Rd - go 2.0 mi
108.4	2.0	Turn left at CA-89 N/Emerald Bay Rd - go 5.4 mi
113.8	5.4	Arrive at Eagle Falls and Lake Trailhead
		Time allocation: Until 6pm

Eagle Falls is a classic hanging valley waterfall that spectacularly spills and plunges 140' into Emerald Bay. During the last ice ages, Emerald Bay and the Eagle Creek Canyon were both filled with glaciers, creating the elongated features of Emerald Bay and the amazing glacially polished Eagle Canyon. After viewing the falls on the east side of Highway 50, we will cross the road to embark on a mile-long hike up to Eagle Lake to acquire a great view of Emerald Bay and evidence of the glaciations that created the magnificent landscape. Keep a sharp eye out for the many examples of erratics, glacial polish and chatter marks (figure 108) attributed to the basal slip of the valley glaciers that once poured down the canyon. Our destination will be the magnificent Eagle Lake, a highly frequented tarn within the glacial cirque that will encompass us. The views are breath-taking, and the relatively quick hike will allow ample time for exploring the area, including the upper Eagle Creek Canyon for the quicker hikers.

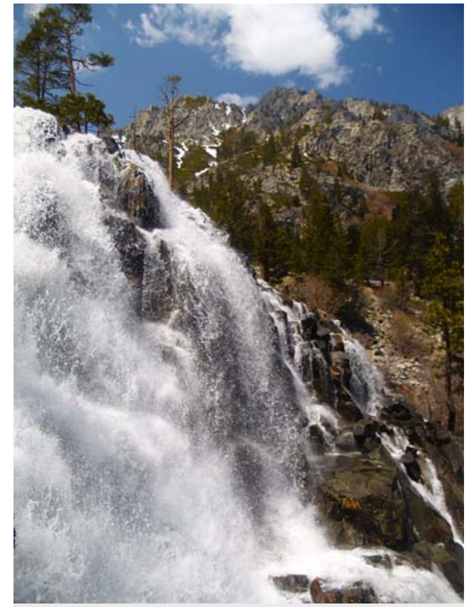


Figure 107 - Eagle Falls.

Figure 108 - Chatter marks in the granodiorite. Note 4" lens cap at left corner for scale.

To Stop #6-8 Lakeside Inn (38.969418°, -119.935402°)

113.8	0.0	Head southeast on CA-89 S/Emerald Bay Rd - go 8.5 mi
122.3	8.5	Turn left at US-50 E/Lake Tahoe Blvd - go 5.8 mi
128.1	5.8	Arrive at Lakeside Inn
		Be ready for our last day by 7:30am – it's a long haul!

We'll return to the hotel on South Shore prior to sunset to allow ample downtime within the vibrant community.

Day 7 – South Lake Tahoe to San Jose: Leaving the Sierras Leaves us a Feeling Little Flat.

Since we can't burry our heads in agony that the trip is ending today, we'll do the next best thing and spend a good portion of the day underground in the Western Metamorphic complex before heading back out across the inverted Sacramento-San Joaquin Delta and past a rare coal seam. From there we'll skirt past Suisun Bay and head to San Jose where we'll all cry that we have to leave such an awesome trip.

Mileage

Cum.	Interval	To Stop #7-1 Carson Pass (38.693951°, -119.985809°)
0.0	0.0	Head south on US-50 W toward 4-H Rd - go 1.2 mi
1.2	1.2	Turn left at Pioneer Trail - go 8.0 mi
9.2	8.0	Turn left at CA-89 S/US-50 W - go 0.9 mi
10.1	0.9	Turn left at CA-89 S (signs for Markleeville/Jackson/CA-88) - go 11.2 mi
21.3	11.2	Turn right at CA-88 W - go 8.6 mi
29.9	8.6	Arrive at Carson Pass
		Time allocation: 10 min

Figure 109 - Volcanics just south of Carson Pass on Pacific Crest Trail.

The first stop at Carson Pass overlooks great volcanic outcrops of Tertiary volcanic formations. The volcanics predate the uplift of the Sierra's and in some spots preserve pre-sierran canyons and river beds. At this stop we'll be quickly looking for telltale evidence of the paleo-canyons and unconformable contacts with the underlying Mezozoic granitic rocks to piece together a small puzzle as we leave the Sierra Nevadas.

		To Stop #7-2 Black Chasm Cavern (38.432446°, -120.626045°)
29.9	0.0	Head southwest on CA-88 W toward Woods Lake Rd - go 49.0 mi
78.9	49.0	Continue onto Volcano Pioneer Rd - go 1.9 mi
80.8	1.9	Arrive at Black Chasm Cavern
		Time allocation: 1.5 hours

This stop will allow us an hour or so underground in the limestones and marbles (limestone knockers) associated with the accreted, tropical terranes of the Shoo Fly complex. First discovered in the late 1800's, the Black Chasm National Monument was awarded National Natural Landmark Status in 1976 for its incredibly preserved and unique cave features. The Chasm is a classic limestone cavern (albeit somewhat small), but is renowned for its rare helictites that project from the walls like a mass of frozen cooked spaghetti noodles. The helictites are formed from hydrologic pressures squeezing the calcite-rich ground waters laterally from the cave walls instead of the more typical vertical dripping that is associated with the formation of stalactites and stalagmites.

Figure 110 - "The Dragon" helictite.

Recall that karst topography, along with caverns, are formed when slightly acidic groundwater penetrates carbonate rocks and slowly dissolves the rocks through ion disassociation. Once an opening is created, subsequent groundwater dripping through the cavern slowly deposits calcite at rates of less than a millimeter per year.

After the guided tour we'll take a few minutes to peruse the sight's visitor center. Of interesting Hollywood note, Black Chasm was used as the inspiration for the set design of the underground city of Zion in "The Matrix" trilogy. Be sure to take a look at some of the old set pieces now displayed in the museum and just be thankful that it's not a Keano Reeves cut-out. "Whoa…."

To Stop #7-3 Kennedy Tailing Wheels (38.363338°, -120.775482°)

80.8	0.0	Head northwest on Volcano Pioneer Rd toward Pine Grove Volcano Rd - go 0.3 mi
81.1	0.3	Sharp left at Pine Grove Volcano Rd - go 2.7 mi
83.8	2.7	Turn right at CA-88 W - go 8.4 mi
92.2	8.4	Turn right at Court St - go 0.6 mi
92.8	0.6	Turn right at Church St - go 0.4 mi
93.2	0.4	Turn right at N Main St - go 0.8 mi
94.0	0.8	Arrive at Kennedy Tailing Wheels
		Of Time allocation:15min

Figure 111 - Kennedy Tailing Wheel.

Jackson was one of the richest Motherlode mining districts between the 1850's and 1942 when the gold miners were either drafted or sent to mine more strategic metals to support the war effort. The Kennedy and Argonaut mines within the district produced somewhere in the neighborhood of $54 million. It is interesting to compare this number with the production of the Round Mountain Mine in Nevada that we visited two days ago. The mines bored deep into the earth, following hydrothermally emplaced quartz veins, along fractures associated with the Melones fault zone, which we'll literally touch on at the next stop beneath the ground. The towers in the far distance down the hill are the remnants of the Kennedy Mine which was in operation from 1866 to 1942 and once held the distinction of being the deepest mine in the world reaching depths of 5912 feet (kennedygoldmine.com, 2010). The large wheels in the background are unbelievably related to the Kennedy Mine. They were ingeniously constructed to haul 850 tons of processed ore every 24 hours out of the Kennedy Mine mills and UPHILL to a large containment reservoir. The reservoir had to be constructed to comply with new state law in 1912 that required all tailings be kept on site and could no longer be flushed downstream. It was yet another early environmental win for California's farmers and valley residents. Originally the wheels would have been housed in a large wooden shack, but those have long ago been salvaged for lumber or lost to the ravages of time.

Stop #7-4 Sutter Gold Mine Tour (38.410210°, -120.812180°)

94.0	0.0	Head northeast on N Main St toward Jackson Gate Rd - go 256 ft
94.0	256 ft	Continue onto Jackson Gate Rd - go 0.3 mi
94.3	0.3	Slight left to stay on Jackson Gate Rd - go 1.3 mi
95.6	1.3	Turn right at CA-49 N - go 1.2 mi
96.8	1.2	Turn right at Old Calfornia 49 - go 2.3 mi
99.1	2.3	Turn right toward String Bean Alley - go 0.4 mi
99.5	0.4	Slight left at String Bean Alley - go 144 ft
99.5	144 ft	Arrive at Sutter Gold Mine Tour
		Time allocation:1.5 hours

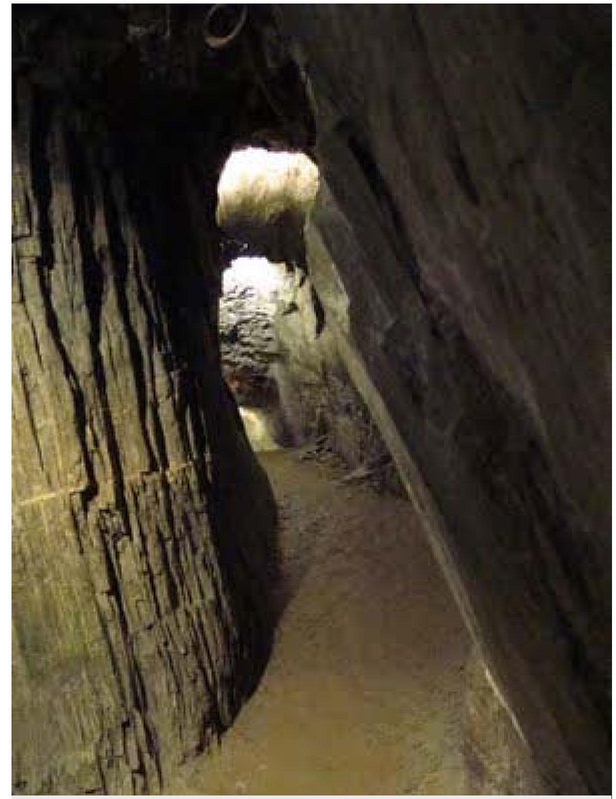


Figure 112 - Melones Fault: Gold-bearing quartz had previously filled the weakness and was subsequently mined. The headwall (r) and footwall (l) are very evident. (photo credit: *Garry Hayes, MJC*)

Just because we couldn't get enough of an underground experience earlier, we're again headed underground here at the Sutter Gold Mine to see a once (and possibly future) active underground gold mine. The tour will take about an hour as we are carted 400 hundred feet below the surface to learn how hard-rock mining is conducted. It should be an interesting comparison between this mine and the Round Mountain mine. The Sutter Mine originally opened in the early 1980's, but has found that mining the constant stream of tourists to be a much more profitable business model. The mine has promised on several occasions that it will reopen once gold prices surpassed $500/oz., but it has remained idol even as prices crept above $1,200, calling into question the future production of the mine.

Most geologists attribute the golds now found in the Sierra to the exotic terranes that smashed into California in the Western Metamorphic belts and older Shoo Fly Complex. For reasons unknown, the subduction zone jumped to the west of what is now the Great Central Valley. The subducted material from this new zone was responsible for creating the Sierra Nevada Batholith. Age dates place quartz-rich gold veins found in the Motherlode at about 115 Ma, nearly concurrent with age of subduction that created the Sierra batholith. That correlation leads to a now common conclusion that the rising plutons were responsible for providing the hydrothermal fluids that dissolved the gold out of the accreted terranes and re-emplaced them within the faults, cracks and fissures between the contacts of the terranes.

Because we're so lucky we'll actually get to hike down the ACTUAL Melones Fault which here separates the Foothills terrane and the Calaveras Complex discussed in Day 2's western metamorphic belts. It's an amazing feeling to hit one's head on a headwall while treading on the footwall of a mine drift that once produced gold. Before we reach that point, however, you will have learned about the many sacrifices once (and still) made to obtain a metal whose most strategic use is as a decoration.

To Stop #7-5 Ione Kaolinite Clay Mines and Ione Fmt. Fossils (38.325970°,-120.929626°)

99.5	0.0	Head east on String Bean Alley - go 144 ft
99.5	144 ft	Slight right toward Old Calfornia 49 - go 0.4 mi
99.9	0.4	Turn left at Old Calfornia 49 - go 2.3 mi
102.2	2.3	Turn left at CA-49 S - go 0.3 mi
102.5	0.3	Take the 1st right onto CA-104 W/Ridge Rd - go 1.7 mi
104.2	1.7	Turn right at CA-104 W/CA-88 W - go 6.5 mi
110.7	6.5	Turn right at Buena Vista Rd/Ione Buena Vista Rd - go 0.3 mi
111.0	0.3	Arrive at Ione Kaolinite Clay Mines and Ione Fmt. Fossils
		Time allocation: 10 min

Not every mine in the foothills area produces valuable metals. Most produce aggregate and some create a great business for themselves by getting crapped-on… well at least their product gets crapped-on by millions of cats each year. This overlook provides us a view of the Ione Minerals kaolinte mine, one of the leading producers of the clay-rich mineral in the state. The clays are used in a variety of products including ceramics, agriculture and even kitty litter. The stunning, unnaturally teal lakes, occupy old quarry pits.

The clay is part of the Eocene-aged Ione Formation, which unconformably rests above angled metamorphic rocks. The fossils and sandy/clay makeup of the area attest to the area's past life as a large, coastal river delta and estuarine environment that predated the existence of the Coast Ranges and Central Valley. Had we been here during the Eocene beach chairs, swimsuits and horrifically strong deet would have been the ticket.

The size of the formation and other evidence such as diamonds and emeralds in ancient river meanders within the formation provide clues that the river that once terminated in this delta was huge. The diamonds and emeralds can be traced back to Canada, which suggests a very long river as well. With this we'll forever leave behind the Sierras and foothills and our next stop will investigate a past and present power source for California.

To Stop #7-6 Rancho Seco (38.333679°, -121.095688°)

111.0	0.0	Head NW on Buena Vista Rd toward Brickyard Rd - go 0.5 mi
111.5	0.5	Turn right at CA-124 N - go 1.5 mi
113.0	1.5	Turn left at E Main St - go 358 ft
113.0	358 ft	Take the 1st right onto Preston Ave - go 0.9 mi
113.9	0.9	Continue onto CA-104 W/Ione Michigan Bar Rd - go 10.5 mi
124.4	10.5	Turn left - go 0.3 mi
124.7	0.3	Turn left - go 1.6 mi
126.3	1.6	Arrive at Rancho Seco
		Time allocation: 20 min.

This stop illuminates energy production within the state, both past and present. Racnhco Seco first went on-line in 1975 as part of the Sacramento Municipal Utility District's push to provide cheaper and more reliable electricity to its customers. At its peak the plant had a capacity to produce 916 MW of electricity but rarely operated at the designed capacity levels. Rancho Seco Lake, the lake at which we sit, was constructed in the early 1970's to provide an emergency water source for the plant in case of fire. The water supply for the lake is provided by the Folsom Lake Reservoir via a large canal. The extra water was nearly needed on March 20, 1978 when the plant had a steam generator “dry out” caused by insufficient water and incorrect instrumentation readings.

The plant was decommissioned in 1989 as mounting costs and environmental concern among voters in the district outweighed any future benefits the plant might have provided. The park and lake have since become a popular local recreation area run by the Sacramento Municipal Utility District. The plant site was retrofitted with a natural gas plant in 2006 to provide 500 MW of electricity, enough to power over 450,000 homes. The site is also home to three stages of solar arrays, the first of which was built in 1984 as the first utility-scaled solar plant in the nation (SMUD.org). Collectively three arrays produce 3.2 MW of electricity, enough for 2200 homes.

Figure 113 - Rancho Seco (Wikipedia.com)

To Stop #7-7 Delta Tracts/Levees and Deflation (38.114841°, -121.505798°)

126.3	0.0	Head northwest - go 1.6 mi
127.9	1.6	Turn right toward CA-104 W/Twin Cities Rd - go 0.3 mi
128.2	0.3	Turn left at CA-104 W/Twin Cities Rd - go 12.2 mi
140.4	12.2	Turn left at Stockton Blvd - go 0.1 mi
140.5	0.1	Turn left to merge onto CA-99 S - go 12.4 mi
152.9	12.4	Take the CA-12 W/Kettleman Ln exit toward Fairfield - go 0.2 mi
153.1	0.2	Turn right at CA-12 W/E Kettleman Ln - go 13.5 mi
166.6	13.5	Arrive at Delta Tracts/Levees, and deflation
		Time allocation: 20 min

Figure 114 - Island "Tracts" within the inverted delta are clearly visible in this Google Map screenshot.

Welcome to the middle of a rare inland delta. You should have noticed the several bridges crossing rivers and sloughs up until this point. The tracts of land at this point are actually completely surrounded by various sloughs technically making inland islands. The rich soils of this area were laid down at the confluence of the Sacramento & San Joaquin Rivers, which deliver over half of California’s rainfall and snowmelt* and supplies over 23 million people their water for agricultural and domestic use. The extremely fertile soil, laid down during the past several million years, has been farmed since the Gold Rush, and now annually produces more in agricultural revenue than the 150 years of gold mining in California*. Ironically, the seasonal floods that brought the rivers out of their channels and deposited the river's mineral-rich suspended load, became a curse when crops were lost to the seasonal inundation.

Artificial levees were erected around the tracts (and alongside most major rivers) to tame the floods and allow for year-round farming. The levees also acted to perpetually dry the major valley cities in all but the most extremely rainy years. However, if you paid close attention while driving over the bridges, you might have noticed the relative height of the rivers & sloughs compared to the surrounding agricultural lands. The surface levels of the levee-bounded waterways are now higher than the surrounding tracts of lands.

Figure 115 - Jones Tract Flood of 2004. Months were needed to repair levee and reclaim land by pumping. A harbonger of things to come during a large earthquake?

The original soils on the 1,100+ square mile tracts were made of peat, which depended on the annual floods to replenish their volume. With the advent of the levees and subsequent plowing of the tracts, the peat within the soil was allowed to dry and oxidize, which has led many of the tracts to deflate below sea level. The deflation averages a bit over ten feet below sea level, but some of the worst-affected tracts are now twenty-five feet below sea level. As long as the levees hold, this is not a problem, but consider the fact that the center of the delta is less than thirty miles away from the San Andreas Fault, and that many levees are 150 years old. It's estimated that a 6.8 magnitude earthquake during the spring runoff has the potential to liquefy and destroy many of the levees. In a worst case scenario several models have predicted the San Francisco Bay waters rushing in to fill the areas below sea level. It's a Katrina-scale catastrophe that has finally been recognized in the last several years by the state and federal government. Moneys have been allocated to repair the 2,600 miles of levee*s, but as witnessed in Katrina, even modern levees cannot prevent the worst case scenario.

Figure 116 - Levee near Lathrop, CA in 2006 separating new housing from the San Joaquin River. The area flooded in 1950 and 1997.

To Stop #7-8 Black Diamond Mine Visitor Center (37.971401°, -121.862305°)

166.6	0.0	Head west on CA-12 W - go 9.9 mi
176.5	9.9	Turn left at CA-160 S - go 12.4 mi
188.9	12.4	Continue onto CA-4 W - go 5.1 mi
194.0	5.1	Take exit 26 for Somersville Rd/Auto Center Dr - go 0.3 mi
194.3	0.3	Turn right at Auto Center Dr/Somersville Rd - go 2.8 mi
197.1	2.8	Arrive at Black Diamond Mine Visitor Center
		Time allocation: 45min

Black Diamond offers up a unique and rare bit of California geology. It is here that one of the largest coal deposits in California was worked from 1860 through the early 1900's. Nearly four million tons of lignite were extracted from this area to power various bay area cities and remote mountain mines in the Sierra Foothills. The road cut just past Rose Hill cemetery shows a well exposed outcropping of the Clark coal vein. Closer inspection of the area should bring one to notice that atop the lignite sits nearly seventy feet of marine shales and sandstones, representing an oceanic transgression. Several more transgression/regression series, known collectively as the Domengine Formation, are visible within the various roadcutss of the park. The transgressive burial of the carbon-rich estuarine environment contributed to the formation of the lignite coal bed from which the park gets its name.

At the bottom of the Domengine Formation are very fine, thin layers of white sands. The white sands here are identical to those that were also visited by us earlier today at Stop #5 in Ione. The correlation provides strong evidence that this layer stretches across the entire central valley, some fifty-five miles east of where we now stand and has some petrologists excited about the fact that there may be untapped natural gas deposits associated with the Domengine Formation that have dipped to the east under the Sacramento Valley. At Black Diamond Park, the sands were mined underground between 1920 and early 1949 for glass making in the bay area. Should time permit, the park offers underground adit tours that show intricately preserved plant fossils preserved between layers of sand and silt from the transgression.

With 3,848' Mount Diablo looming over us at this site and while viewing marine formations exposed at the surface, the question begging to be asked at this stop is how did it all get uplifted and exposed? Mount Diablo's angled flanks actually provide the answer (Harden 255). While the core of Mount Diablo is Mesozoic serpentinite associated with an accretionary subduction zone, the edges of the mountain and surrounding flatlands are covered by the Lawlor Ashflow Tuff that erupted from the Sonomoa Volcanic field to the north nearly five million years ago. Based on the angled tuff on the side and near the peak of Mount Diablo, and utilizing the law of original horizontality, we can safely assume that Mount Diablo must not have been present 5 million years ago, making the mountain, and the uplift of the surrounding Eocene sediments, younger than 5 million years. Evidence points to the shifting of the San Andreas Fault from a subduction boundary to an oblique transform fault in this area nearly four million years ago as the compressional impetus for the Coast Range's uplift.

And so our trip ends, near where it began. We've successfully traced and discussed the geologic, climatologic, and meteorological origins and cycles found within Central California and Nevada. Hopefully this trip has ignited a curiosity within the participant to further explore the nooks and crannies of these two amazing states and will provide useful knowledge that can be utilized in the classroom for years to come.

		To Stop #7-9 San Jose Airport Vicinity (37.358971°, -121.940689°)
197.1	0.0	Head north on Somersville Rd toward Paso Corto Rd - go 2.8 mi
199.9	2.8	Turn left to merge onto CA-4 W - go 10.6 mi
210.5	10.6	Take exit 15A to merge onto CA-242 S toward Oakland/Concord - go 4.5 mi
215.0	4.5	Merge onto I-680 S - go 43.4 mi
258.4	43.4	Take the Landess Ave/Montague Expy exit - go 0.2 mi
258.6	0.2	Keep right at the fork, follow signs for Heald College and merge onto Montague Expy - go 2.9 mi
261.5	2.9	Turn left at E Trimble Rd - go 1.9 mi
263.4	1.9	Slight left at De La Cruz Blvd - go 1.1 mi
264.5	1.1	Slight left at Coleman Ave (signs for San Jose) - go 112 ft
264.5	112 ft	Arrive San Jose Airport Vicinity

Evening instructions- Group Dinner?

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