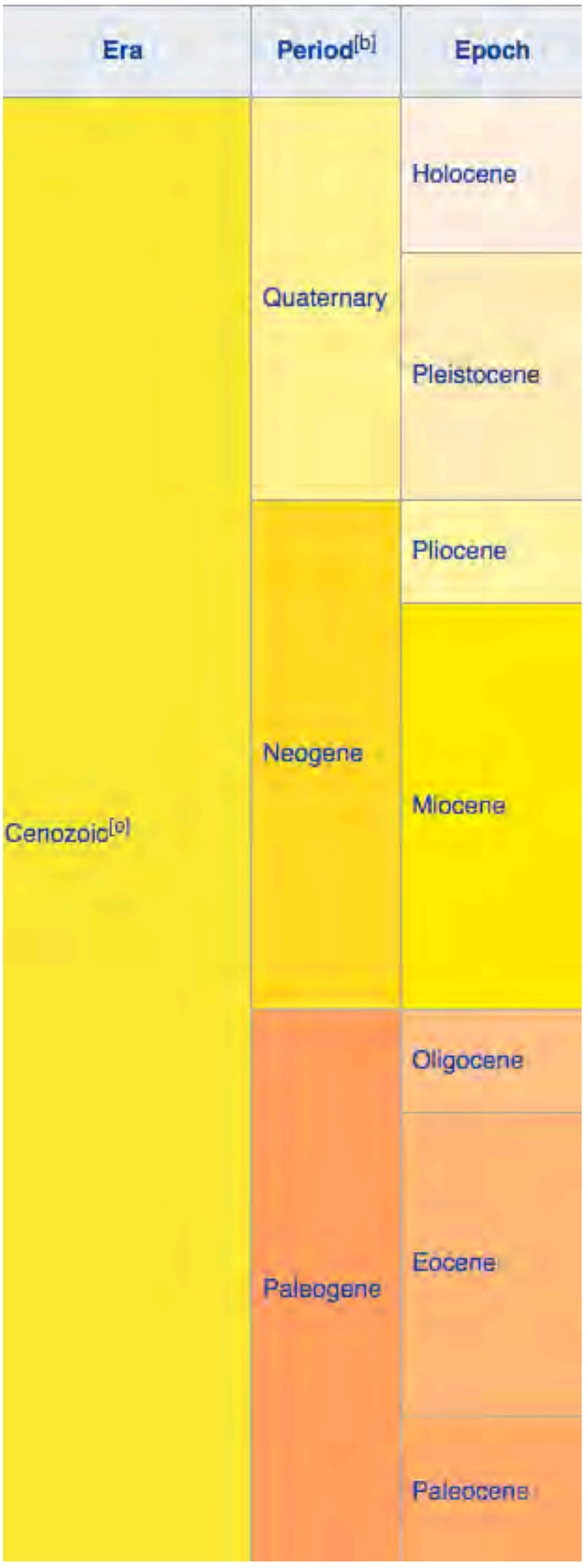
GEOLOGIC ROAD GUIDE TO SODA LAKE ROAD

This trip will take you through a long valley developed from deformation along the San Andreas fault. The fault lies on the east side of the valley. Rock outcrops are rare along the road, but the trip offers some great views of the fault and associated features, and many features can still be appreciated from a distance. The trip is 45 miles, lacks services, and the southern end can be very difficult if the road is wet. Set your odometer at the junction of Highway 58 and Soda Lake Road. GPS locations are provided alongside the odometer reading.

GEOLOGIC UNITS SEEN ALONG SODA LAKE ROAD



ALLUVIAL FILL OF VALLEY FLOOR
(Continental)

PASO ROBLES FORMATION
(Continental)

MORALES FORMATION
(Continental)

QUATAL FORMATION
(Continental)

MONTEREY FORMATION (Marine in west)

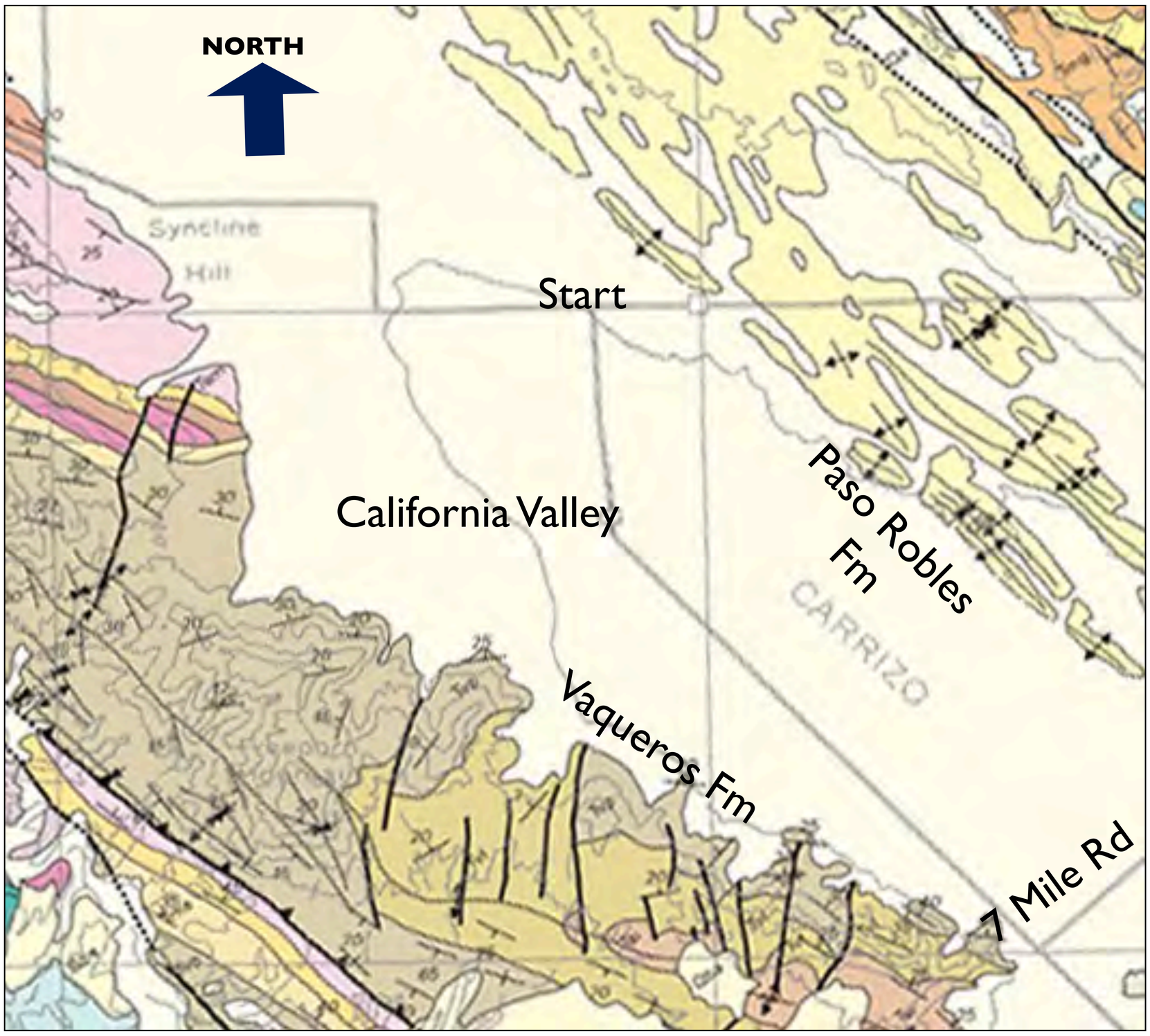
BRANCH CANYON SANDSTONE
(Continental in east)

VAQUEROS FORMATION (Marine in west)

CALIENTE FORMATION
(Continental in east)

SIMMLER FORMATION (Shoreline or lake)

Descriptions of the geological units can be found at the end of this guide



0.0 miles 35.35141-120.04521 If you came from the west, you would have crossed a synclinal fold dominated by sandstones and siltstones of the Santa Margarita Formation in the aptly named Syncline Hill, and seen to the west as you start the trip. Drive south on Soda Lake Road. The hills on the right are dominated by Hubbard Hill, which has a spine composed of the **Painted Rock Member** of the **Vaqueros Formation**. This is a shallow marine and nearshore sandstone of late **Oligocene** and earliest **Miocene** age. You can see the lines of bedding dipping to the north and toward the Carrizo Plain, as Hubbard Hill is also at the core of an **anticlinal** fold, and the beds to the north are getting progressively younger as they lean in a stack against the central core. These younger beds are the **Saltos Shale Member** and the **Whiterock Bluff Member** of the **Monterey Formation**, representing deeper marine conditions in mid-Miocene time.

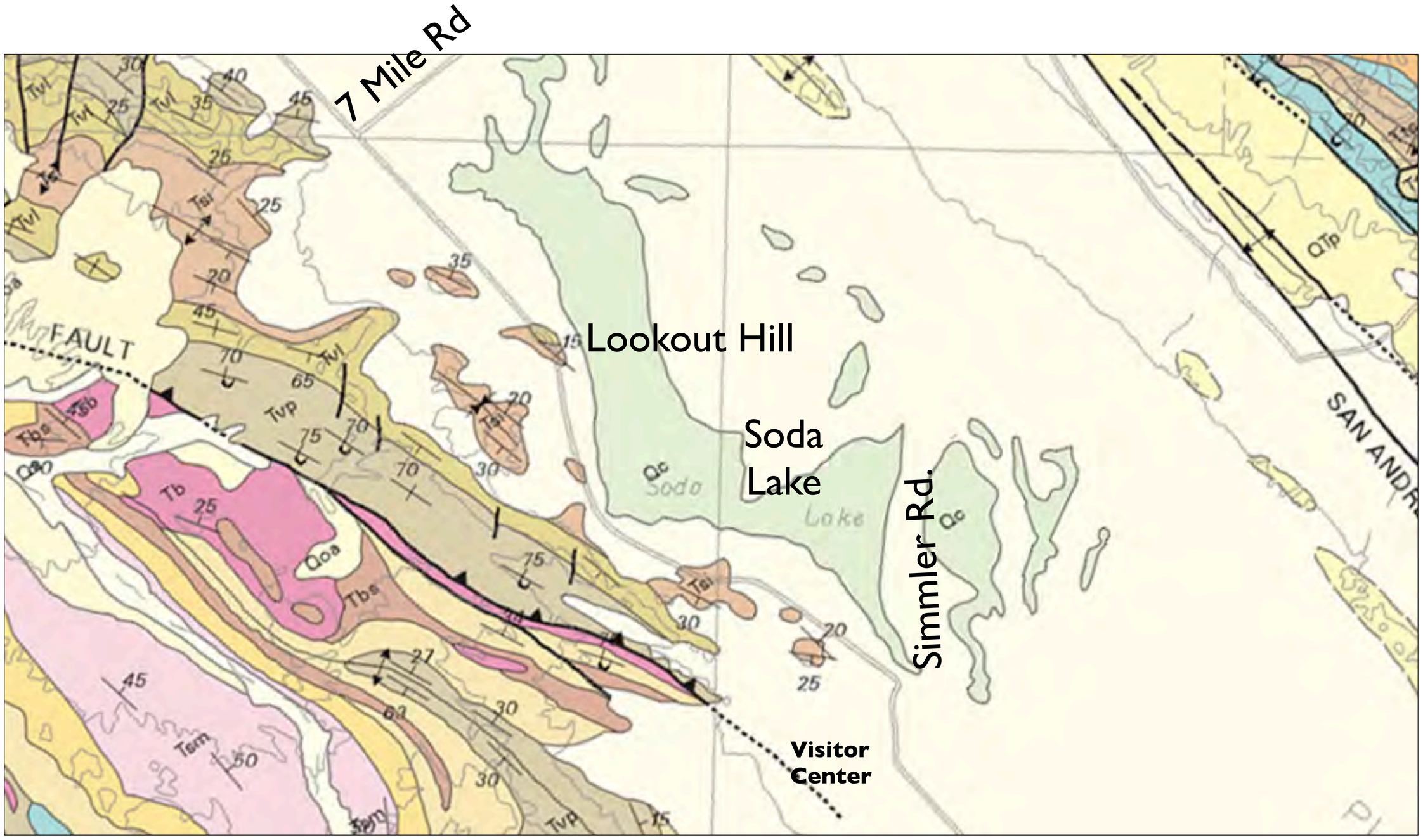
1.7 (1.7) miles 35.32023-120.00257 Downtown California Valley with Fire Station. Continue south.

3.4 (1.7) miles 35.30781-119.98746 Belmont Trail on the left will take you to some nice offset stream channels on the San Andreas, and also back to 58. Continue south on Soda Lake Rd.

Continuing south, the hills on the right are drawing closer. You can see outlier hills of the massive sandstones of the **Painted Rock Member** standing out from the main range. These continue until you reach the junction with 7 Mile Road at **7.4 miles 35.26397-119.93453**.

View from northern entrance to the national monument. The eastward dipping white layers are Simmler Formation sandstones, (Tsi) with Soda Lake Shale Member of the Vaqueros Formation (Tvl) above. Bold outcrops of the Painted Rock Member (Tvp) of the Vaqueros Formaion lie above the shale and can be seen from Soda Lake Road near 7 Mile Road .

7.4 (3.3) miles 35.26397-119.93453 Cross, all at one place, a transmission line, section line, and road junction. Continue across the cattle guard, stop, look back to the right, where you can see the **Soda Lake Shale Member** of the **Vaqueros Formation** exposed below the **Painted Rock Member**, and the **Simmler Formaion** exposed beneath the Soda Lake Shale.



The country now opens up to the west, as the more erosion-prone rocks in the core of the anticline have been removed. The ridge in the distance to the west is formed from beds dipping off the far side of the anticline, and is composed of firm sandstones of the **Painted Rock Member**. At the far side of the ridge, and hidden from view, is the Big Spring Fault, which will merge with the Carrizo Plain near Painted Rock.

After about a half mile, the salt flats of Soda Lake appear on the east side of the road. Soda Lake is a closed drainage basin, generated by warping of the bedrock along the San Andreas Fault. Runoff entering the lake contains salts dissolved from the weathering of rocks by the rain. The salts are concentrated on the floor of the basin as the water evaporates. The white encrustations develop as groundwater is drawn off from the wet anoxic muds around the shoreline, pulling the salts to the surface.

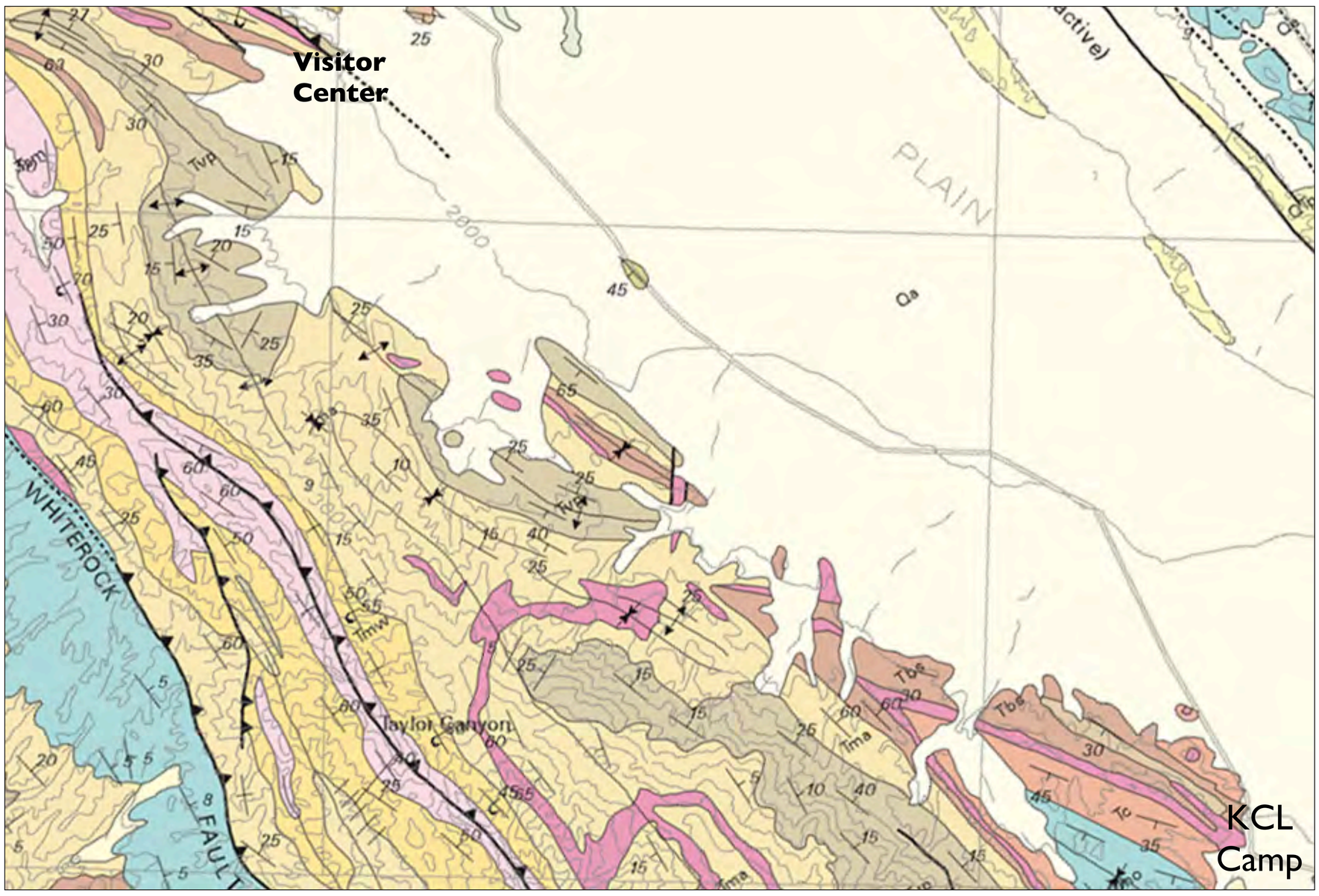
8.7 (0.6) miles 35.24905-119.91663 To the west, pass a small hill and the Goodwin Ranch. The hill is underlain by **Simmler Formation** sandstones. These are continental or deltaic sediments of **Oligocene** age.

9.4 (0.5) miles 35.24195-119.90824 Access road to Lookout Hill (and toilets) on the right, and parking for a trail to the Soda lake boardwalk on the left. The latter will allow close views of the lake shore. Lookout Hill has **Soda Lake Shale Member** of the **Vaqueros Formation** on the east side, and **Simmler Formation** sandstones on the west side. There is a trail to the top of this hill offering spectacular vistas.

View from Lookout Hill. South of the hill, the only outcrops of rock along the road are of Simmler Formation at 12.3 miles (35.212137 -119.879898)

The road continues south along the shore of Soda Lake, skirting the lake shore. After crossing a cattle guard, in the next half mile there are several low hills west of the road, all underlain by the reddish **Simmler Formation** sandstone**,** which can be seen in low road cuts as the road traverses a low hill. The mica and feldspar dominated sandstones of **Oligocene** age were deposited on land in rivers and on alluvial fans. The ridge that marks the southern end of Soda Lake is a **clay dune**, formed from dust that piled up downwind of the lake floor.

14.0 (0.9) miles 35.24195-119.90824 The road takes a sharp turn to the right, at an intersection with Simmler Road, which runs along the bottom shore of the lake on the clay dune (see p.11) and up to the San Andreas Fault. After the bend there is a straight stretch of Soda Lake Rd. that offers a view of Painted Rock, a little to the right of straight ahead. It looks a little like a gray molar tooth sticking from the base of the hill. The Rock can be visited by reservation from www.recreation.gov but is otherwise closed to visitors. Find out more from Goodwin Education (Visitor) Center, which is the house you can see on the right. Bathrooms and information are available.



14.8 (0.8) miles 35.19020-119.85454 Pass under a small transmission line and entrance to the Goodwin Education Center and toilets. The hills lying to the south of Painted Rock are the flanks of Caliente Mountain, with Cuyama Valley lying on its western side. It is essentially an anticlinal structure with a core of erosion resistant **Painted Rock Member** sandstone, and thus is similar to Hubbard Hill. The foothills in front of the main range contain a structural anticline and syncline involving the **Painted Rock Sandstone**, **Saltos Shale Member**, and **Branch Canyon Sandstone**

View of Caliente Ridge's northern end from near the Visitor Center. Painted Rock can be seen at the left margin of the photo.

About 3/4 mile past the road to the visitor center there is another road running due south from Soda lake Road. This leads to the Selby Campground and the top of Caliente Ridge,

Massive sandstones of the Painted Rock Member of the Vaqueros Formation on the road to Selby Campground and the road to Caliente Ridge

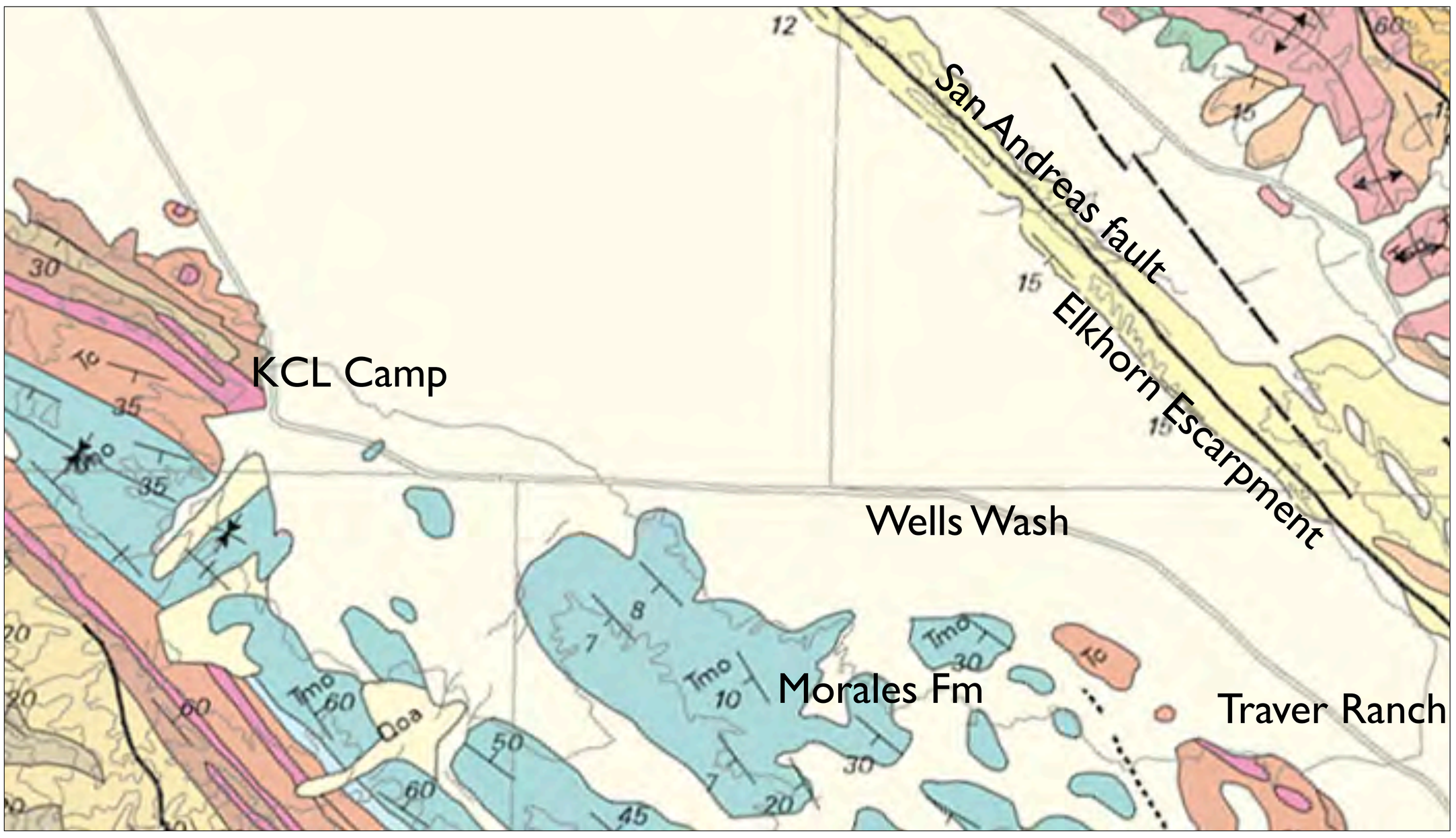
16.5 (1.7) miles 35.17073-119.83324 Pass a low hill on the east side underlain by the **Soda Lake Shale Member** of the **Vaqueros Formation**, which underlies the sandstone of the **Painted Rock Member**.

18.4 (1.9) miles 35.15399-119.80904 Cattle guard, with sign warning that the road ahead might be impassable in wet weather. Continue past Panorama Road to the left. This crosses the valley floor and connects with Elkhorn Road, but is truly impassable when wet as the valley floor is formed from sticky clay of the old lake bed.

23.5 (5.1) miles 35.10801-119.73618 The pyramidal hill on the right, standing away from the main range, is intrusive **olivine-diabase igneous rock** at the summit, underlain and surrounded by the **Saltos Shale Member**. The pyramidal form is **not** a volcanic feature. There are several other **Miocene basalt** layers in the Caliente Range. The hills at the rear are fronted by the deeper water **Saltos Shale w**ith interbedded tongues of the shallower water **Branch Canyon Sandstone**. These units continue on the right past the KCL campground **(25.1 miles 35.09316-119.72984). The two conical hills contain sensitive resources and are closed to public access**

One of two “not a volcano” cone-like hills north of the KCL Campground entry road. Note the dark cap of igneous rock that has protected the underlying shale from erosion.

25.1 (1.6) miles 35.09316-119.72984. KCL Ranch Campground entrance. The ridge coming into this road intersection from the northwest is underlain by the upper flow of the **"Triple Basalt"** , a set of dark igneous intrusions into the sedimentary rock. The basalt is a dark gray to brownish black, locally vesicular (has gas holes), olivine bearing basalt that was deposited on land (see p.11). Behind the ranch are large exposures of the **Painted Rock Member** dipping steeply off Caliente Mt.. Between the main mass of the mountain and the road are stacked the **Saltos Shale Member**, interbedded with the **Branch Canyon Sandstone**, the continental **Caliente Formation**, interbedded with basalts, the continental **Quatal Formation**, and in the foreground the continental **Morales Formation**. The sequence marks the emergence of the land from the ocean. This northeast dipping package of strata will parallel our road nearly all the way to the end of the trip. This area has been above sea level since mid- Miocene time.



After a mile you will cross a cattle guard. Looking forward you will see west dipping beds of the **Morales Formation.**, lying on the east side of a broad and shallow syncline that has developed between the main east-dipping stack of rocks and the road.

27.6 (1.5) miles 35.07413-119.66119. Cross another cattle guard and then Wells Wash. For the next three miles the hills on the right are underlain by the **Morales Formation**. Looking east from Wells Wash and along the road toward Traver Ranch, you will see 'The Dragon's Back'. This is older valley-fill sediment of late Pliocene or early Pleistocene age, assigned to the **Paso Robles Formation,** that has been squeezed upward along the San Andreas fault. The rocks are poorly consolidated and have eroded into a badland-type of ridges and gullies. The San Andreas fault is on the far side of this ridge,

Sandy hills underlain by Morales Formation west of the road from Wells Wash to Traver Ranch

The Dragon's Back: A recently uplifted strip of alluvial sediment along the San Andreas fault, as seen from the vicinity of Traver Ranch.

30.9 (3.3) miles 35.07413-119.60799 Traver Ranch. At this point the road turns due east and crosses the valley's alluvial fill. Low hills west of the road in the vicinity of Traver Ranch are underlain by west dipping beds of Morales Formation that lie on the east limb of the Wells Syncline (named after the Wells Ranch which can be reached by driving west on the track just north of the Wells Wash crossing, and lies in the axis of the syncline.

Note the severe erosion that has taken place north of the road at the lowest point of the crossing Thos is a result of northeast flowing drainage dropping sediment on the southwest side of the road, enabling renewed erosion on the other side of the road. In spite of assertions in socil media, this is NOT the San Andreas Fault.

Severe erosion on the north side of Soda Lake Road

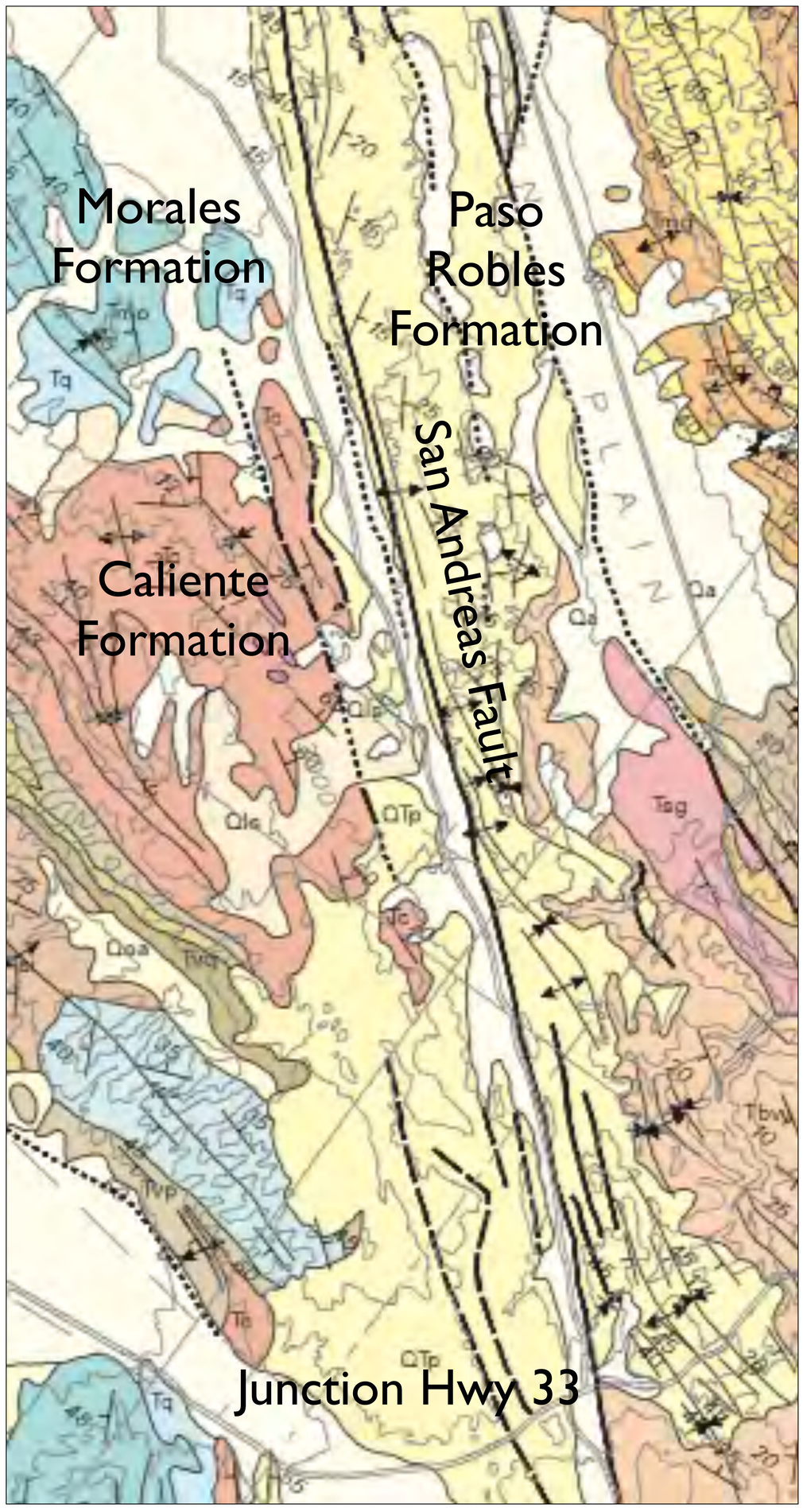
The road now runs along the foot of the Elkhorn Scarp, next to the San Andreas fault. The hummocky terrain along the road is deformed alluvial material, warped by very recent movement along the fault. Dibblee assigned these sediments to the **Paso Robles Formation**. The last quake on this section was 1857, and was probably a high-8 on the Richter Scale.

33.9 (3.0) miles. Cattle guard. Note the groove-like topographic feature about halfway up the side of the scarp, and paralleling the scarp. This is the actual fault line, and the groove is made up of the offset segments of stream channels that formerly ran across the scarp. The lower part of the scarp is an almost continuous set of 'shutter ridges', the name given to bits of hillside moved by a fault across a former valley. The rocks are Paso Robles Formation.

The San Andreas fault lies a quarter up the slope. Channels draining westward are diverted toward the northwest by offsets along the fault line.

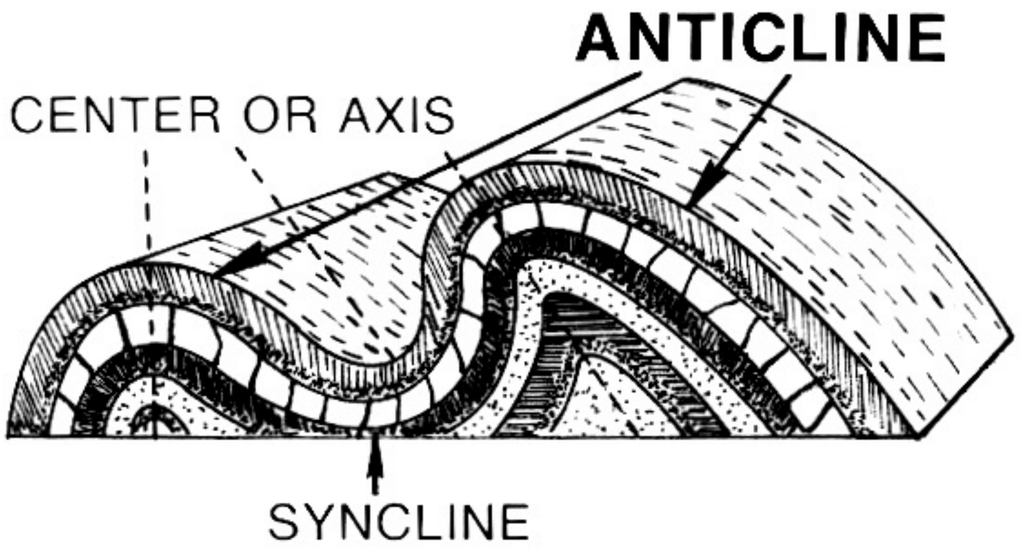
38.0 (4.1) miles 35.004034 -119.506319 Cattle Corrals. Note the closed drainage on the west side of the road, which forms a large seasonal wetland or vernal pool in rainy years, drying to a salt pan in the summer. This is not on the current active line of the San Andreas fault, but the closure of the drainage is probably caused by recent topographic tilting in the area. Offset drainages continue to be seen to the east.

Vernal pool west of the corrals generated by uplift adjacent to the San Andreas fault. Hills behind the pool are underlain by the Caliente Formation, which lies below the Morales Formation



39.2 (1.2) miles 35.97909-119.46576 Junction with Elkhorn Rd. The road enters a valley developed by the tilting of rock and by erosion along two parallel strands of the fault. The valley is closed, and a 'sag pond' has developed on the floor of the valley. Note the multicolored sheared shales on the far side of the south end of the sag pond. This is fault gouge, altered by groundwater moving along the fault zone and reacting with the rocks. Such mineralization is encouraged by the fine nature of the ground up rock, or gouge, in the zone. Rocks to the east are Plio-Pleistoce Paso Robles Formation and late Miocene Bitterwater Shale.

41.2 (2.0) miles 34.96696-119-45046. Another sag pond. The fault is marked by a well defined set of scarps as it climbs toward the crossing of Highway 33, at the culvert on the left of the road. Reach Highway 33.at **42.6 (1.4) miles.** END OF GUIDE



Sag pond just north of Highway 33/166

Clay dunes consist of fine silt blown out of the bottom of Soda Lake which then accumulated as long ridges downwind of the lake floor

Diabase (left) is a crystalline form of basalt (right). The former is formed underground where slower cooling enables larger crystal growth. Basalt forms at the surface and cools fast enough that crystals cannot be seen with the naked eye. Both rock types can be found in the Triple Basalt unit.

DESCRIPTIONS OF GEOLOGIC FORMATIONS

SIMMLER FORMATION

The Simmler Formation is found in the Caliente Range, where it is about 3,000 ft. thick, and also along the western edge of the Carrizo Plain, where it is 2,000 ft. thick. The unit consists of fine grained (generally) sandstones, siltstones, and mudstones. The rocks are commonly either olive green of dusky red in color. In some areas there are basal conglomerates, but the formation is generally finer than areas mapped to the east as Sespe Formation. It is possible that the formation represents a lacustrine (lake) environment, and the area of the Cuyama Valley (Sespe or Simmler Formation) represents continental alluvial fans that perhaps ended at the lakeshore. The lack of fossils makes dating difficult, but the unit's position between late Eocene and early Miocene marine strata supports assignment to the Oligocene epoch. The unit can be seen along Highway 58 and also in the low knoll on Soda Lake Rd. between Lookout Hill and Simmler Road in Carrizo Plain National Monument. There the sediments were deposited from southward flowing streams.

VAQUEROS FORMATION

The Vaqueros Formation generally represents a shallow marine environment developed as the ocean transgressed over former land area. It is generally a coarse sandstone, but varies considerably throughout the county. The thickest development of 7,000 ft. is within the Caliente Range and eastern La Panza Range in the southeast of the county. The late Oligocene and early to middle Miocene formation contains two members, the upper Painted Rock Sandstone Member and the lower Soda Lake Shale Member.

The Painted Rock Sandstone is a light colored, medium grained, thick bedded sandstone that forms bold outcrops and is almost 6,000 ft. thick. Formed on a shallow marine shelf and shoreline, the unit contains reefs of shell debris, cross bedded thick sandstone beds, lenticular beds and other signs of strong current and high energy transport. The unit stands well when weathered, and forms the spine of Caliente Mountain and much of the ridge line on the west side of the Carrizo Plain. The beds grade eastward into the continental Caliente Formation. The unit is of Saucesian age.

The Soda Lake Shale Member is a clay shale and silty shale, dark gray in color, and very similar to the Rincon Formation, a deeper water facies deposited in the Zemorrian and Saucesian stages synchronously with the Soda Lake Shale. The upper boundary with the Painted Rock Sandstone is gradational, and also lateral with the shallow water sandstone on the east and the deeper water shale on the west. Within the Caliente Range, the unit varies between 900-1,500 ft. in thickness. In the southeastern Caliente Range there is a thin (200 ft.) sandstone below the Soda lake Shale that resembles the Painted Rock Member, and is named the Quail Sandstone Member. It is cross bedded, and like the Painted Rock Sandstone, forms bold outcrops.

SALTOS SHALE AND WHITEROCK BLUFF MEMBERS OF THE MONTEREY FORMATION

The Monterey Shale Formation is about 2,000-3,000 ft. thick on the southwest side of Caliente Mountain, where the type areas of both the Saltos Shale and Whiterock Bluff Members is located.

The Saltos Shale is dominantly a clay-rich shale, and the Whiterock Bluff a white diatomaceous shale. The lower part is composed of gray siltstones and argillaceous shales that become more siliceous toward the top of the unit. A basalt sill intrudes these rocks at the type locality. The unit thins to about 1,000 ft. to the northwest, and contains no basalt, although it retains the same appearance.

The unit both intertongues with, and lies conformably above, the Painted Rock Sandstone Member of the Vaqueros Formation. At the northwest end of the Cuyama Valley the Saltos Shale grades upward into siltstones, and then into the Branch Canyon Sandstone Formation. On the northeast side of Caliente Mt., the shale becomes siltier and contains interbedded sandstones. The upper siltstones grade westward into the Whiterock Bluff Shale Member. The Shale intertongues with the Branch Cayon Sandstone near the San Andreas fault.

The Whiterock Bluff Shale Member is 1,200 ft. thick at its type locality at Whiterock Bluff, a prominent landmark that suites its name, 8 miles WNW of New Cuyama. The unit looks like ‘typical’ Monterey Formation with thin bedded siliceous shales interbedded with punky diatomaceous shales. The unit lies conformably above the Saltos Shale Member, but grades in the northeast Carrizo Plain into the Saltos Shale and the Branch Canyon Sandstone, implying progressive shallowing in that direction.

CALIENTE FORMATION

The continental Caliente Formation is equivalent to the marine Vaqueros, Monterey, and Santa Margarita Formations further to the west, and therefore represents a long period of on-land deposition. The formation is 4,200 ft. thick in the Caliente Range, where it is exposed on the eastern flank of the mountain ridge at the south end of the Carrizo Plain. It is conformably overlain by the Quatal Formation, but tongues laterally into the Branch Canyon Sandstone and Vaqueros Formations. The age of the unit ranges from the latest Oligocene at the base to possibly earliest Pliocene at the top.

The lithology of the Caliente Formation shows local variability, but is dominated by variegated red and green mudstones, sandstones, and conglomerates typical of alluvial fans and floodplains. It contains lenses of very coarse conglomerates, with clasts

derived from a granitic and a metamorphic basement complex. The lower half of the reddish deposits are dominated by unbedded granitic fanglomerate derived from high energy flash flooding on an ancient alluvial fan.

Continental deposits are usually hard to date, due to the paucity of fossils, but the Caliente Formation is interbedded at Caliente Mountain with the "Triple Basalts", that have been dated at 16.1, 14.4, and 14.2 million years B.P.. The flows, sills and dikes are fine grained basalt and diabase, the layers being locally in excess of 300 ft. thick. The basalts pass laterally into tongues of the Branch Canyon Sandstone bearing fossils of the "Temblor" molluscan stage, which elsewhere is known to be equivalent to a Barstovian mammallian stage. The basalts are found only in the Caliente and southern La Panza Ranges.

BRANCH CANYON SANDSTONE

This formation is a nearshore, marine, coarse to medium grained, eastern equivalent of the Saltos Shale Member of the Monterey Formation. It is exposed in the southeastern Caliente Range. The middle Miocene unit contains thick-bedded, locally cross stratified, light gray to yellow gray sandstones that are interbedded with green gray siltstones. It locally contains some red beds, as it passes laterally into the continental Caliente Formation. Locally there is an intricate intertonguing and interbedding between the Caliente Formation and Branch Canyon Sandstone that is indicative of a shifting shoreline. The unit contains two basalt flows, part of the "Triple Basalt" that continues into the Caliente Formation. The formation is best developed in the central Sierra Madre Range, west of Santa Barbara Canyon in Santa Barbara County.

QUATAL FORMATION

The Quatal Formation is only represented in the southernmost Caliente Range and up through the Carrizo Plain area. It consists in the Caliente Range of several hundred feet of gypsiferous clays of Pliocene age. The depositional environment was that of a large inland lake. The rocks pass conformably upward into the Morales Formation, and downward into the Caliente Formation. The best exposures are in the vicinity of Padrones Spring, at the southern end of the Carrizo Plain, where the rocks are grey sands and clays, in contrast to the underlying Caliente Formation red beds.

MORALES FORMATION

This unit consists of Pliocene, and possibly earliest Pleistocene, continental beds in the Cuyama Valley, Caliente Range, and Carrizo Plain areas of the southeast county. It is dominated by light gray, crumbly sandstone and conglomerate, and gray to red siltstones. Pebbles in the conglomerates appear to have been derived from older conglomerates. The formation is almost 3,000 ft. thick in the western Cuyama Valley, with the upper half dominated by coarse grained sediments and the lower half by gray clays that were deposited in a lake bed. South of New Cuyama, the unit is coarser and about 5,000 ft. thick, passing downward into the Quatal Formation.

The Morales Formation has been identified on the east side of the San Andreas fault in the Panorama Hills, east of Soda Lake, where it is 2,500 ft. thick and unconformably overlies conglomerates assigned to the Santa Margarita Formation. It forms the low hills between Wells Ranch and Soda Lake Road south of KCL Campground where it overlies the Quatal Formation.

PASO ROBLES FORMATION

The formation consists of sediments washed into the valley in Pliocene or early Pliocene times, and are distinguished from modern alluvium by being partly consolidated, and also by being deformed into folds by tectonic movements along the San Andreas fault. The name has been applied to all sediments of this type that resemble extensive deposits in the Paso Robles area.

This field guide was prepared by Dr. David Chipping and the Friends of the Carrizo Plain. Maps are taken from Tom Dibblee's Miscellaneous Geologic Investigations Map I-757, published by the U.S. Geological Survey