

ROCKS AND RICHES

EXPLORING CALIFORNIA'S
STUNNING GEOLOGY

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North America's Natural Wonders*



When I retired and moved back to California, I decided to go on road trips to learn about the geology of the state I was born in (but left at age 17)

This book is the result of those trips.



I was lucky to have my son Adam do the artwork for this book.
.... and to get Tom Killion's permission to use some of his prints.

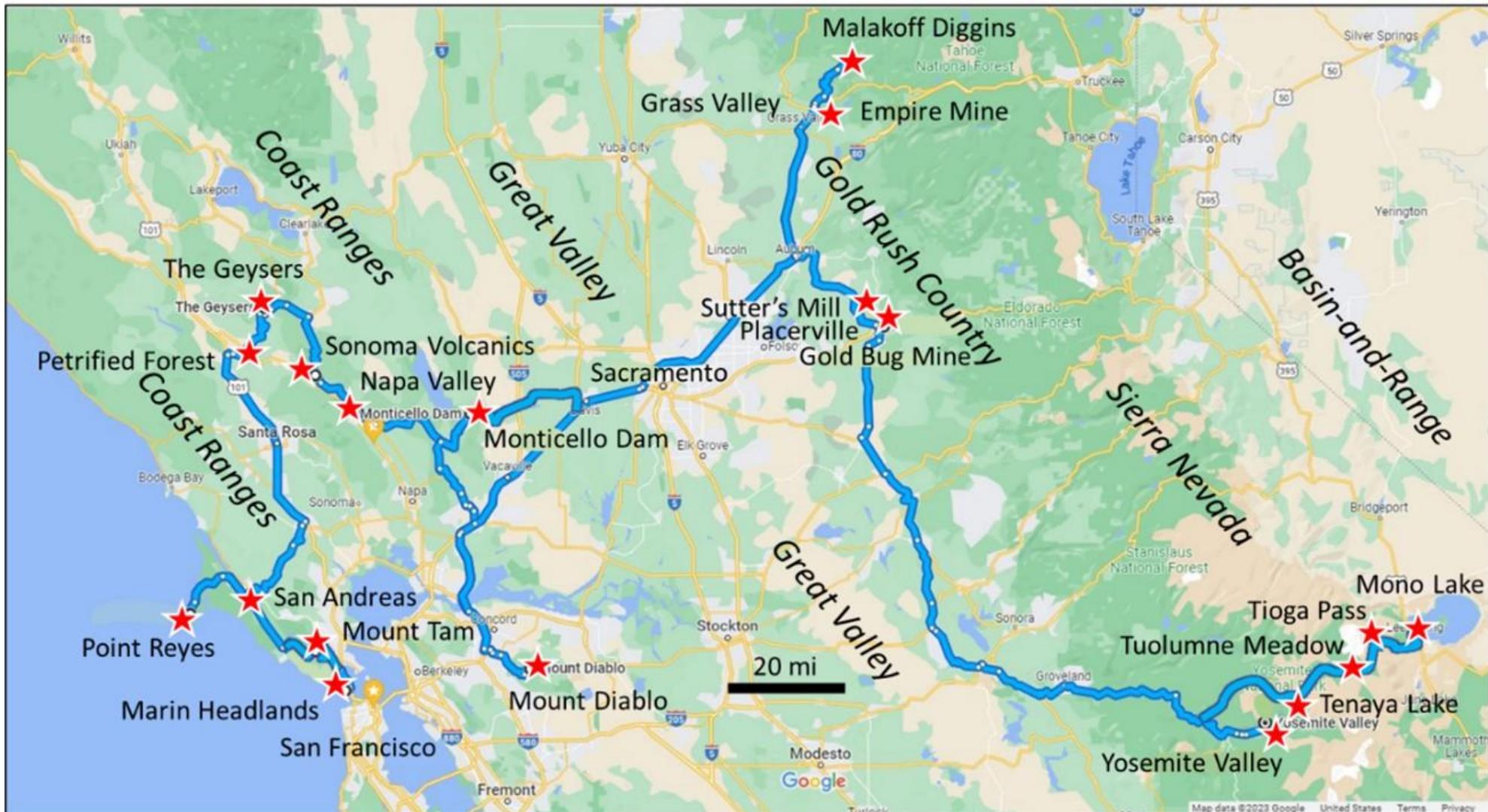


I love a road trip...

Me: “Those rocks are sooooo cool.”

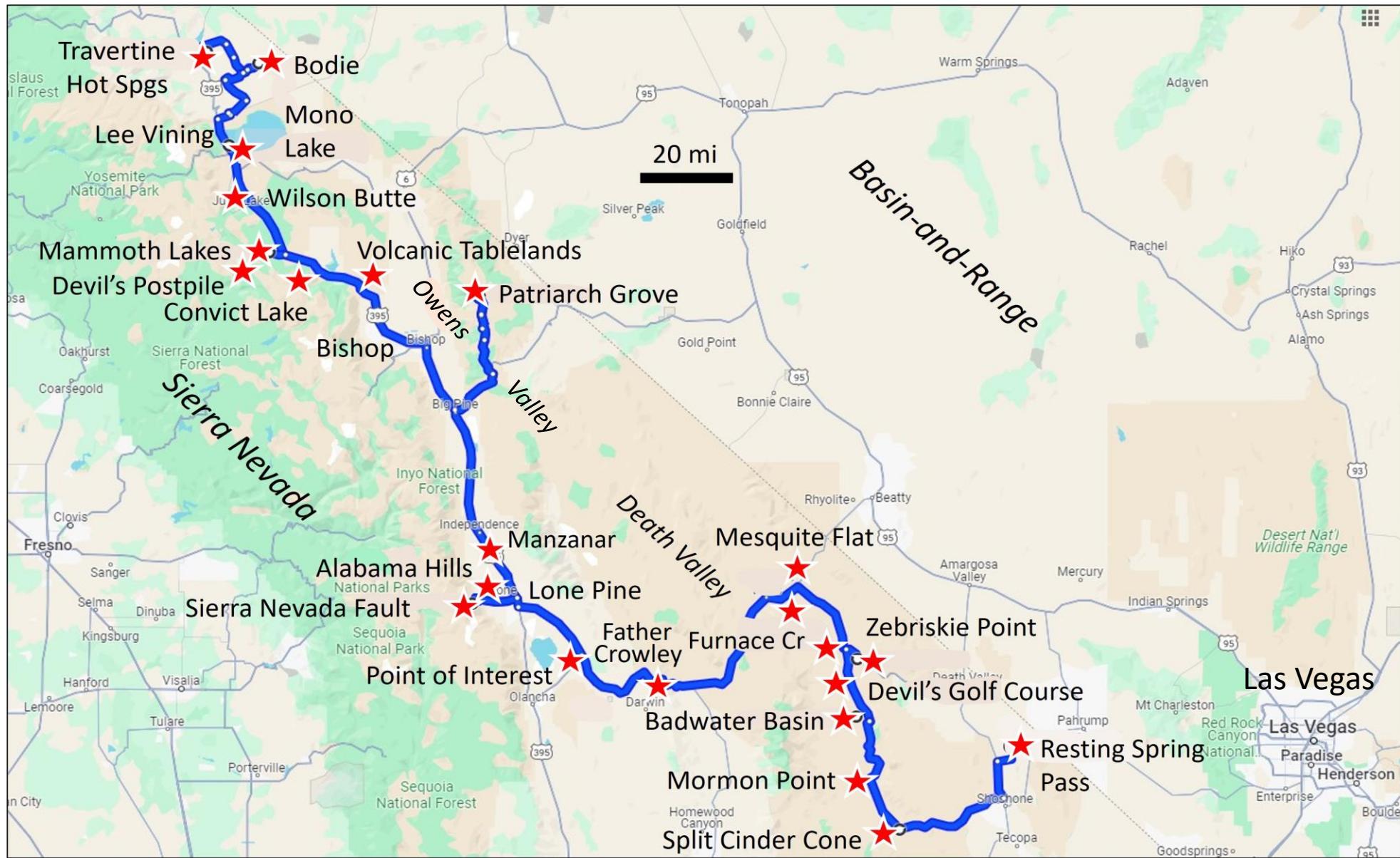
Wife: “Watch the road!”

The Western Half



This shows the main geologic provinces: Coast Ranges, Great Valley, Sierra Nevada, Basin-Range

The Eastern Half

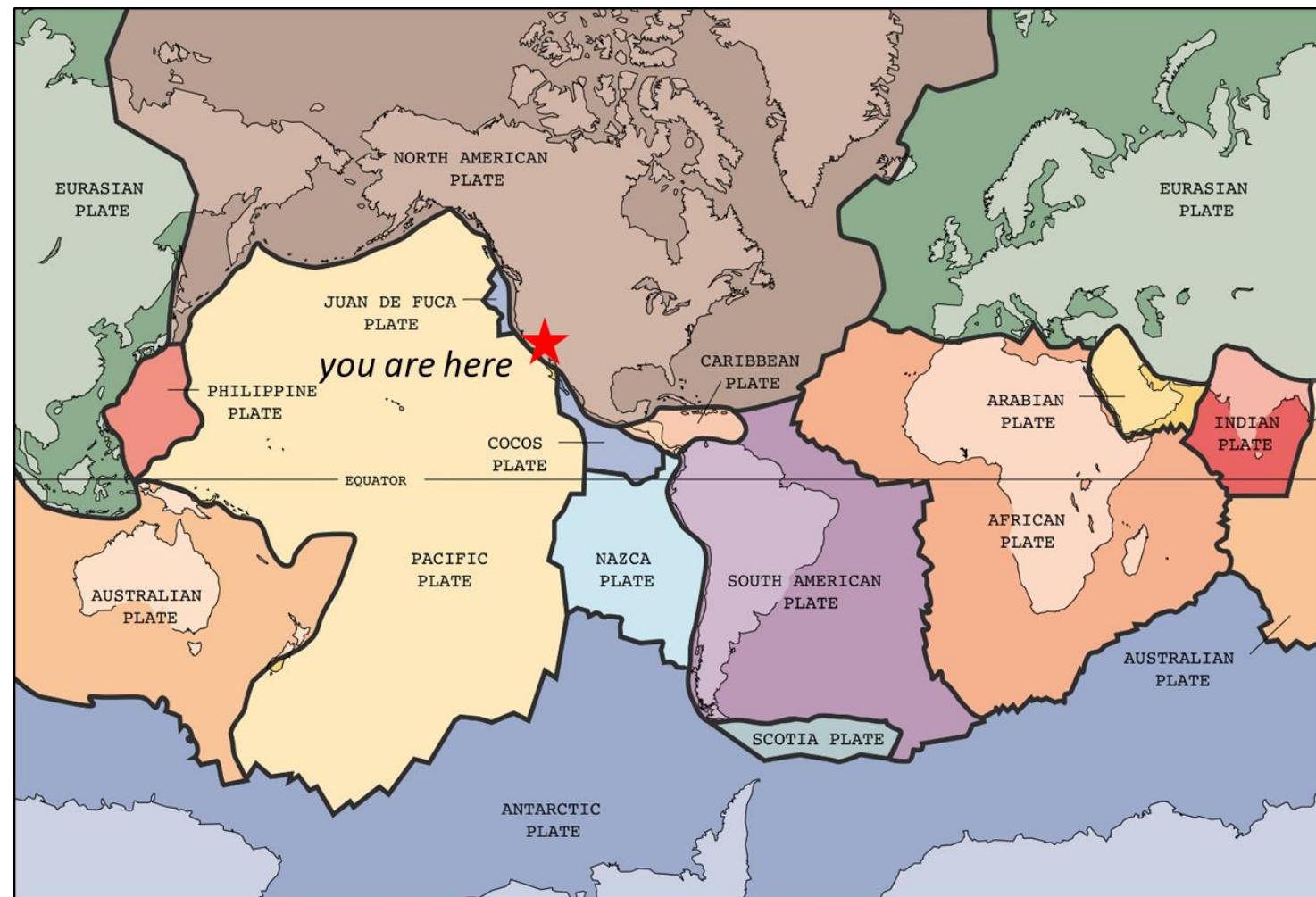


GEOLOGIST AT LUNCH



©1993 Tom Swanson

Background: World's Tectonic Plates



“Jurassic Arc” - California Began With Collision



It is 215 Million Years Ago

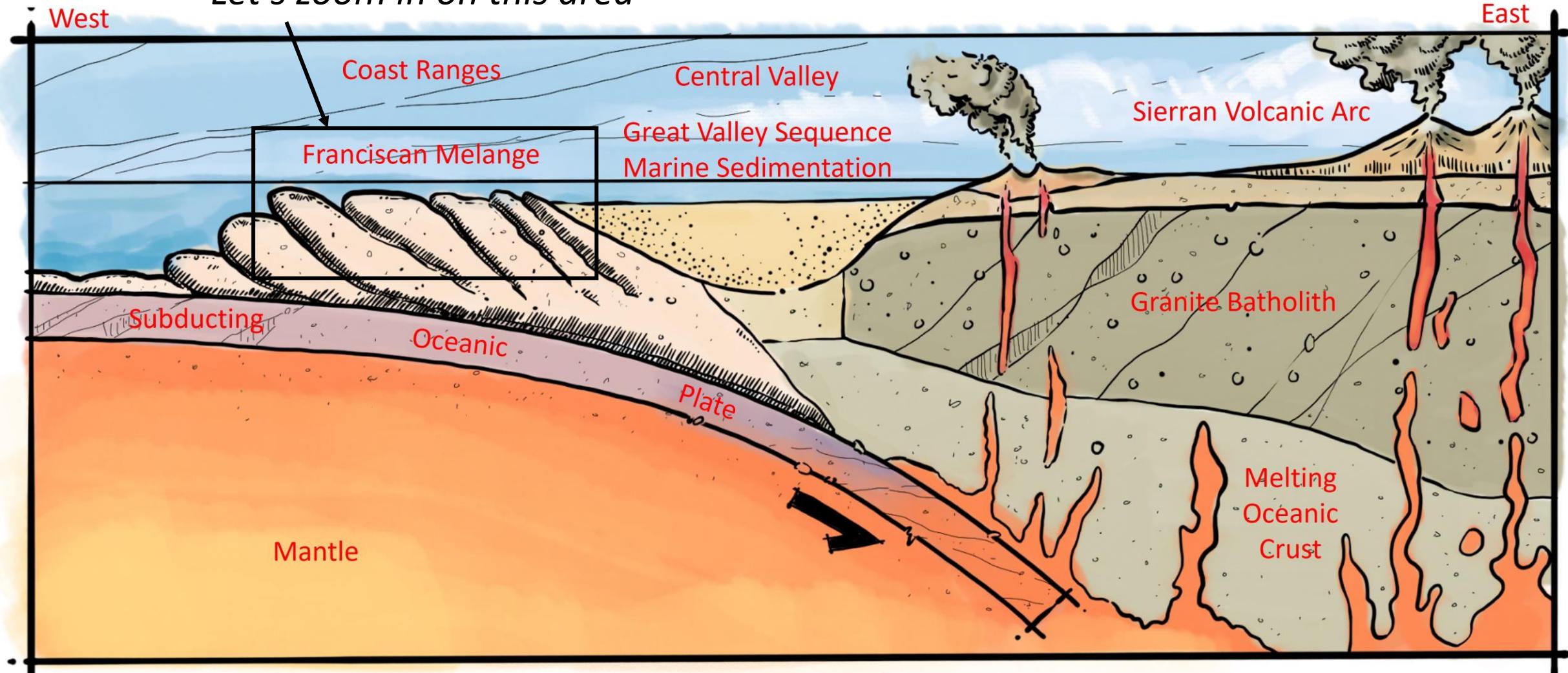
The Farallon plate is diving beneath North America (subduction)

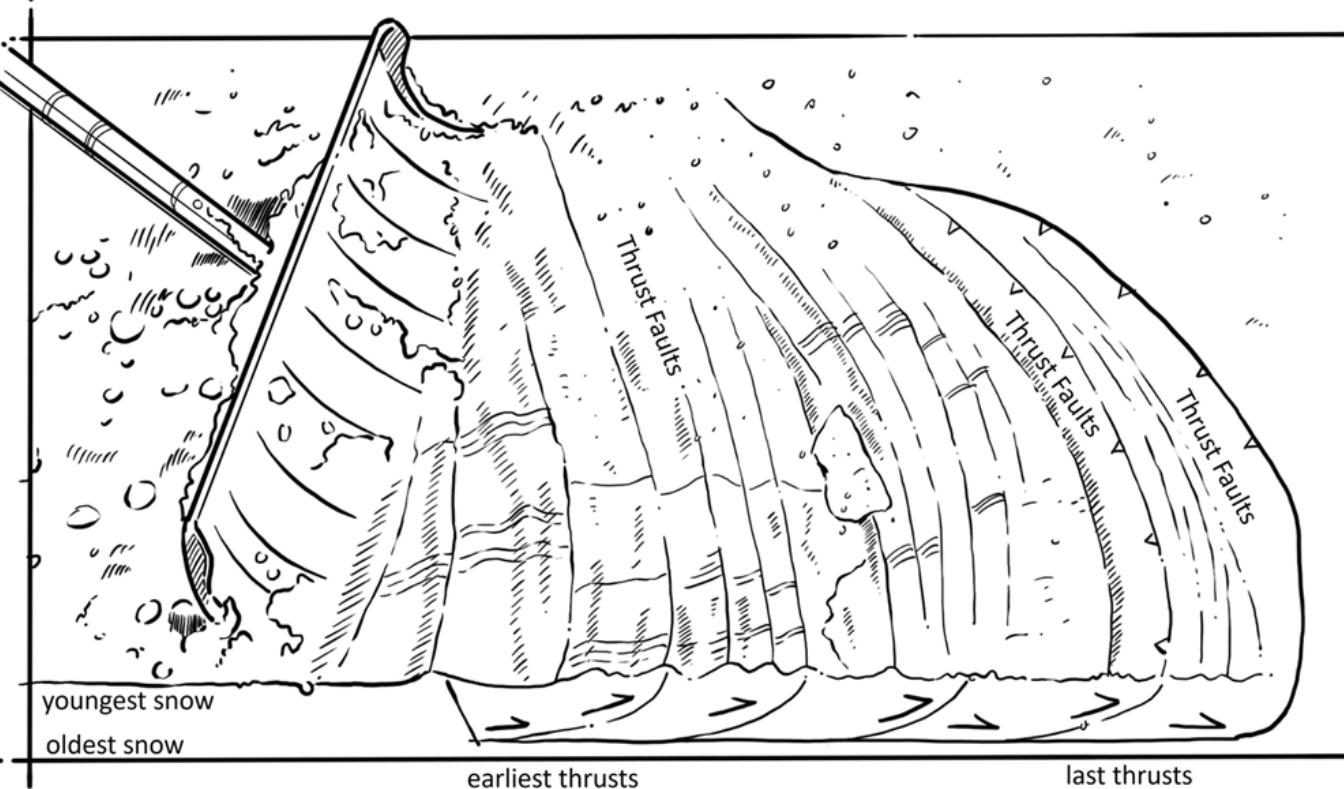
This caused a mashup of marine sediments and slivers of ocean floor, the Franciscan Melange

Melting of the downgoing plate caused a volcanic arc that today is the Sierra Nevada

Before ~25 million years ago

Let's zoom in on this area





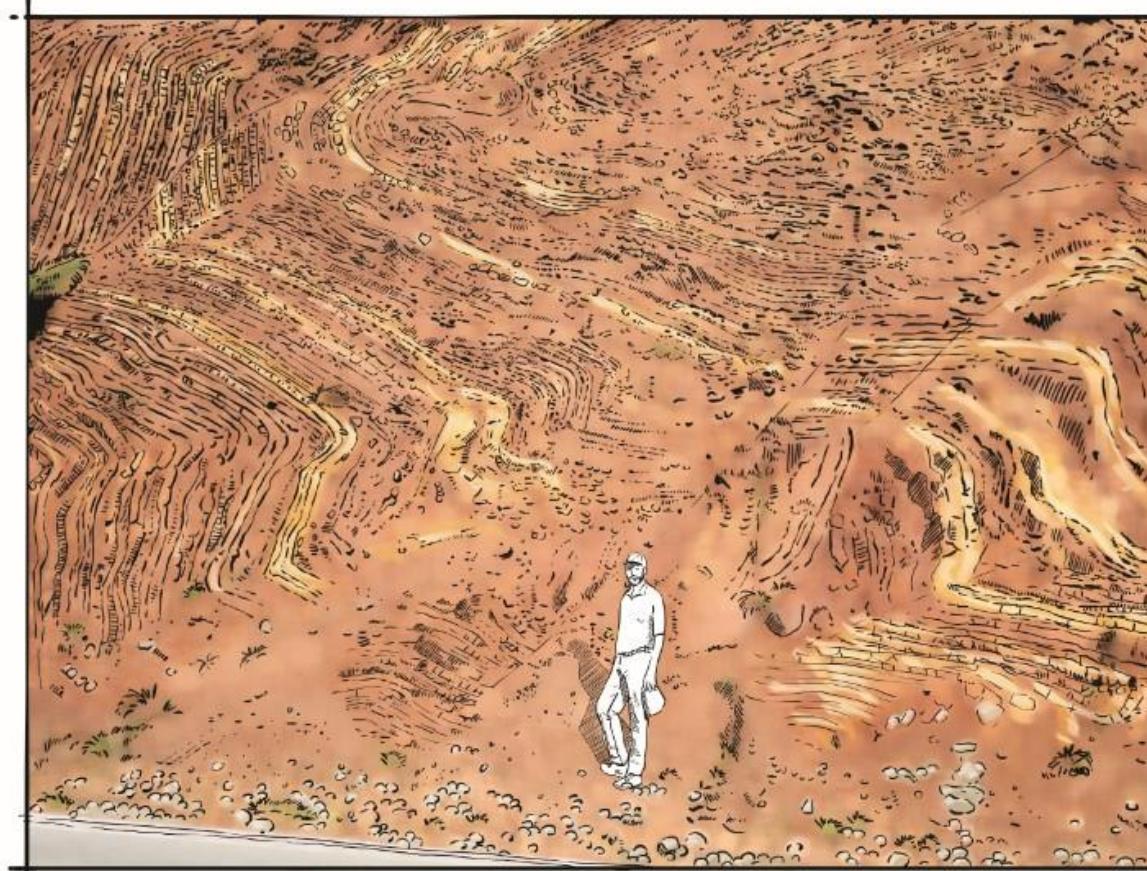
Snow shovel analog to thrust faulting

So how do you get rocks to deform like toothpaste?

As Morgan Freeman's character in the Shawshank Redemption said, "Geology is the study of pressure and time. That's all it takes, really. Pressure and time."

One of the first stops on this road trip is at deformed Franciscan at the Marin Headlands

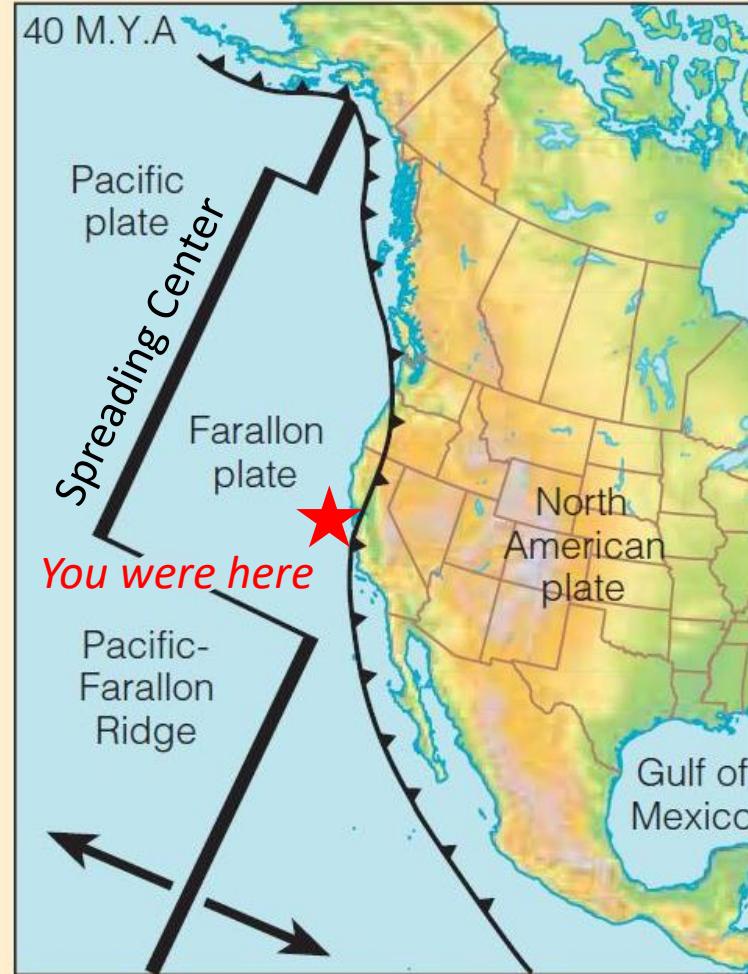
Stop 2, Franciscan Melange, Conzelman Road



Then, about 25 million years ago everything changed

North America overrode the spreading center. Subduction stopped. Sideways slip began

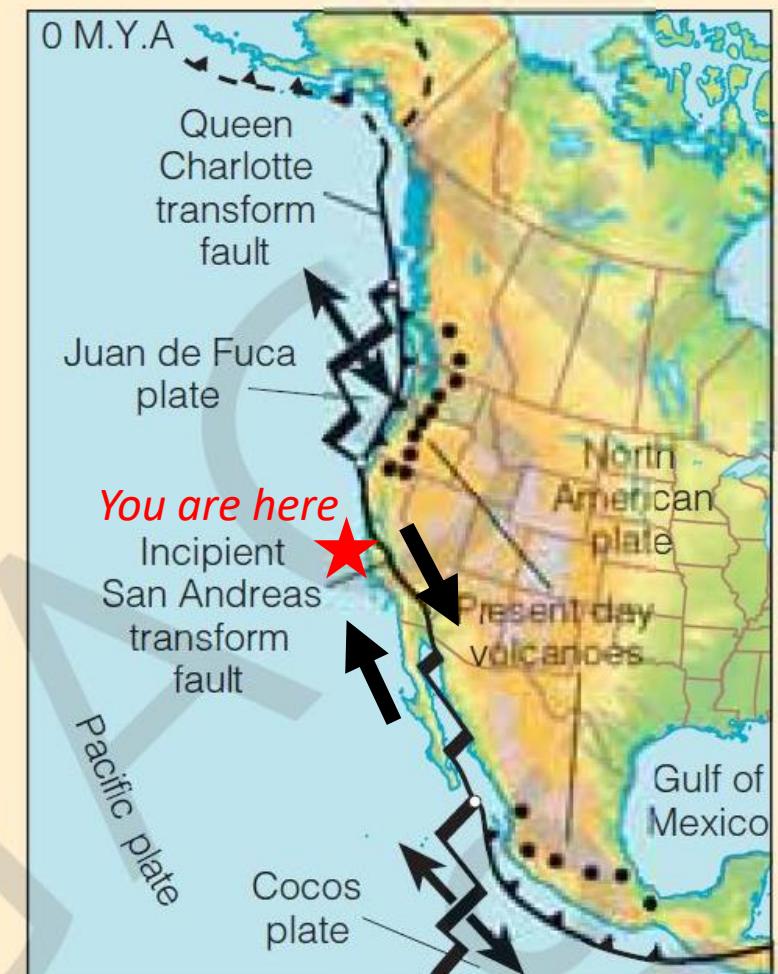
40 million years ago



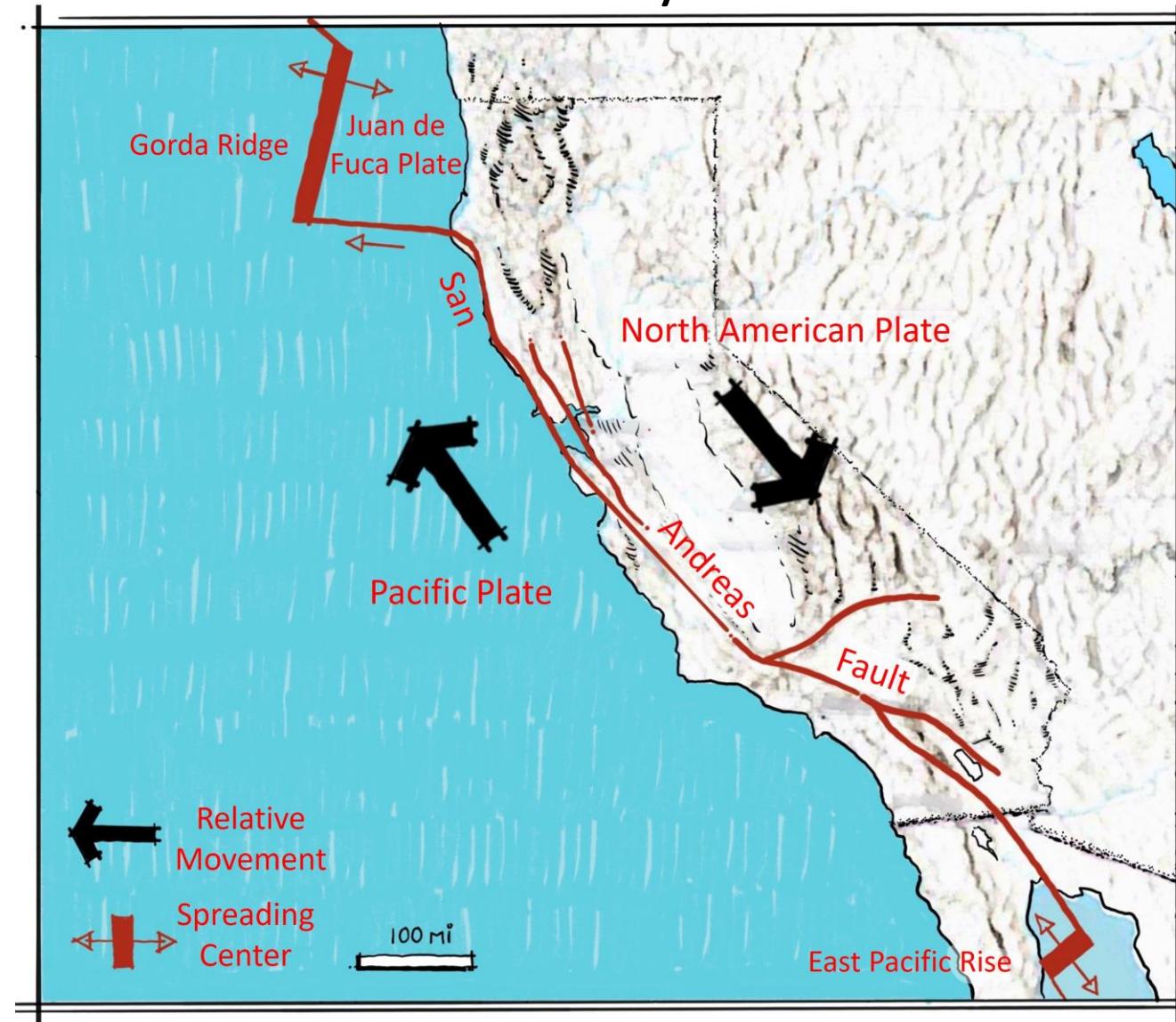
20 million years ago



Today

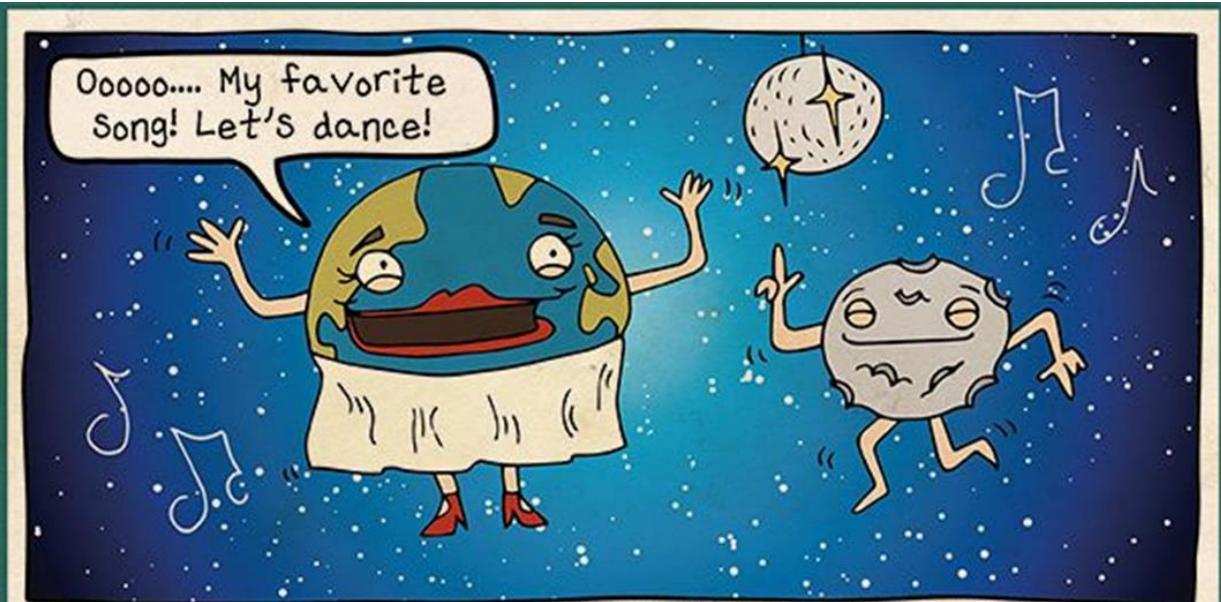


Today



and that leads to earthquakes

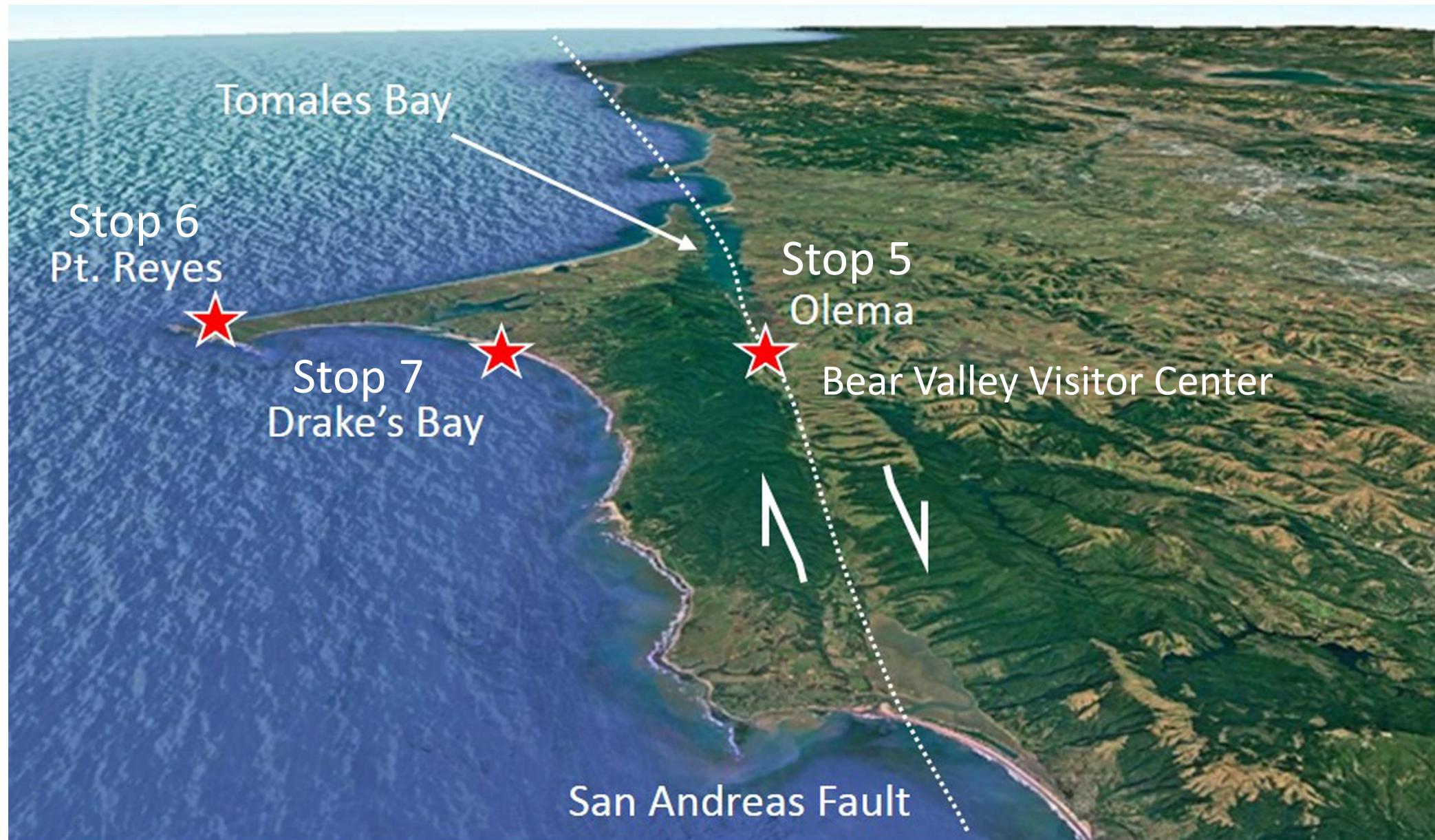
“I feel the Earth move, under my feet...”



Stop 5: Bear Valley Visitor Center, Olema



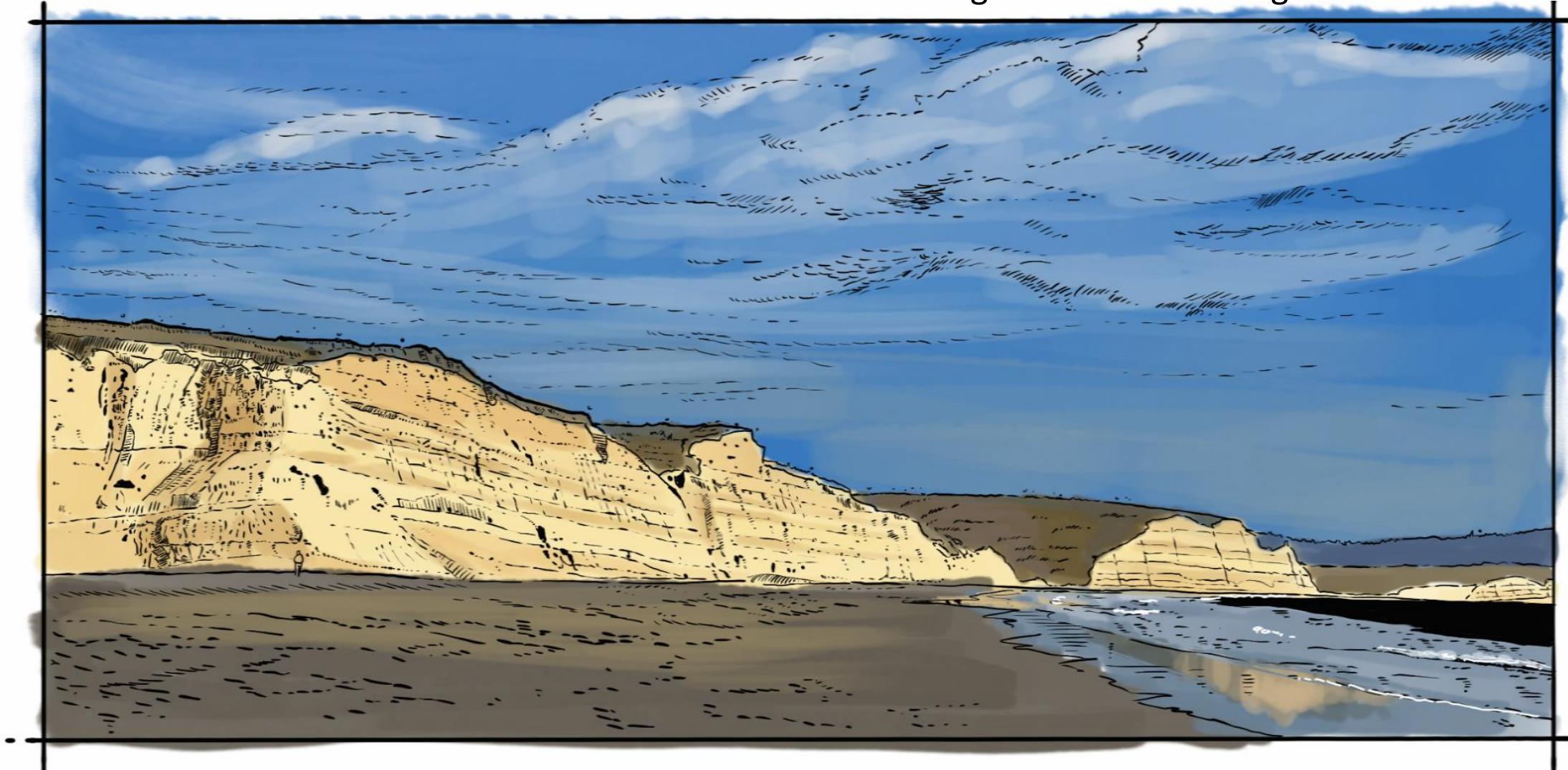
1906 San Andreas rupture near Olema. Lateral offset here was about 20 feet.
Gilbert, 1907, U.S. Geological Survey Bulletin 324.



The granite at Pt Reyes is the same as that at Salinas, 120 miles to the south; the conglomerate above the granite is the same unit as the Carmelo Formation east of the San Andreas Fault at Monterrey.

Stop 7: Drakes Bay, Point Reyes Peninsula

Cliffs of Purisima Formation sandstone turn golden in the setting sun



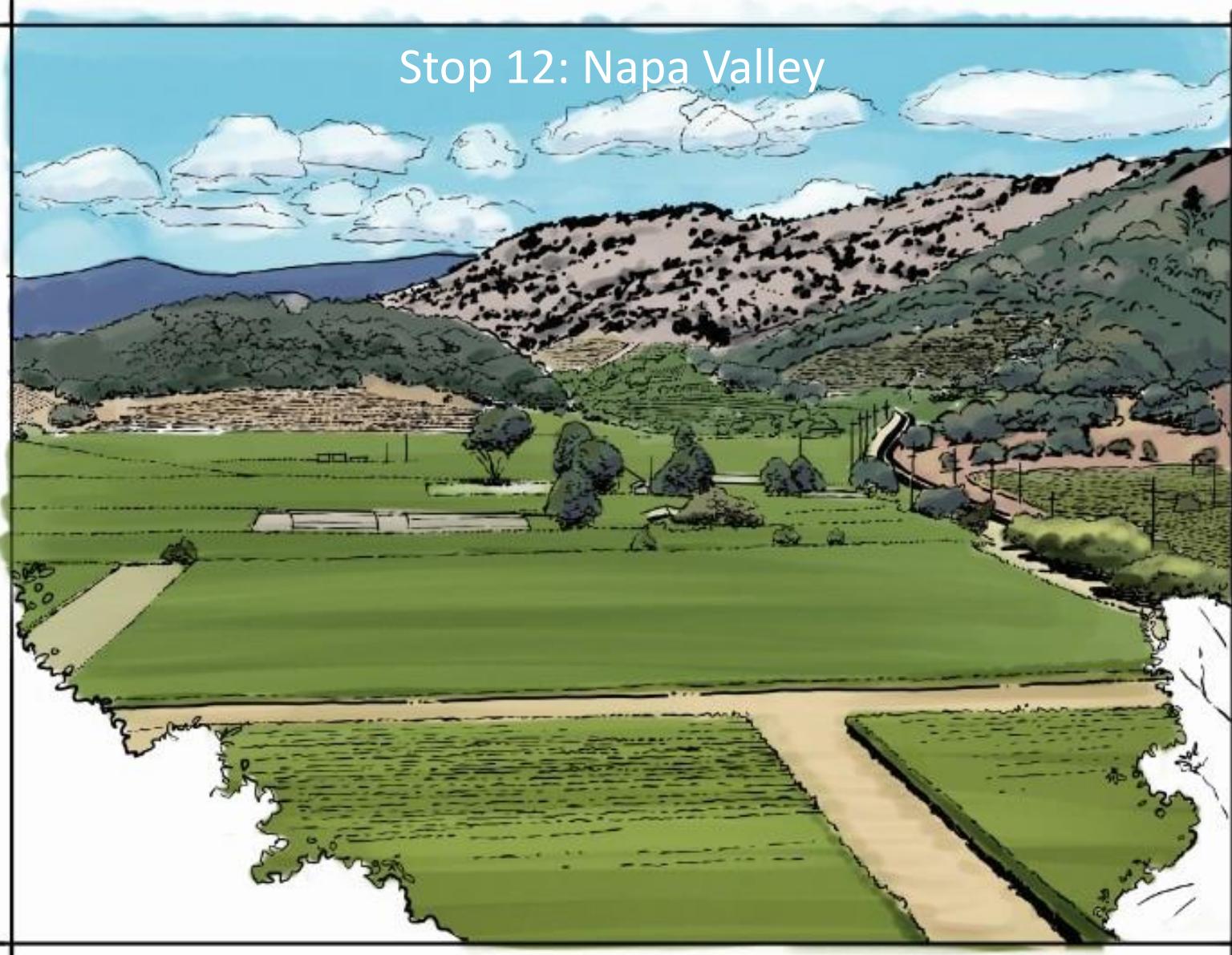
In 1595 the *St Augustine*, a Spanish treasure ship, sank here during a storm. Although bullion has never been found, treasure hunters still find bits of Chinese porcelain washed up on shore.

Wine and Rock Licking Pairing Guide



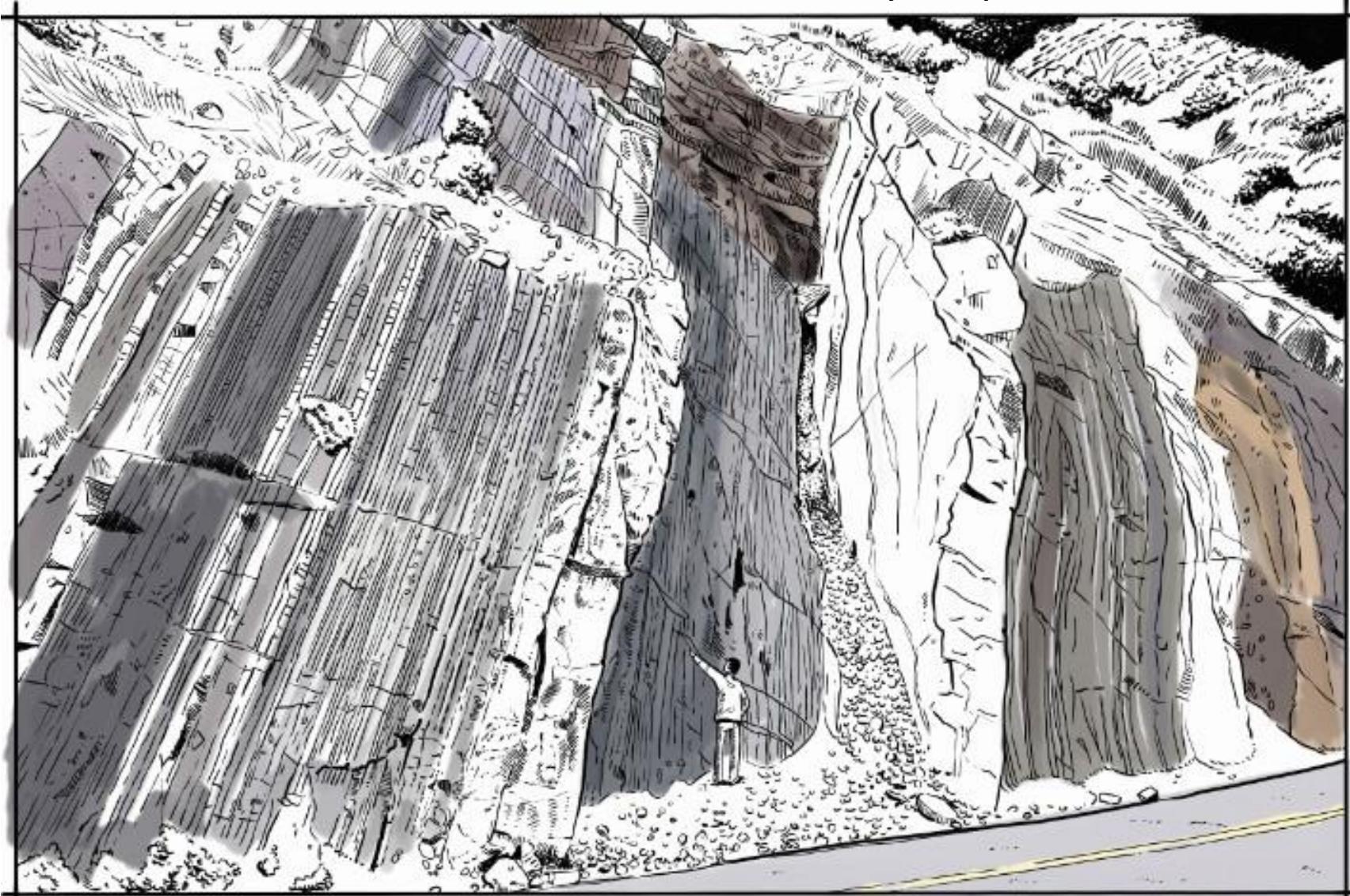
California's agricultural bounty is intimately tied to its rocks and soils

Stop 12: Napa Valley

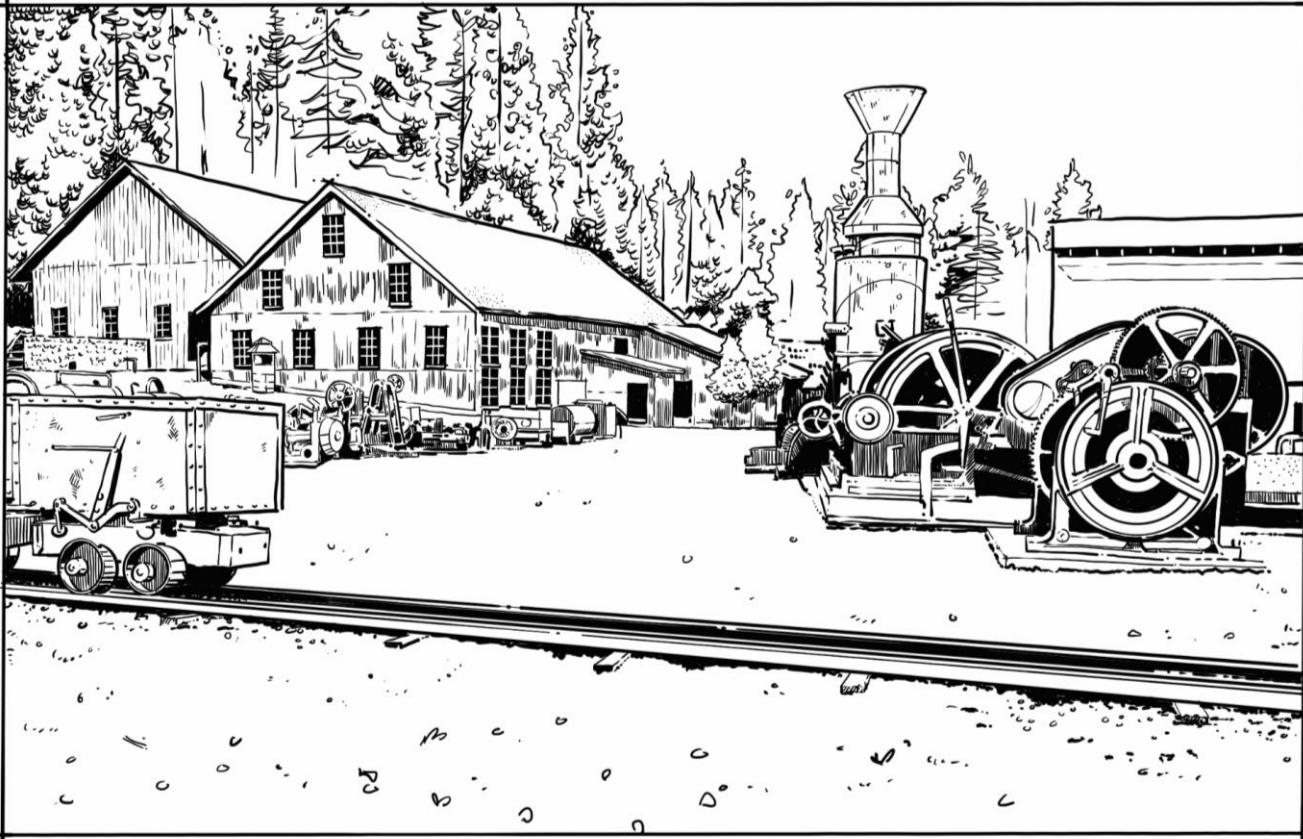


The first Napa vineyard, in 1854, was planted only 4 years after statehood. There were no wine presses, so Charles Krug had to use a cider press.
A few vineyards survived Prohibition by making sacramental wine for churches.

Stop 13: Venado Turbidite Sandstone, Great Valley Sequence, Monticello Dam



These rocks underlie and contribute to the rich soils of the Central Valley. Originating at the Sierra Nevada, they were deposited as submarine fans. They were tilted by faults near Lake Berryessa.

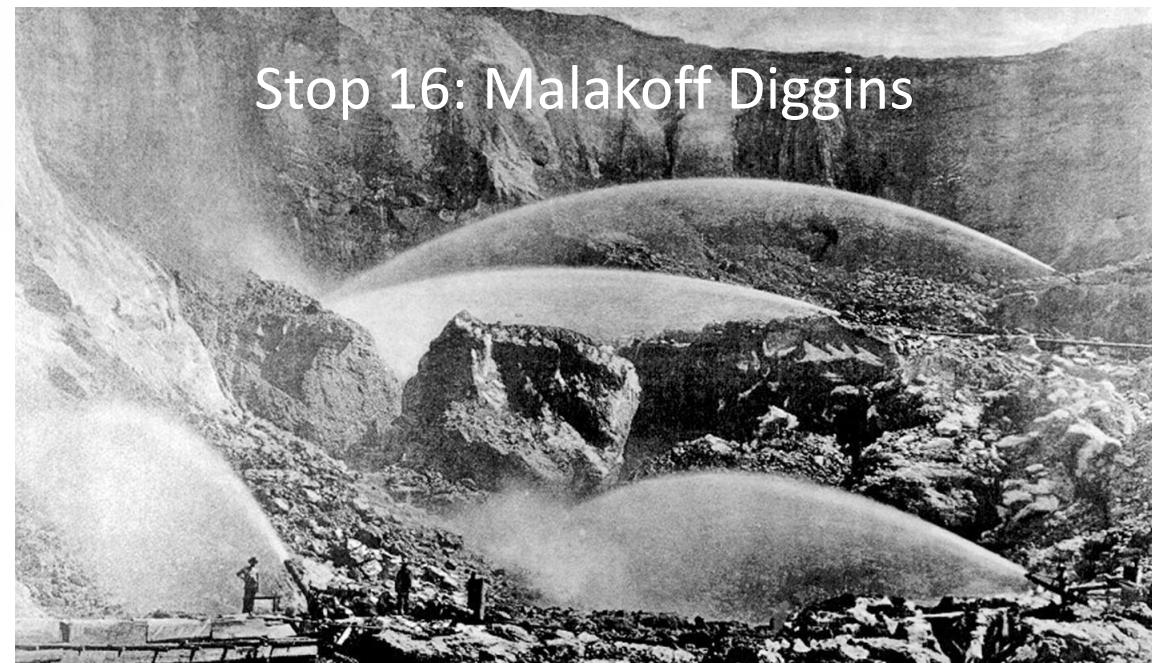


Stop 15: Empire Mine, Grass Valley

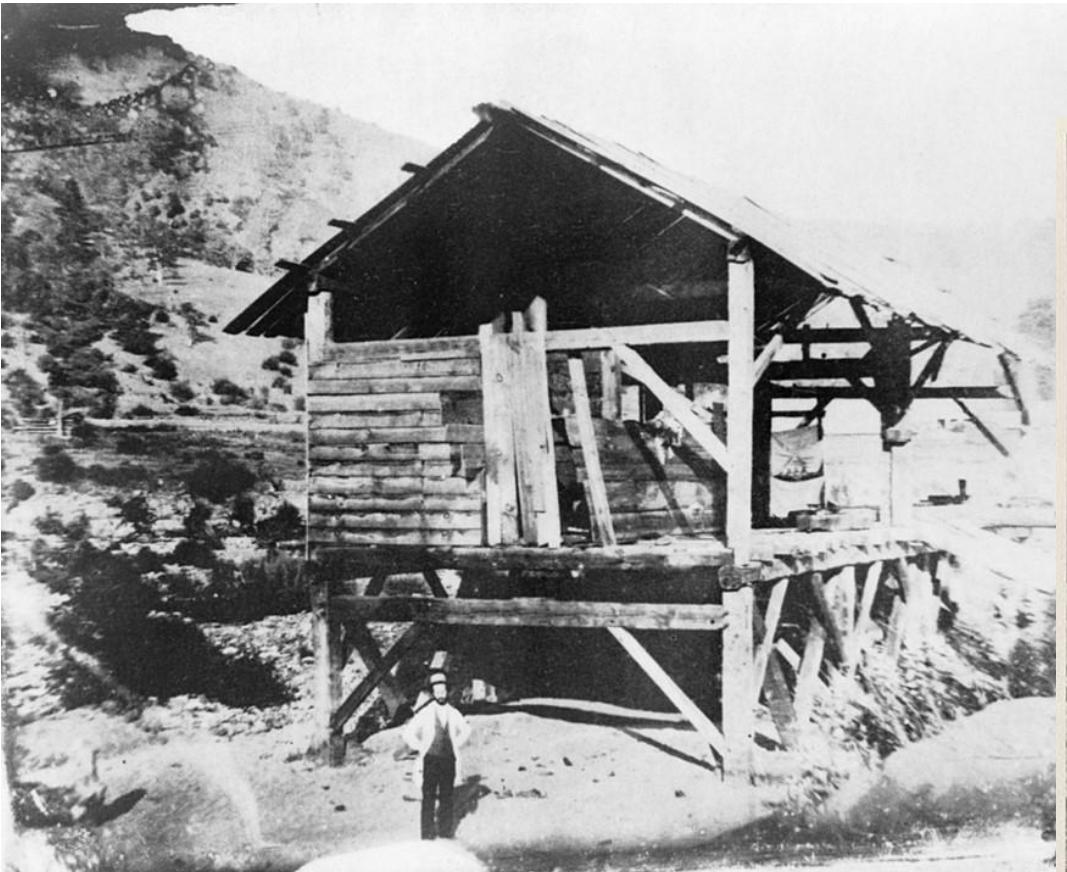
Discovered in 1850, the Empire lode (vein) mine produced a whopping *5.8 million* ounces of gold before closing in 1957. It is “the oldest, largest, deepest, longest, and richest gold mine in California.”

I was amazed to learn that much of the placer gold originated not in California, but in Nevada.

Miners followed the river gold upstream to its source. Turns out, much of the gold was from “dry placers,” ancient riverbeds now high on valley walls. To get at it, water cannons shot high pressure water at the hillsides to wash the gravel down to giant sluice boxes.



Stop 16: Malakoff Diggins



Stop 18: Sutter's lumber mill



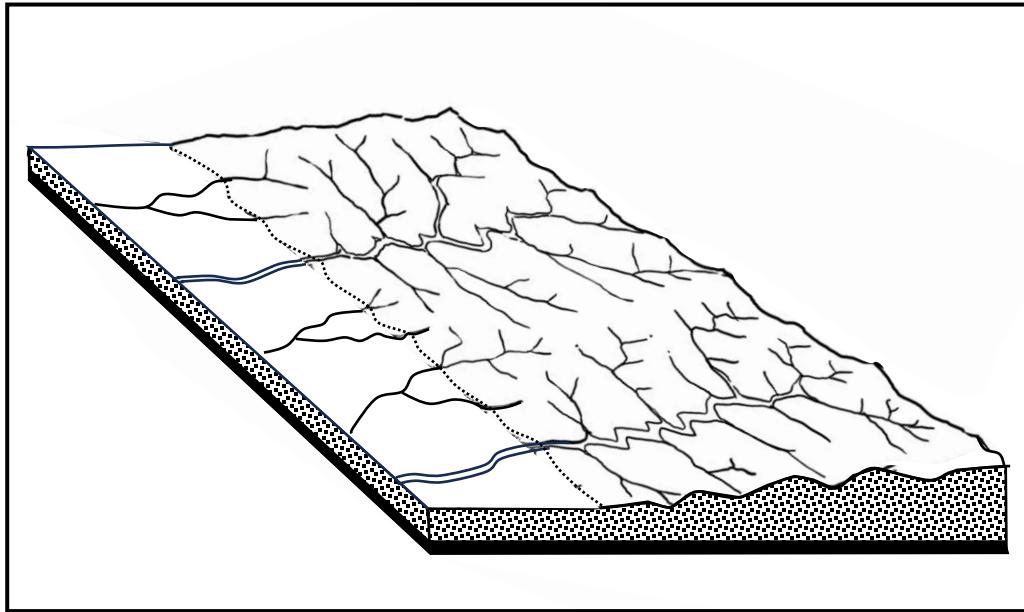
When Sutter arrived in 1839, Upper California was a Mexican province. Sutter went to Monterrey to get Governor Alvarado's permission to establish the town of New Helvetia (Sacramento). In one of the greatest ironies of all time, Alvarado granted Sutter 48,400 acres to stop American encroachment into California.

Sutter built a lumber mill to supply the new town. In January, 1848, James Marshall, a carpenter at Sutter's mill, noticed shiny pebbles in the American River near the saw mill. The rest is history.

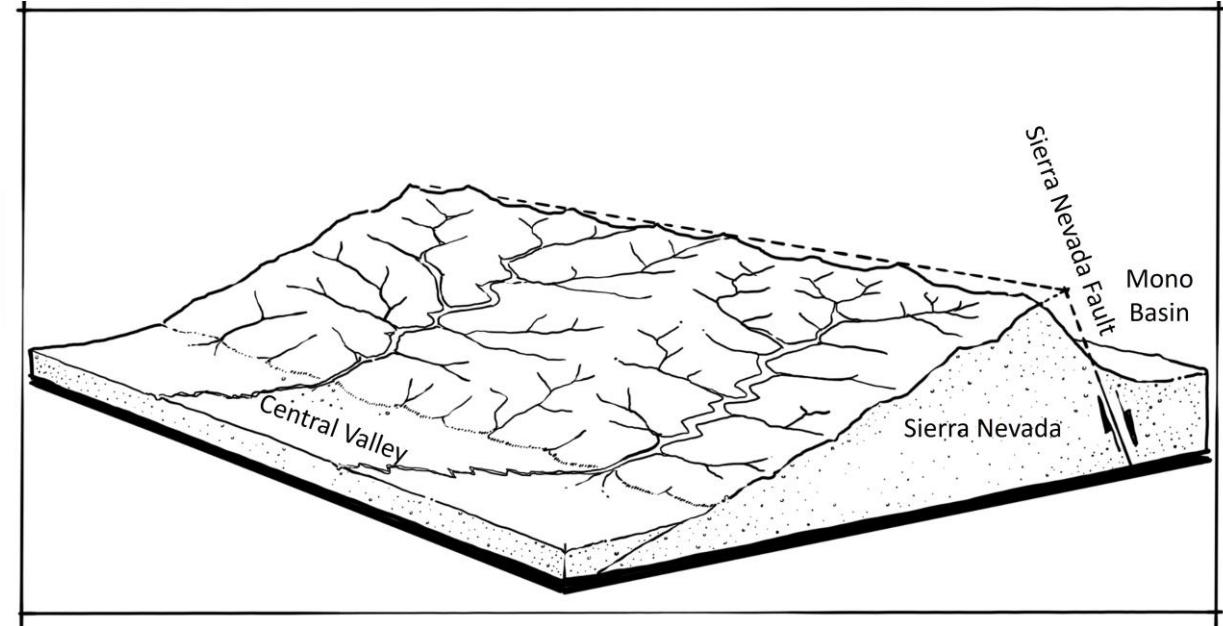
Stop 20: Hangtown, 1849 (Placerville)

The Sierra Nevada granite is Jurassic to Cretaceous (roughly 80 to 160 million years)

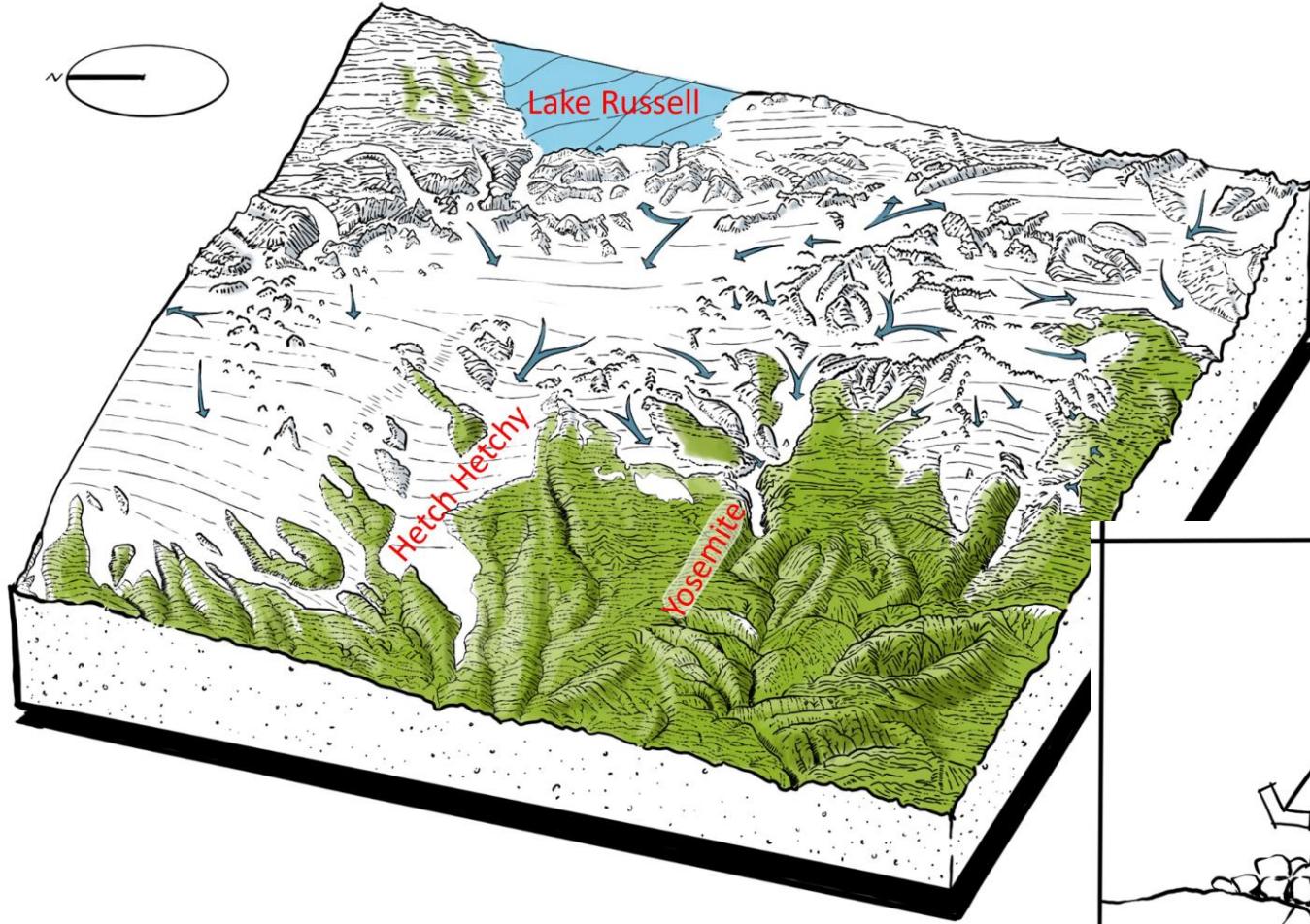
And yet, the range only began to ratchet upward 5 to 10 million years ago



The Ancient Sierra Nevada pre-10 million years ago
had eroded to low hills

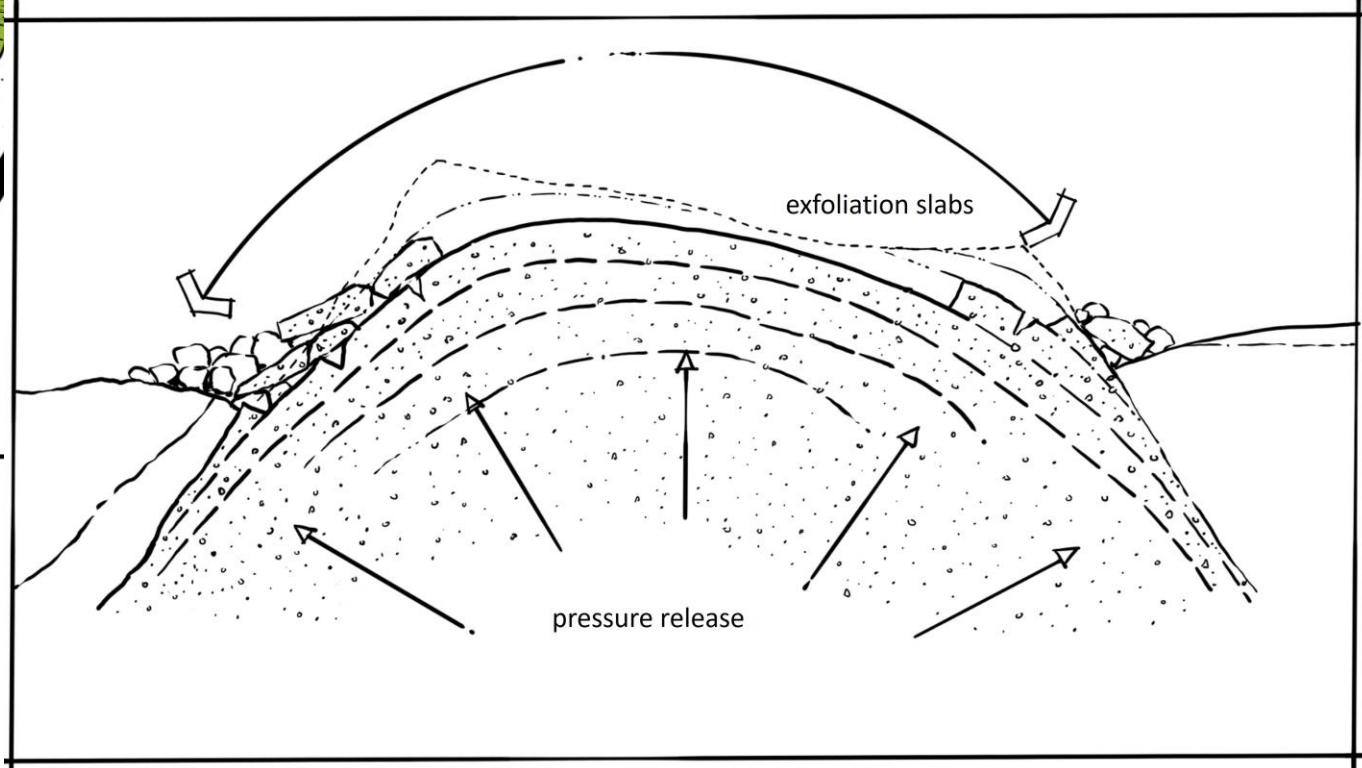


Modern Sierra Nevada

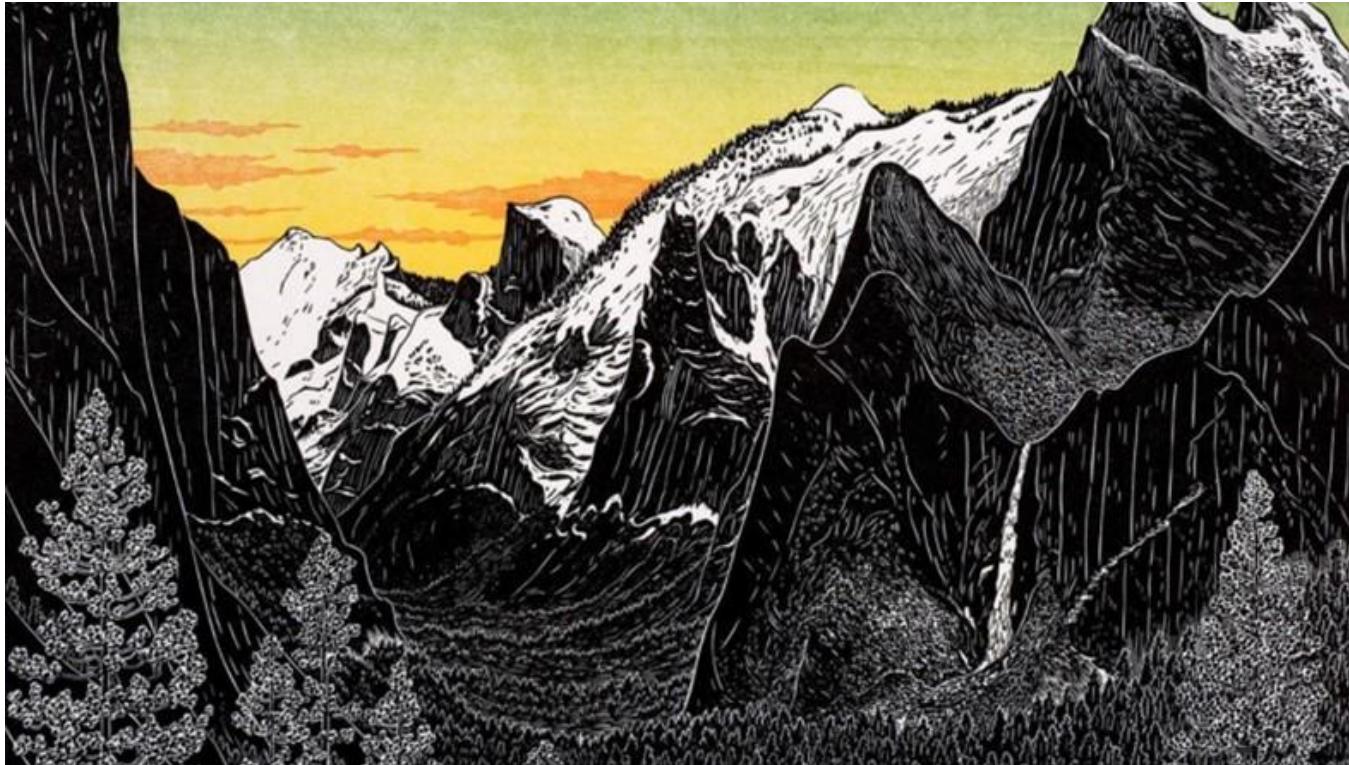


Sierra Nevada literally means Snowy Sawtooth Range. Glaciers carved the range starting around 1.3 million years ago. The last Ice Age ended about 12,000 years ago.

The Domes that are so characteristic of the high country are a result of pressure release as the overlying rocks are eroded. The rock expands upward and exfoliates.



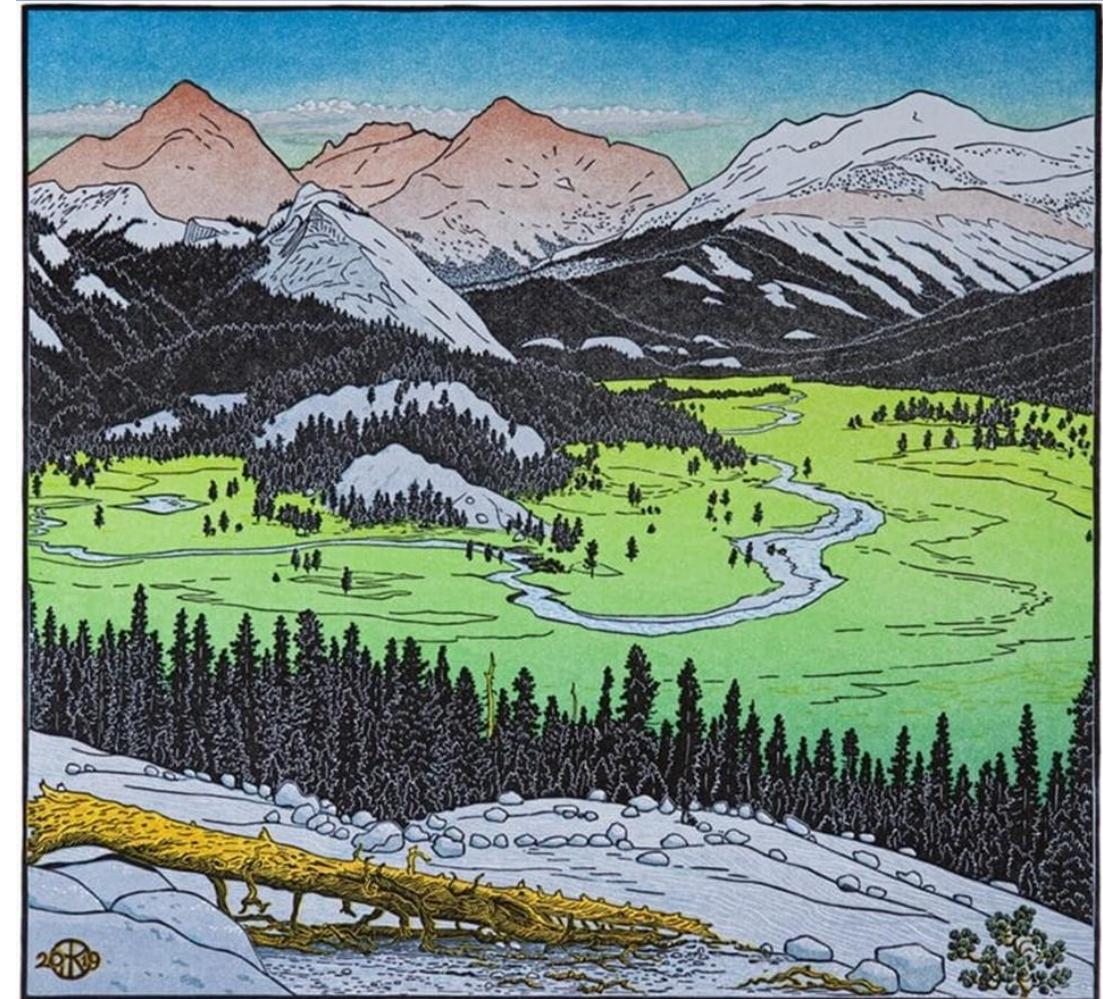
Tom Killion graciously allowed me to use some of his magnificent woodcut prints

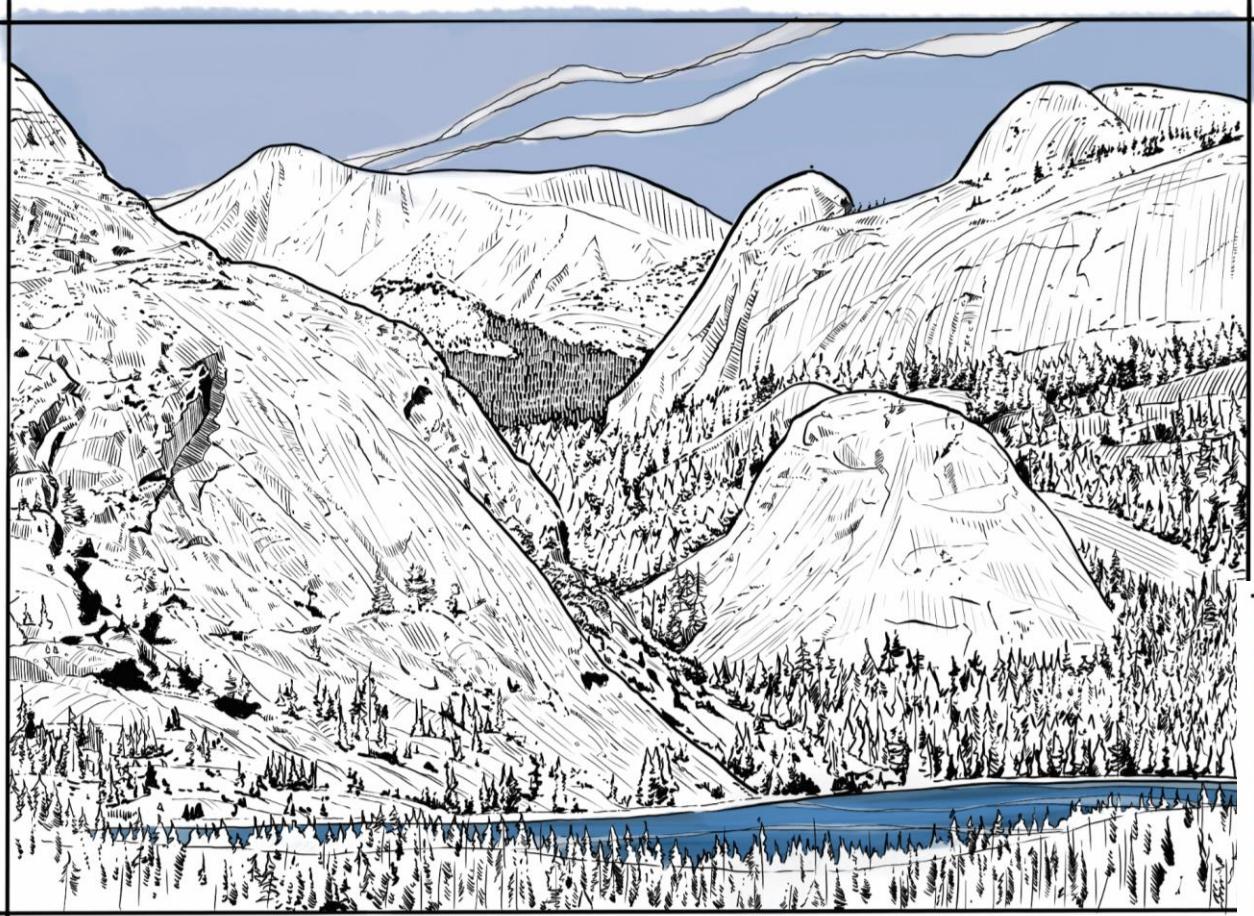


Stop 21: Yosemite Valley

Woodcuts © Tom Killion. Reproduced with permission.

Stop 23: Tuolumne Meadows,
Lembert Dome



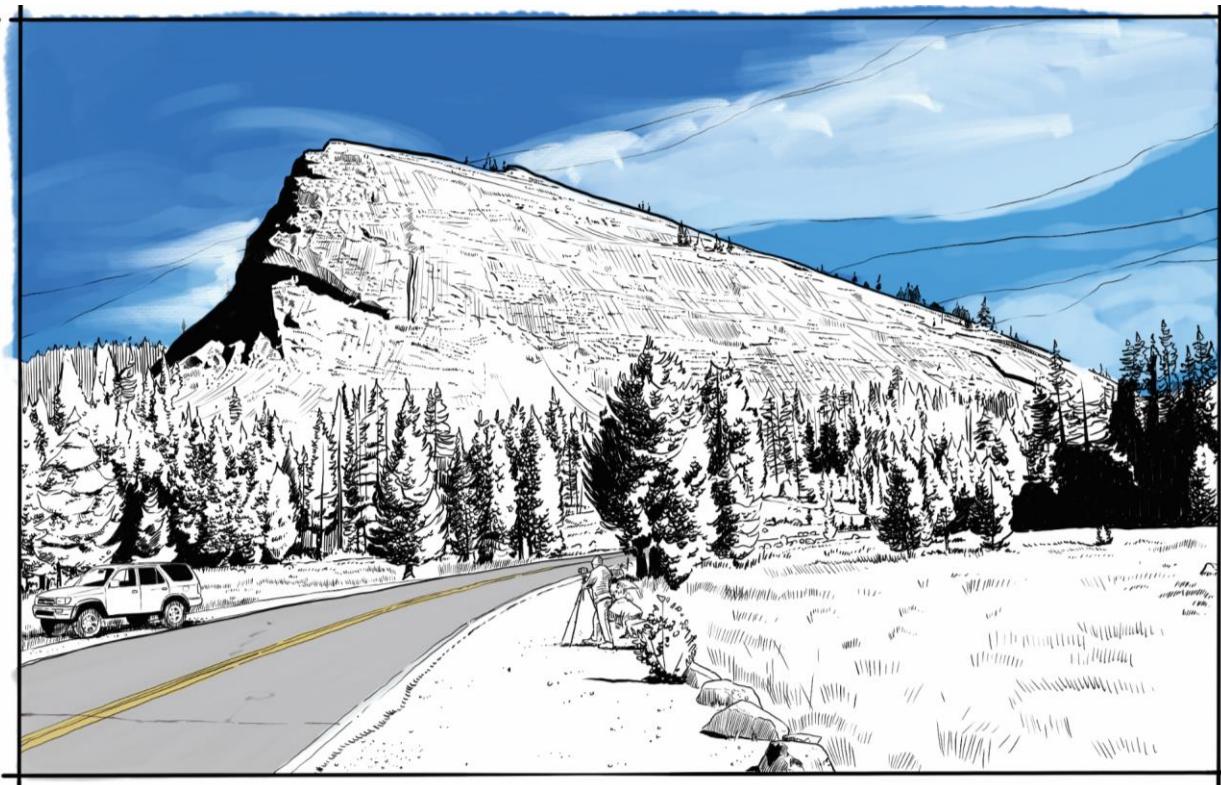


Stop 22: Tenaya Lake from Olmsted Point

The indigenous Ahwahnechee name is Pywiak, meaning “lake of the shining rocks.”

Stop 23: Lembert Dome, Tuolumne Meadows

This wedge-shaped dome tells which way the glacier was moving



Eastern California is part of the Basin and Range Geologic Province



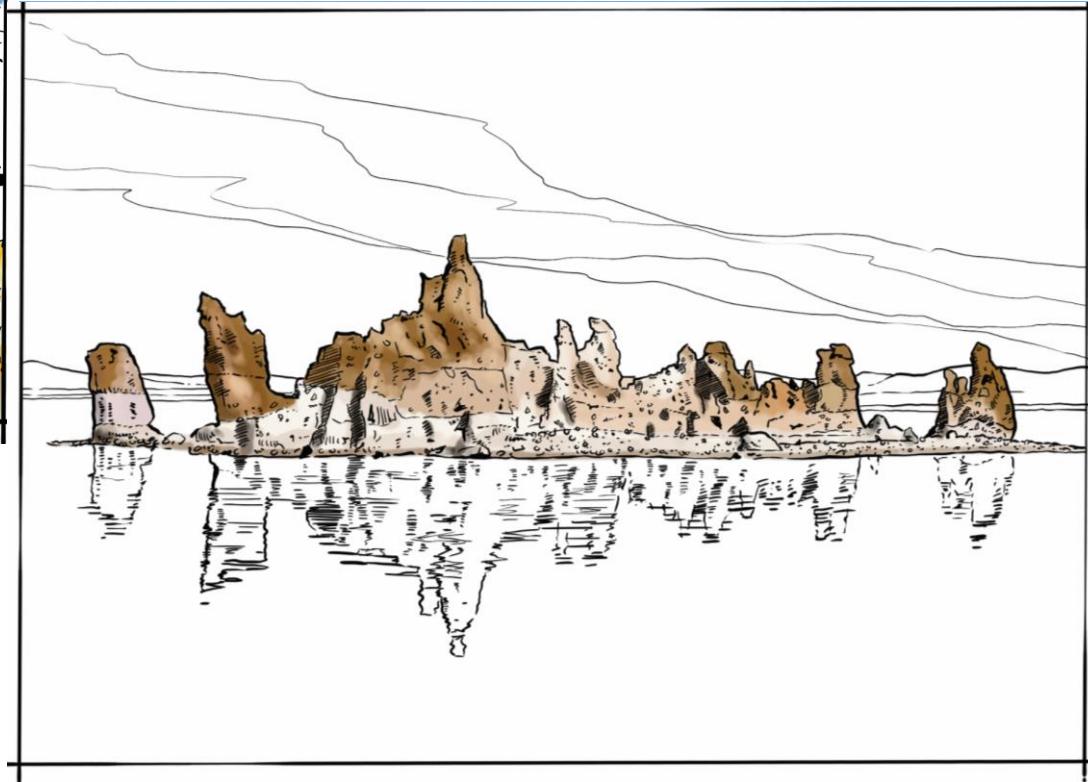
"There are no fish in Mono Lake—no frogs, no snakes, no pollywogs—nothing, in fact, that goes to make life desirable. Millions of wild ducks and sea-gulls swim about the surface, but no living thing exists under the surface, except a white feathery sort of worm, which looks like a bit of white thread frayed out at the sides. If you dip up a gallon of water, you will get about fifteen thousand of these.

Then there is a fly, which looks something like our house fly. These settle on the beach to eat the worms that wash ashore—and any time, you can see there a belt of flies an inch deep and six feet wide, and this belt extends clear around the lake." Mark Twain, Roughing It.

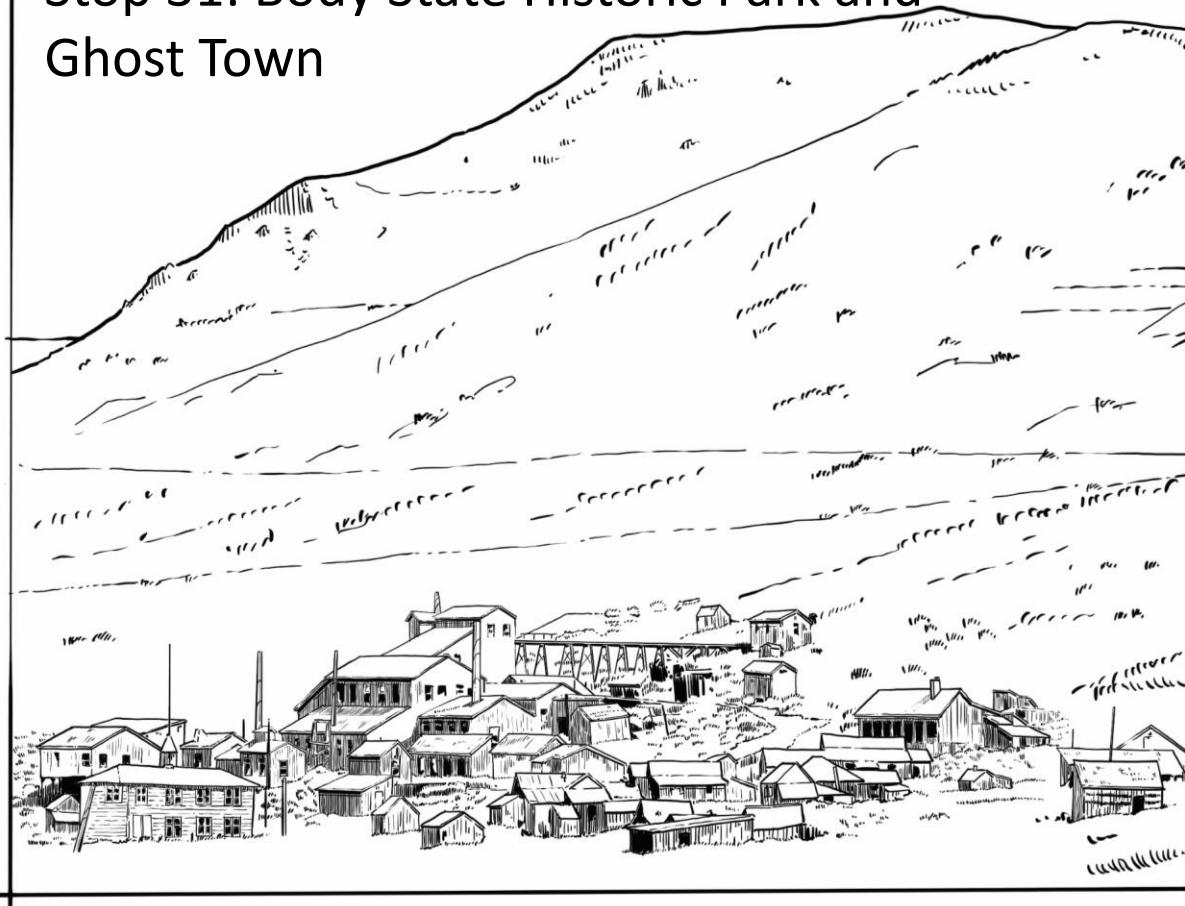
Stop 30: Mono Lake

Mono Lake is the remnant of glacial Lake Russell that was as much as 1,300 ft deep

Tufa Mounds



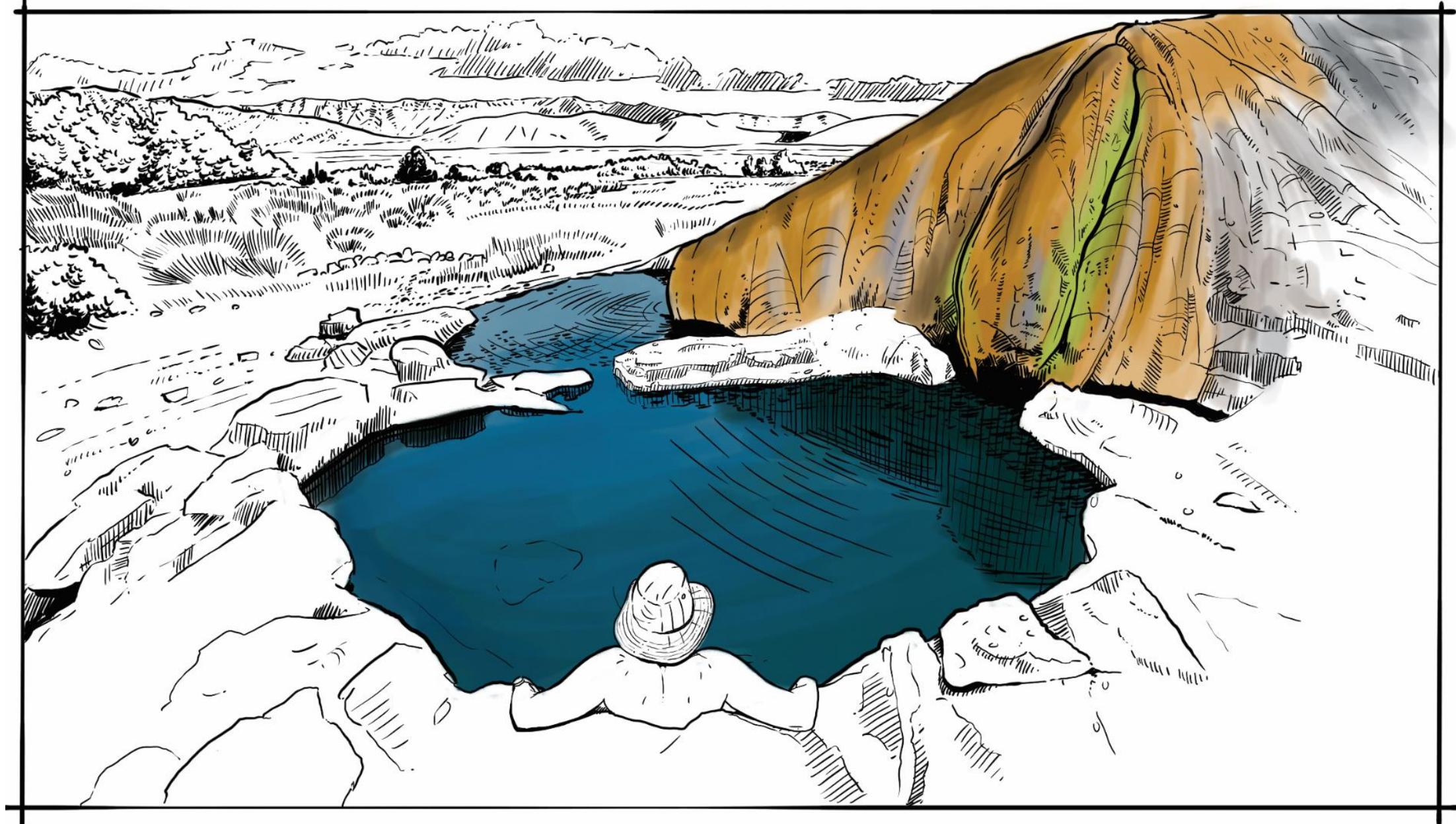
Stop 31: Bodie State Historic Park and Ghost Town

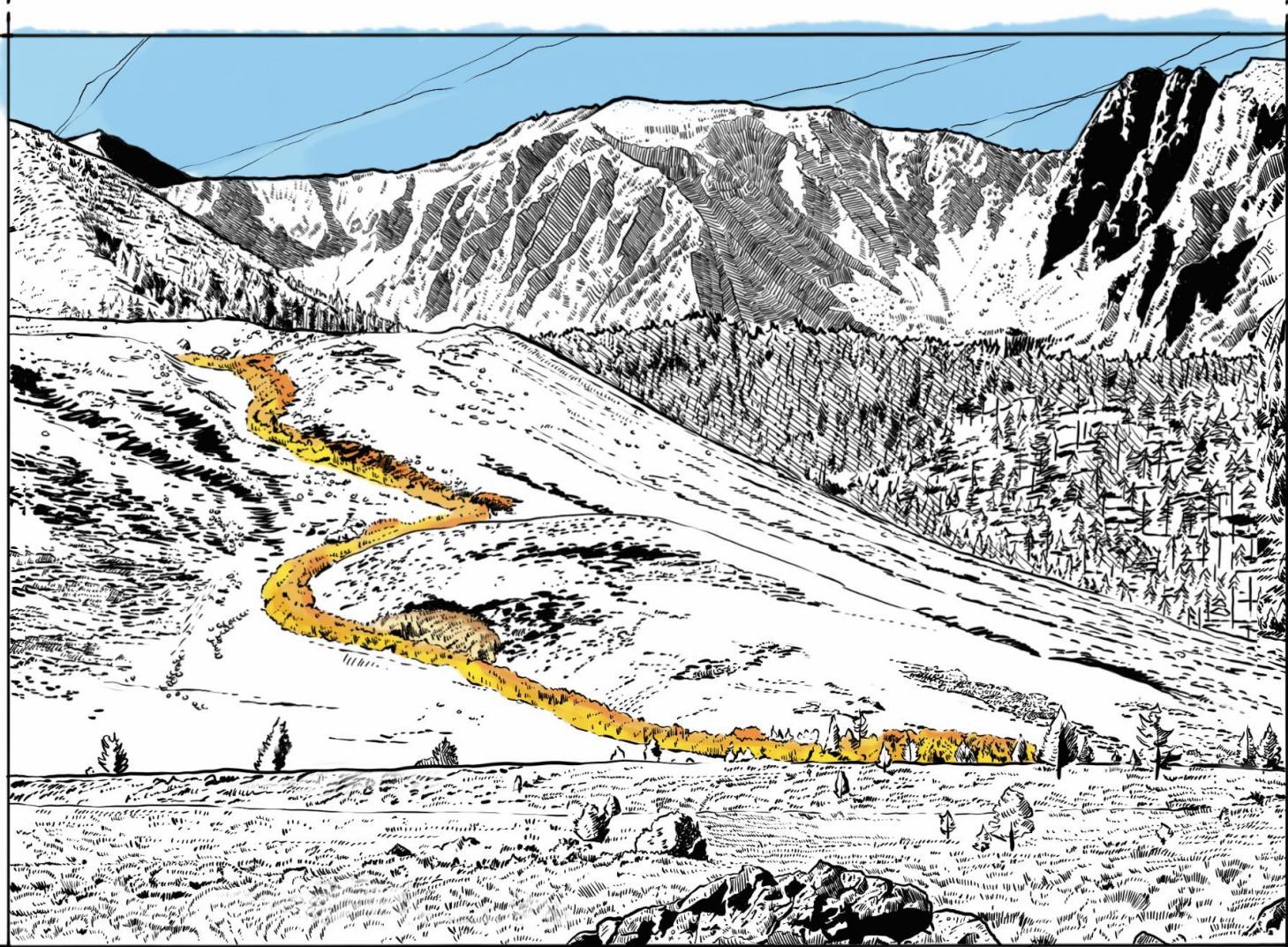


At its peak, saloons, dance halls, opium dens, and brothels lined the streets of the scruffy, ramshackle town. A reverend described it as “a sea of sin, lashed by the tempests of lust and passion.” A little girl who was moving there from San Francisco reportedly wrote in her diary, “Goodbye, God: we are going to Bodie.”

An irritated Bodie editor responded that the girl had been misquoted. What she had really said was “GOOD. By God, we are going to Bodie.”

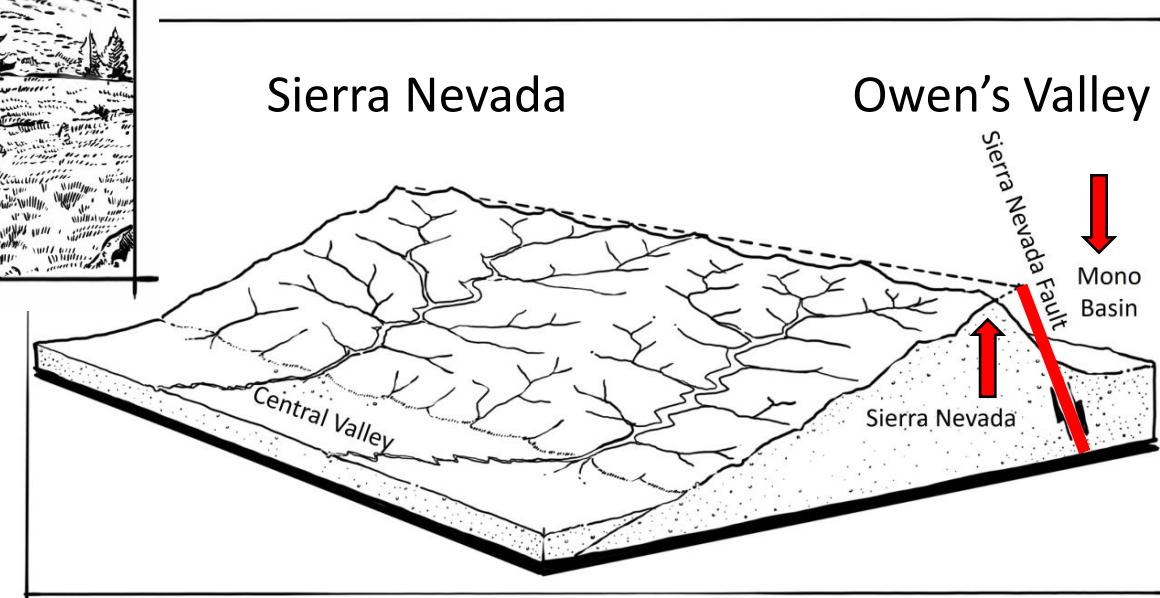
Stop 32: Travertine Hot Springs, Bridgeport



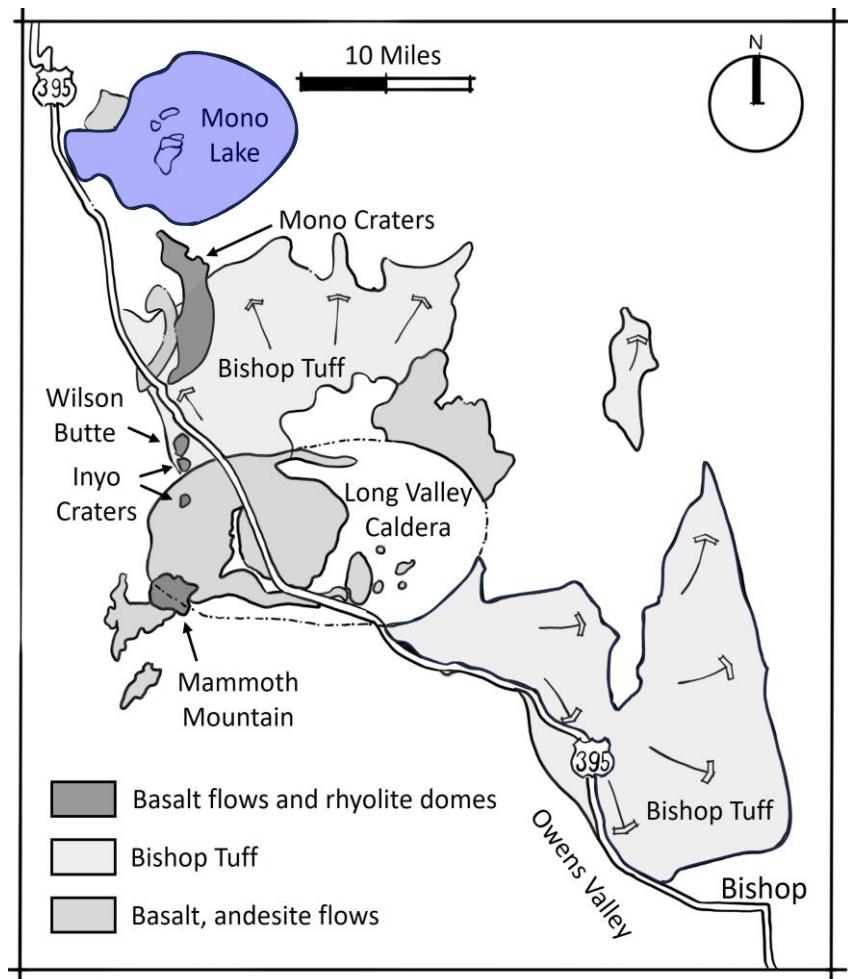


Stop 34: The Sierra Escarpment

This fault has over 10,000 feet of offset



Stop 36: Mammoth Mountain



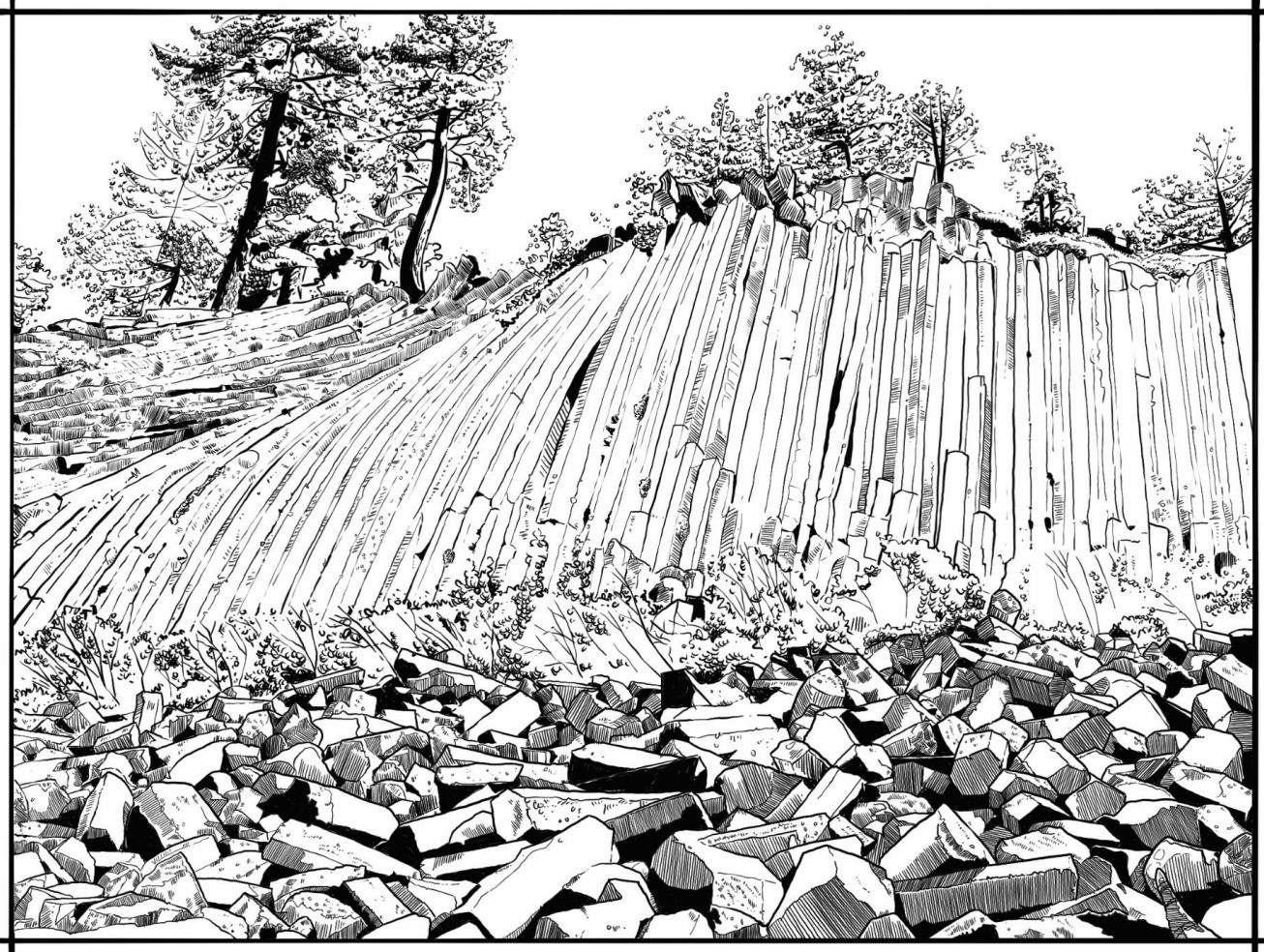
An exploding volcano 760,000 years ago left a crater 10 mi wide and 20 mi long. The ash, the Bishop Tuff, covered 850 square mi up to 660 ft thick. The eruption was 2,000 times larger than the 1980 eruption of Mt. St. Helens.

Stop 37: Minarets Vista, San Joaquin River headwaters

Woodcut © Tom Killion. Reproduced with permission.



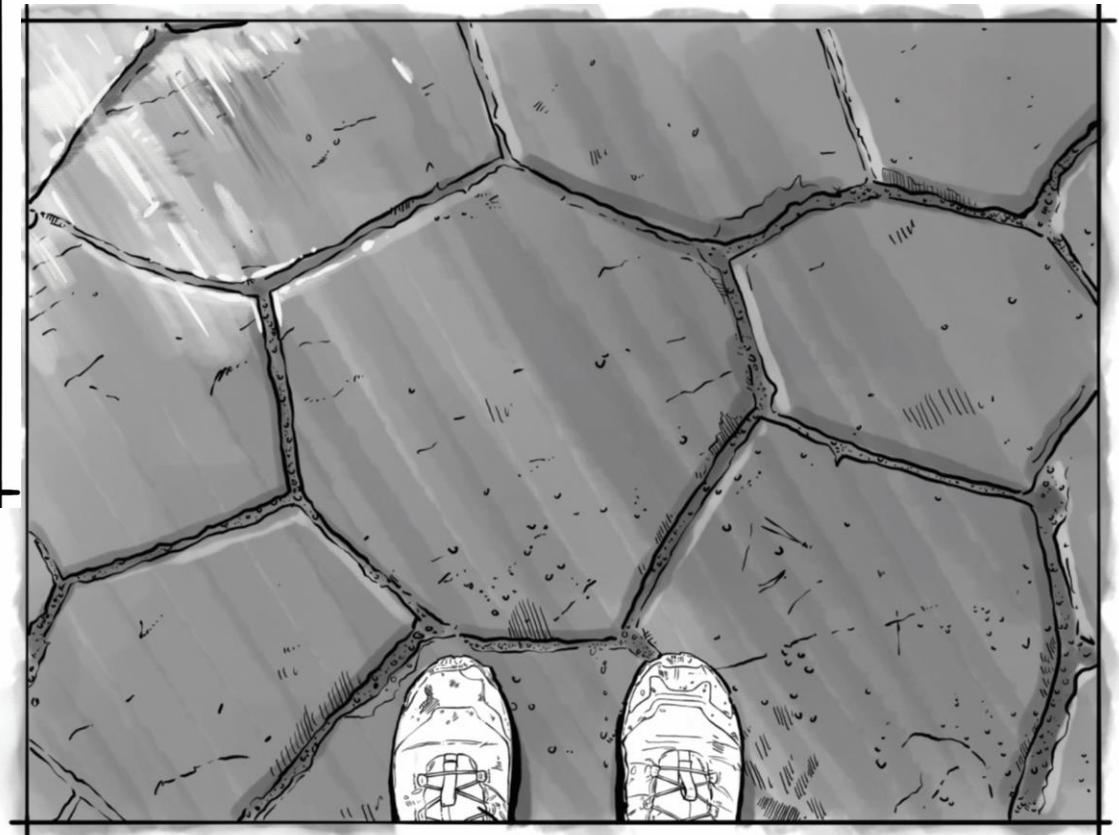
The San Joaquin used to drain Nevada...



These columns, 40-60 ft high, are almost perfect hexagons and pentagons. They are shrinkage cracks formed as a lava lake slowly cooled 82,000 years ago.

Stop 38: Devil's Postpile

Climb to the top and you see glacial polish and striations (scratches) that show which way the glaciers moved over the rocks.



Stop 42: Bristlecone Pines, Patriarch Grove, White Mountains

Imagine trees that were already 3,000 years old when the Roman Empire was at its peak.





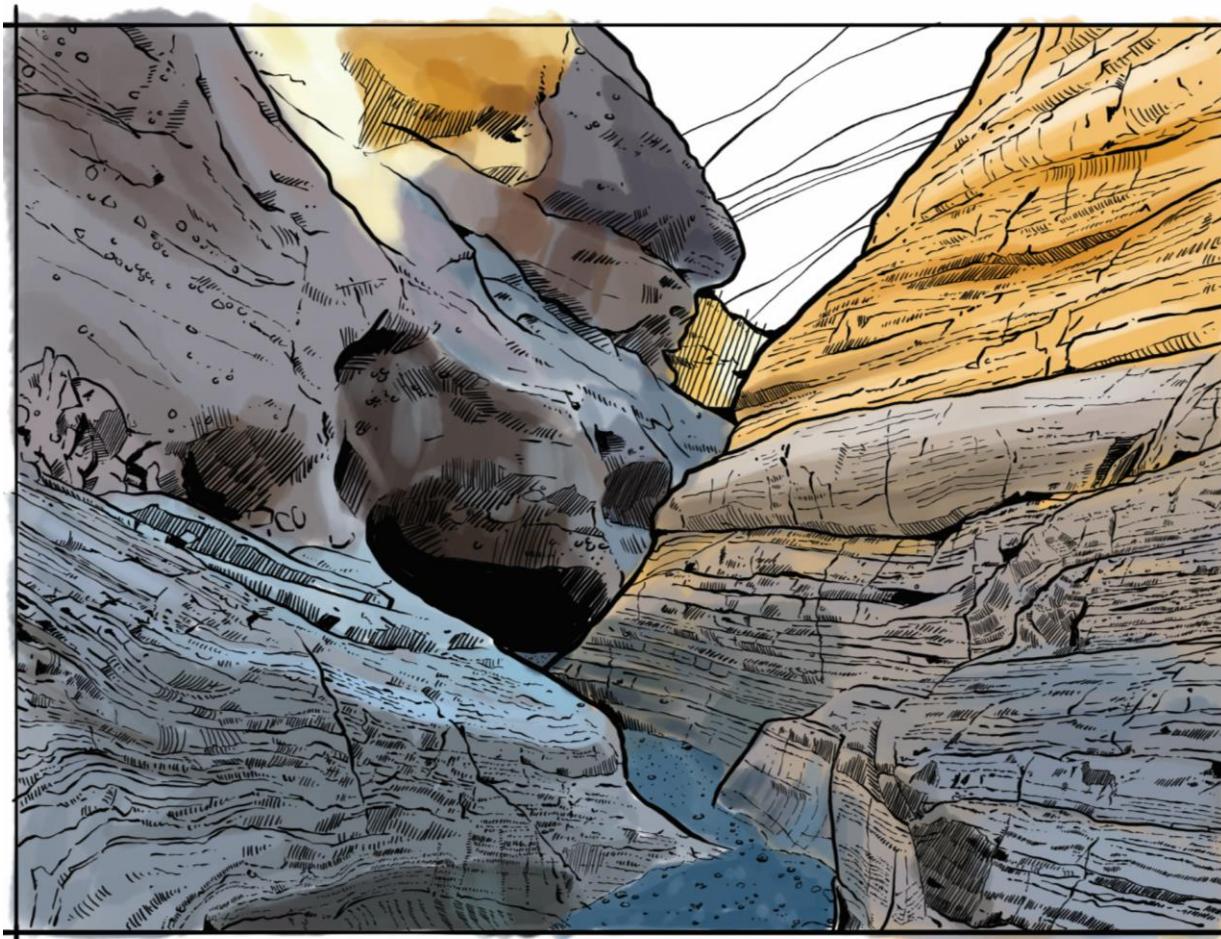
Stop 43: Owens Valley fault scarp

In 1872 a 7.4 to 7.9 magnitude quake struck Lone Pine, killing 26. This is the same magnitude as the 1906 San Francisco quake. The scarp, up to 20 ft high at the time, is still 10 to 13 feet high.

Stop 44: Mt Whitney from Movie Flats, Alabama Hills

Hundreds of movies, TV shows, and even commercials have been filmed here.



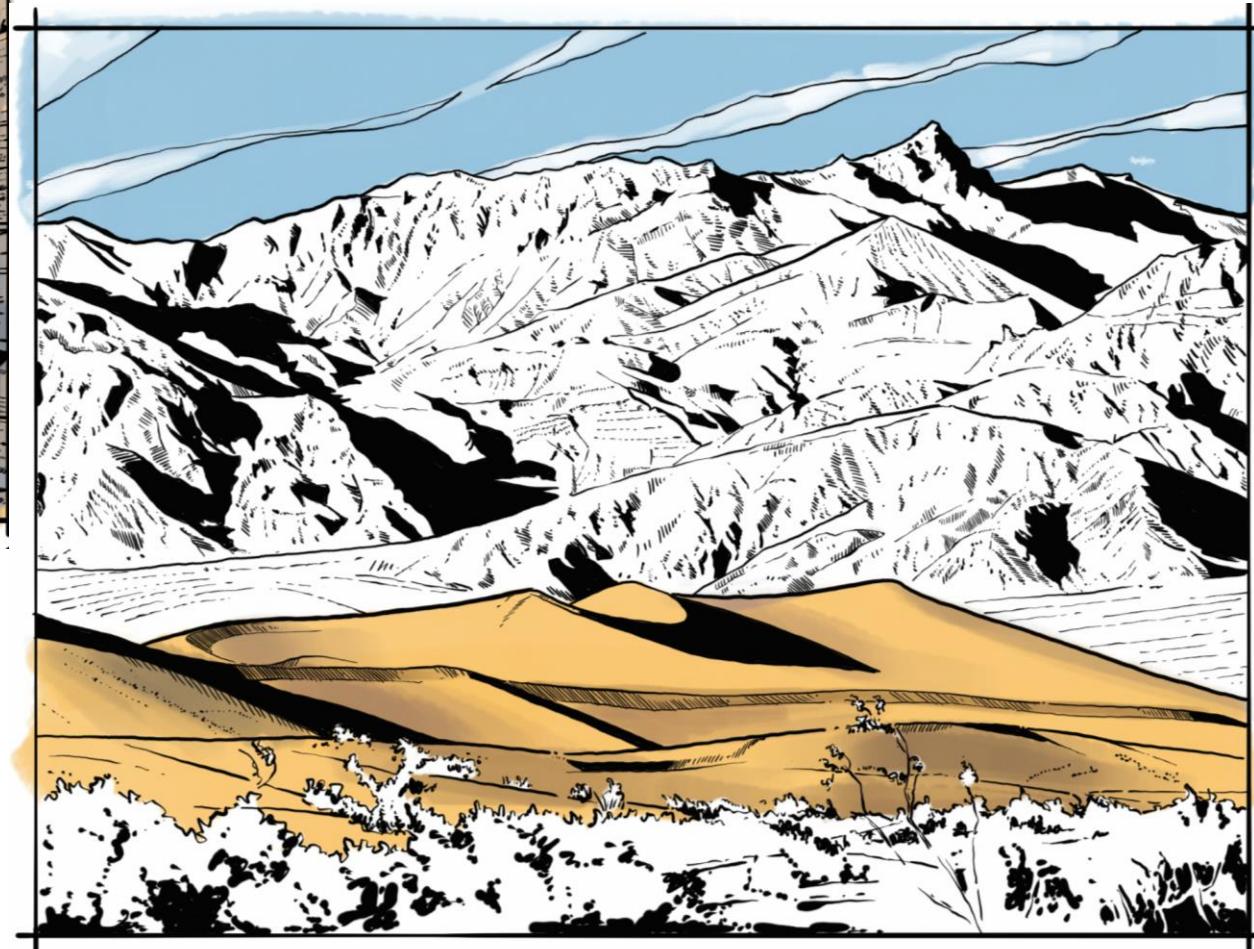


Stop 47: Mosaic Canyon, Death Valley

This colorful slot canyon is carved into 630 million-year-old limestone by flash floods. It is named after the Mosaic Breccia, made of angular rock fragments.

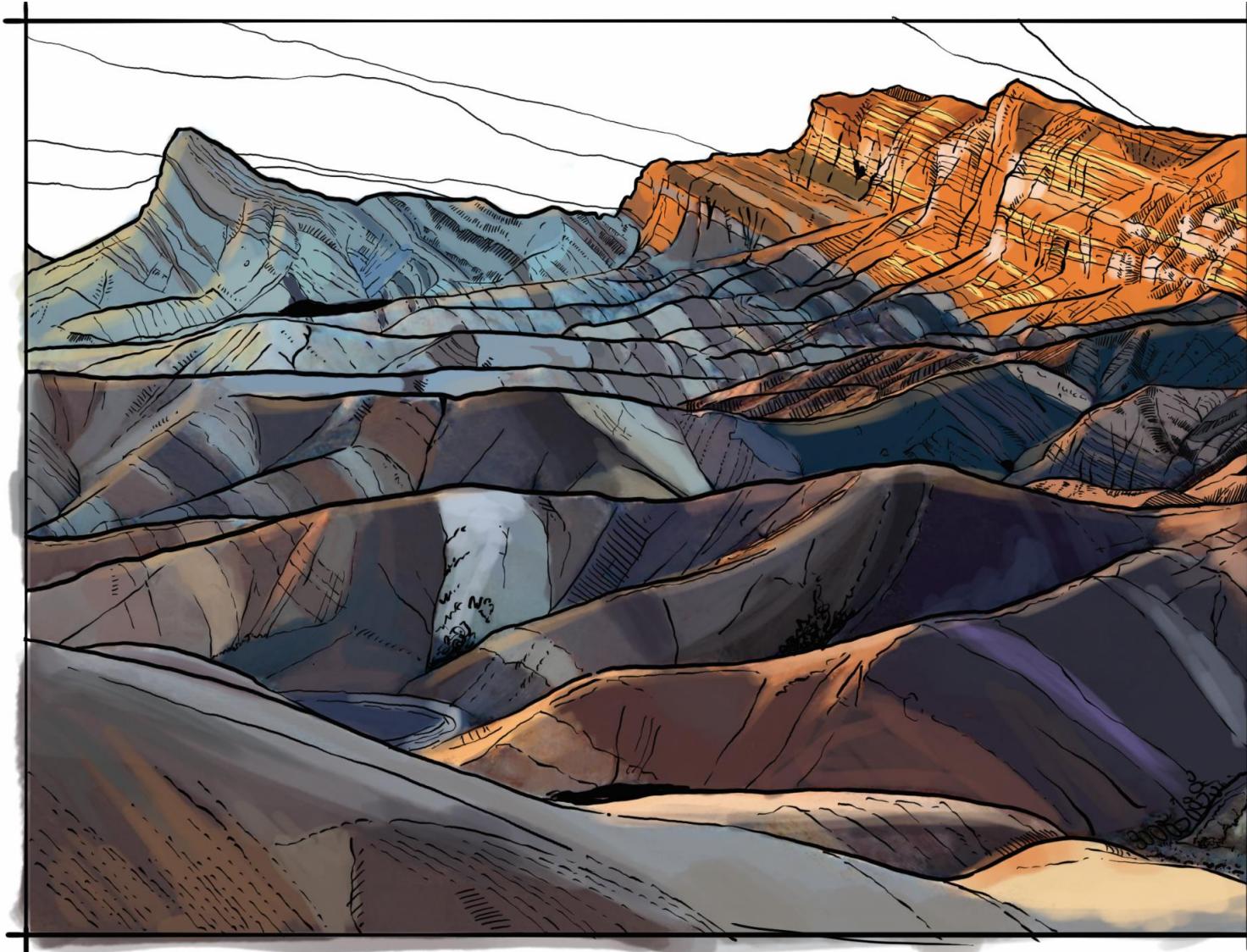
Stop 48: Mesquite Flats Sand Dunes

100 ft high golden sand dunes, this is the little cousin to Great Sand Dunes in Colorado



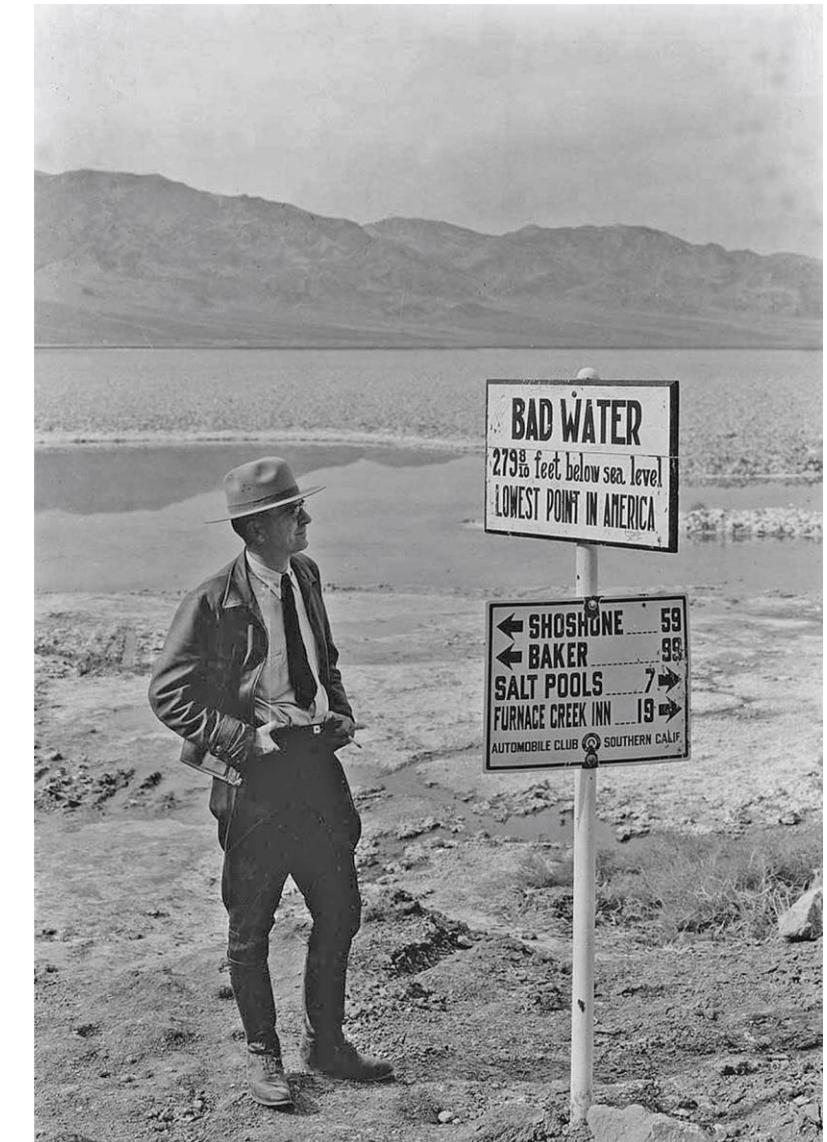
Stop 50: Zabriskie Point

One of my all-time favorite places to watch the sunset.



Stop 53: Bad Water

282 feet below sea level



So, Why “Rocks and Riches”? Because Geology is Destiny

California has the 5th largest economy in the world

- Largest state in gold production: 3,100 metric *tons*, or 35% of the US gold supply
- Produced over 3 Billion barrels of oil, the 7th or 8th largest oil producer in the US
- Largest geothermal energy producer in the US; produces 70% of US geothermal energy
- #1 Agricultural producer: 8% of the US food supply, including half of all fruits and vegetables
- 4th largest wine producer in the world; produces 85% of all wine in the US



Orange Groves & Oil Fields, Los Angeles



Geothermal Energy, The Geysers

I'm getting out to look at this classic roadcut when a car, a rare sight on this remote highway, slows down to see if anything is wrong. "Need a hand fixing a flat?" the man asks. "Nah, I'm just looking at rocks." He looks at me like I'm nuts and, as the car speeds away, yells "Good luck to ya."

Stop 56:
Resting Spring Pass



This is what I love about California. It doesn't matter how crazy you might appear; someone will give you the space to do your thing. Mark Twain said "America is built on a tilt, and everything loose slides to California."

I feel like I'm finally home.