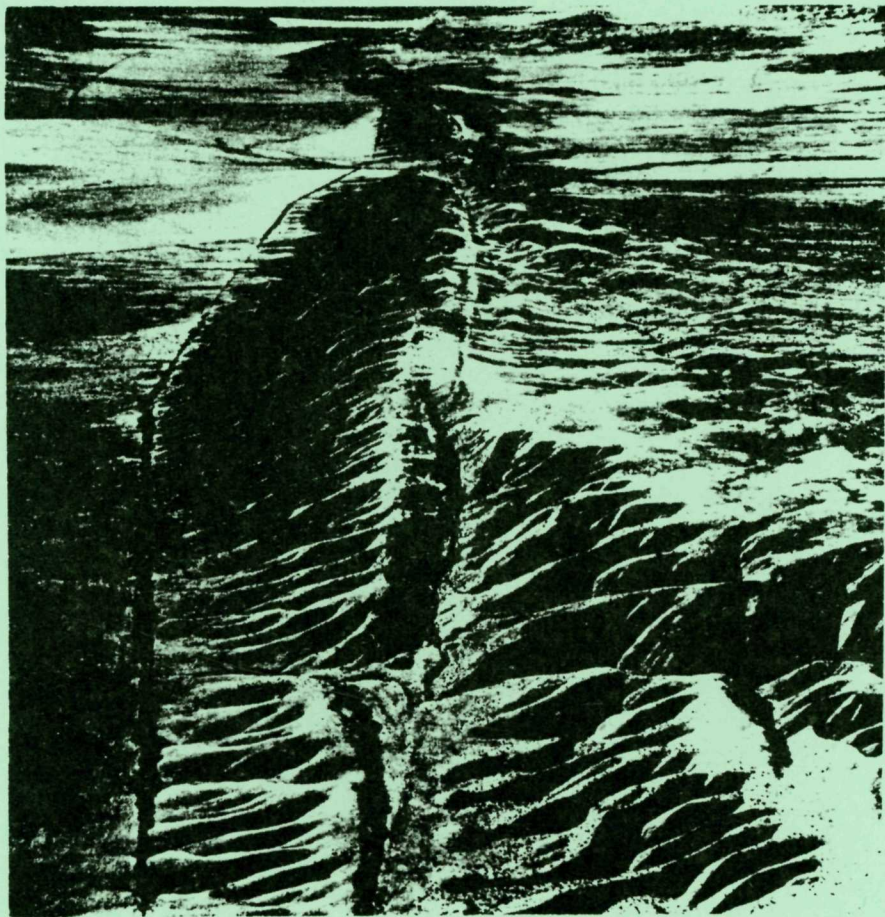


Carrizo Plain Natural Area

Two Self-Guided Geologic Auto Tours



View looking northwest along the San Andreas Fault (center).
Carrizo Plain and fence covered with tumbleweeds on the left.

Tour #1: Goodwin Education Center - Soda Lake - Wallace Creek

Tour #2: Goodwin Education Center - KCL Ranch - Highway 166

The Carrizo Plain Natural Area

The Carrizo Plain Natural Area was established in 1988 to protect habitat for endangered species and to restore native ecosystems. It is the largest contiguous remnant of the San Joaquin Valley ecosystem. The Carrizo Plain Natural Area is cooperatively managed by the Bureau of Land Management, the California Department of Fish and Game, and The Nature Conservancy.

Explore the Fault on Two Auto Tours

In addition to an extraordinary biological diversity, the Carrizo Plain is renowned for its dramatic topographic expression of the San Andreas Fault. You are invited to discover the fault and to explore other geologic features and their roles in the evolution of this vast, quiet place. During your journey, please stay on established roads, and be aware that all dirt roads may become **Impassable When Wet**.

Tour 1: Goodwin Education Center - Soda Lake - Wallace Creek. This tour is the shorter of the two, eight miles one way on dirt roads, due north of the Goodwin Education Center to the trace of the San Andreas Fault at Wallace Creek. You will see perhaps the best example of a fault offset stream drainage in the world.

Tour 2: Goodwin Education Center - KCL Ranch - Highway 166. This tour will take you the length of the south half of the Carrizo Plain. It is on paved and improved dirt roads. Near Highway 166 you will drive down a narrow linear valley carved by movement on the San Andreas Fault. The one way mileage is 32 miles.

How to use this Field Guide

Both field trips begin at the Goodwin Education Center. It is located 13 miles south of Highway 58 and 32 miles north of Highway 166, one mile west of Soda Lake Road. To use this field guide please refer to the map on the back cover. In the guide, cumulative mileage is given, as well as mileage between stops or points of interest along the way. In this guide mileage between stops or points of interest are shown within parenthesis. Only stops are shown on the map on the back cover. On the map stops for tour 1 are in larger type than those of tour 2.

We encourage you to visit the Goodwin Education Center. The Center is staffed during the winter and spring. Please call the Nature Conservancy or Bureau of Land Management for hours of operation. Addresses and telephone numbers are on the inside back cover.

Tour #1: Goodwin Education Center - Soda Lake - Wallace Creek

Mileage

(Miles Between Stops)

- 0.0 (0.0) Goodwin Education Center. The Carrizo Plain trends northwest-southeast. The Caliente Range is to the southwest. The San Andreas Fault runs along the base of the Temblor Range to the northeast.
- 0.5 (0.5) Turn left on Soda Lake Rd.
- 1.3 (0.8) Turn right on Simmler Rd.
- 1.6 (0.3) Note drainage channel rimmed with salts; you are entering the Saltbush Scrub plant community.
- 2.8 (1.2) **STOP 1.** Soda Lake on left. The surface crust at Soda Lake is about 82% anhydrous (lacking water) sodium sulfate, 9% sodium chloride (table salt), and 9% miscellaneous salts.

The entire Carrizo Plain drains internally - water does not flow to the ocean, but rather to Soda Lake and nearby ponds, which usually dry out in the summer. Salts, dissolved from sediments and carried down into the plain, accumulate through evaporation. A lack of old shorelines or terraces suggests that, unlike other alkali lakes in the western states, Soda Lake is not a remnant of a larger, ice age lake. Instead, the plain once held a meandering river. Over the last 1-3 million years, the river, which once flowed southward toward Maricopa, changed direction (due to uplift associated with the San Andreas Fault) and drained northward into the Salinas River watershed. Later, further uplift at the north end of the plain blocked this outlet, causing all runoff to drain to Soda Lake.

From the 1880s to the 1940s, a number of enterprises intermittently mined salt and sodium sulfate. In the early 1900s, a narrow gauge railroad was used to haul salt to a refining plant on the south side of the lake. Then it was hauled to the railway at McKittrick. Sodium sulfate is used in the manufacture of textiles, soap, glass and paper.

The road runs along an elevated berm, about 40 feet higher than Soda Lake. This feature, unusually long and straight on a

map, may be the remnants of a clay dune. Clay dunes form as dried salts blow across a lakebed, picking up dust particles along the way to make larger grains. At this site, after hitting some kind of impediment, they piled up along the south side of Soda Lake. With time the grains became compacted and are no longer visible. This dune formation does not seem to be happening here today; the dunes are stabilized by vegetation so they must be at least a few thousand years old.

There is another salt pond on your right. This pond is actually lower than Soda Lake and holds water longer in the dry season. The ridge, approximately 30 feet high on the east side of the lake, may be another clay dune.

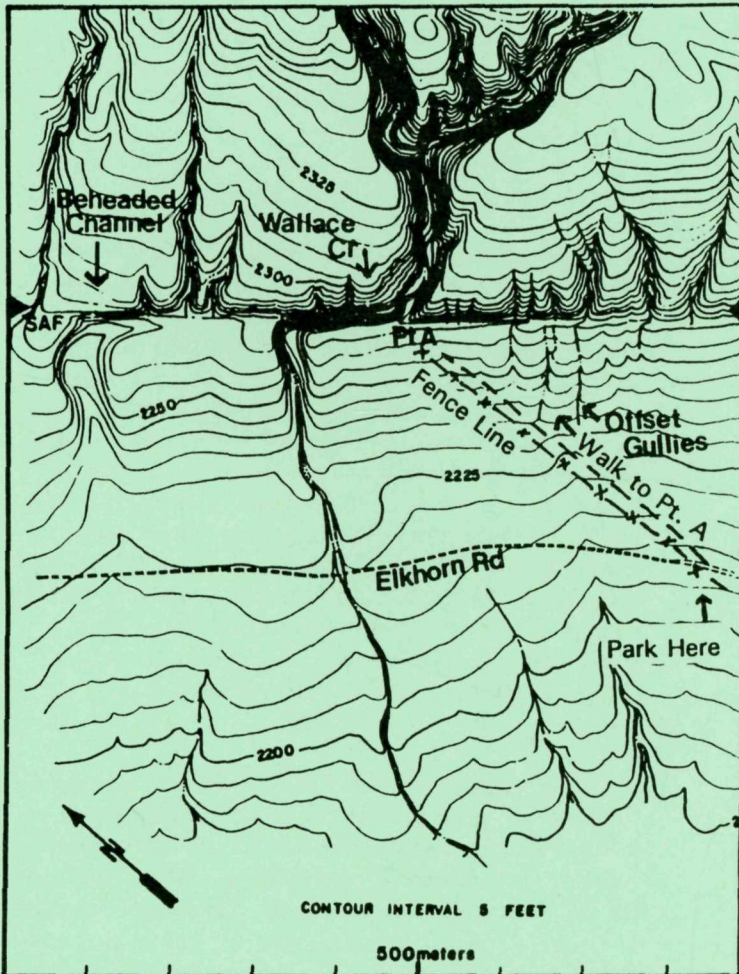
- 3.3 (0.5) Note the steep white face in the Temblor Range straight ahead. This is **not** the San Andreas Fault scarp -- it is composed of highly erodible marine and non-marine sediments, less than 2 million years old. The San Andreas Fault lies just above the water tanks in the distance. In late afternoon it is easier to see the low fault **scarp** running along the base of the Temblor Range. During earthquakes, the San Andreas Fault primarily moves horizontally, however smaller vertical movement creates a discontinuous line of hills or ridges known as scarps.
- 3.5 (0.2) More inlets of Soda Lake.
- 4.2 (0.3) Road descends off berm.
- 5.0 (0.1) Cattle guard and tank. Note: you are returning to Valley Grassland community.
- 6.8 (1.8) Power lines. These lines originate at Diablo Canyon Nuclear Power Plant on the coast southwest of San Luis Obispo and run to a transfer station in the San Joaquin Valley at Buttonwillow.
- 7.4 (0.6) Turn right on Elkhorn Rd.

STOP 2. The La Panza Range is in the distance, west of Soda Lake. Sandstone beds in the mountains directly above the northernmost part of Soda Lake are tilted to the north and are part of the Soda Lake **anticline**, a large upwarping of rocks folded into an upside down U shape.

7.8 (0.4) Cattle guard and Power lines just ahead. The fault scarp lies to the left.

8.6 (0.8) The gully crossing the road is Wallace Creek.

8.8 (0.2) **STOP 3.** Observation of fault offset at Wallace Creek. Cross the cattle guard and park on the side of the road. BE CAUTIOUS -- fire danger may be extreme. Walk north (uphill) 0.3 mile along the fence to the base of the scarp from which Wallace Creek exits onto Carrizo Plain. One you reach Wallace Creek, you will walk in either direction along the fault from Point A (see map below).



POINT A. View of Wallace Creek You are standing on the San Andreas Fault here it runs northwest to southeast (your left to right) at the base of these hills. At one time Wallace drained straight across the fault, but movement by the San Andreas Fault has offset its drainage course, with the downstream segment about 430 feet northwest of the upstream segment. This is one the best examples of stream offset across a fault in the world.

The San Andreas Fault is about 800 miles long and accounts for over half of the movement between the Pacific and the North American plates -- a feature visible for hundreds of miles above the surface of the earth. The side you are standing on is moving north at an average rate of 1.5 in/year relative to the opposite side. This rate, equivalent to 125 feet every 1000 years, is an average that takes into account the many years that there is absolutely no movement here and the brief moments when large quakes cause 10-20 feet of movement at once. If you could stand at this point 9 million years in the future, you might be waving at San Francisco across the fault.

Walk northwest (across the barbed-wire fence) from Point A to the downstream segment of Wallace Creek -- do you agree with the estimate of 430 feet of offset? This amount is estimated to have occurred over the last 3,700 years due to many large-magnitude earthquakes. Look for the whitish, angular shale chips in Wallace Creek derived from the 20 million-year-old Monterey shale that makes up most of the Temblor Range. Cross the channel and continue walking northwest along the San Andreas Fault. You will pass 3 small gullies on your right (east) side, and then reach a wider channel (50-75 feet wide) draining to the plain. This is a much older downstream segment of Wallace Creek which has been completely separated from the upstream portion. This is known as a **beheaded** channel. It matched up with the upstream segment of the creek approximately 10,000 years ago.

A second beheaded channel of Wallace Creek lies farther to the north, but is more difficult to find. Carbon dating of material in these channels indicates that the San Andreas Fault and Wallace Creek have been dynamically interacting for the last 13,250 years! Return to Point A. If Wallace Creek erodes

a path straight across the fault here, yet another beheaded stream channel will be formed to the northwest.

From Point A, look to your right (southeast) and note the 20 - 25 foot high fault scarp. The San Andreas Fault runs along the base of this scarp. The scarp shows that the San Andreas also has a small component of vertical motion, estimated here at 10 feet elevation gain over 3,700 years!

Walk south along the base of the scarp to see more offset streams. Keep your eye out for three small gullies cut into the fault scarp -- mere wrinkles. Can you see how much the fourth gully is offset as it crosses the fault? It is roughly 30 feet, which could have occurred all in one quake, the 1857 Fort Tejon quake. Geologists are not sure if it accumulated in one or two major quake events. The next gully is also offset, as is the next! Have fun exploring, but please preserve these fragile features. Return to Point A.

We can only imagine what it will be like the next time the earth quakes here -- will we have 18 feet or 30 feet of displacement? Will it be within the next 100 years, or the next 300 years? Geologists aren't sure. Take a moment to reflect on this incredible force. Are you prepared for an earthquake at your own home?

END OF TOUR #1

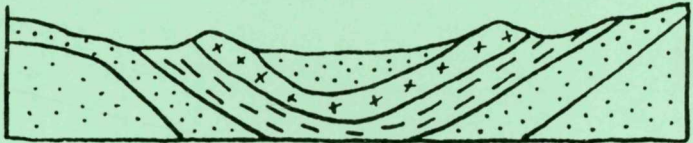
Tour #2

Goodwin Education Center - KCL Ranch - Highway 166

- 0.0 (0.0) Goodwin Education Center. We will follow Soda Lake Rd. south to Highway 166. The Carrizo Plain trends northwest - southeast. The Caliente Range is to the southwest; the San Andreas fault runs along the base of the Temblor Range to the northeast.
- 0.5 (0.5) Turn right on Soda Lake Rd.
- 1.3 (0.8) **STOP 1.** The Selby campground in the hills on the right rests on the site of the deepest oil well drilled in the Carrizo -- in 1985 Arco drilled 17,697 feet! The well had some oil and gas shows, but never produced commercially and was abandoned the same year.
- One of the most famous oil fields in the U.S lies just east of the Temblor Range near Taft. Other major oil fields in the Cuyama Valley just over the Caliente Range are also quite productive. Yet, despite drilling at least 142 exploratory oil wells in the Carrizo Plain since 1901, oil and gas has not been present in large enough quantities to economically produce. Currently there are only a few producing wells in the Carrizo Plain Natural Area - one in the Temblor Range, and several on the southwestern flank of the Caliente Range.
- On the right, Painted Rock dominates the plain. It consists of coarse sandstone, deposited in a delta where a river entered the ocean about 20 million years ago. Shallow water molluscs and large **cross beds**, a feature which indicates strong longshore currents, are found in this sandstone. Since the sand was deposited, the sea has retreated, the sand has become sandstone, and rock layers now dip down to the southwest. Painted Rock stands out on the plain because it is well cemented with calcium carbonate.
- 2.3 (1.0) On the left a small hill crops out. If you stop to explore this shale outcrop, note the more resistant rocks containing **chert**, a microcrystalline quartz.
- 3.1 (0.8) To the east, a small salt pond is visible. If it's a clear day, look for the low ridge that is the San Andreas Fault scarp across the valley to the southeast.

- 4.2 (1.1) Pavement ends. Note steeply dipping sandstone that dips to the northeast in the bottom part of the Caliente Range to the right. Continue on dirt road.
- 6.4 (2.2) **STOP 2.** Panorama Road turnoff. Scarps along the San Andreas fault are the first topographic highs between here and the Tumbler Range. The Panorama Hills, located behind the scarps, are composed of nonmarine sediments less than 2 million years old and have probably been upwarped along the San Andreas Fault.

To the west, the Washburn Ranch, now a Bureau of Land Management administrative site, lies directly below sandstones in the Caliente Range. The ridge that runs from the Washburn southward to the conical hill is composed primarily of sandstone and volcanic **basalt** similar to the volcanic rock which erupts nearly continuously in Hawaii. Although not visible here, these beds dip down to the southwest and form part of a large **syncline** that runs along the base of the Caliente Range southward.



A syncline occurs when rocks are folded into a U shape.

- 9.6 (2.3) The conical hill on the right is composed of **diabase**, a dark black crystalline rock. This was probably a volcanic neck, and the source for some of the 15 million-year-old basalt flows found in the Caliente Range -- it has fairly large crystals. When the vent was active, its mouth was probably higher than the top of the hill is now -- it has since tilted and the surrounding less resistant rock has eroded, leaving the cone we see today.
- 10.5 (0.9) Look for dark basalt and lighter colored sandstone in low

hills to the right. Shales form low spots between the hills.

11.2 (0.7)

STOP 3. Stop at the road junction to KCL Ranch. The wash which crosses Soda Lake Road drains from the vicinity of KCL Ranch. It has deposited an assortment of cobbles and boulders. Look for sandstone, black basalt, granite, and fine-grained, whitish shale. You may also find some fossiliferous sandstone containing snail and shell fossils. Some boulders are very large -- imagine the size of the mudflow that "floated" these boulders downstream and deposited them thousands of years ago. The new channel is now cutting down and exposing these large boulders. At the remains of KCL Ranch house there is an unimproved campground and portable toilet. Remember to reset your odometer if you go into KCL to take advantage of the shade and rest.

From the road intersection look above the barn to the base of Caliente Range in distance. Can you see large slabs of sandstone dipping steeply to the northeast? The Caliente Range is largely composed of sedimentary rocks less than 30 million years old. Caliente Peak, 5,106 feet high, is the highest peak in San Luis Obispo County. The Caliente Range is an anticlinal structure - rocks that were deposited as flat lying sandstones and shales have been upwarped and folded within the last 3 million years. This folding, found throughout the California Coast Ranges, shows that not only do the North American and Pacific Plates slide by each other along the San Andreas Fault, they also have a component of convergent motion which causes the California Coast Ranges to contract and rocks to fold.

Over the next five miles you will cross several cattle guards. The low hills on your right are composed of young, unconsolidated nonmarine sediments.

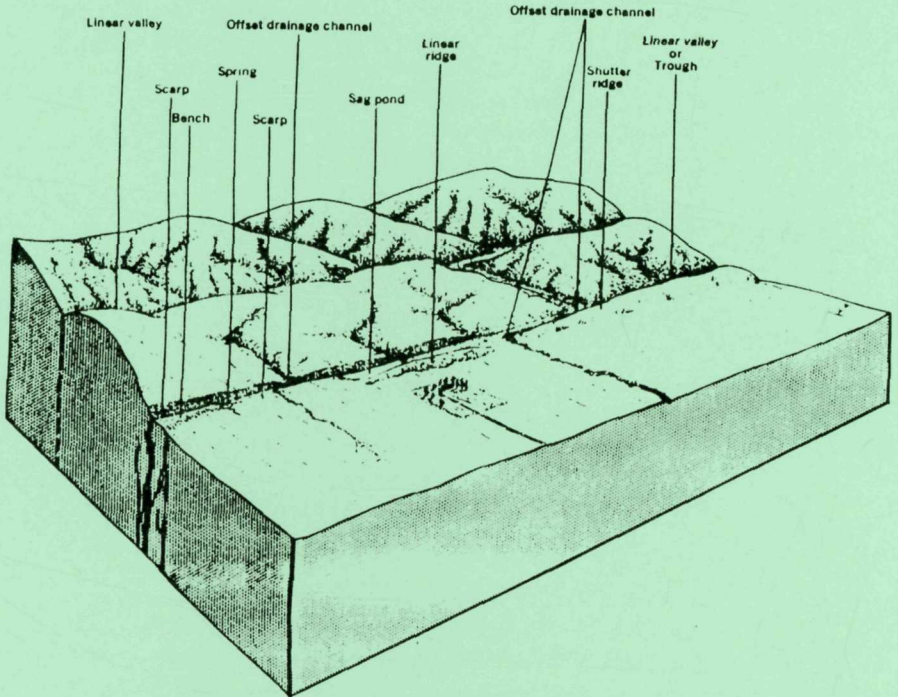
16.4 (5.2)

An excellent view of the Elkhorn scarp from this area.

17.3 (0.9)

STOP 4. Elkhorn scarp **pressure ridge**. The large ridge to the left across the valley is a complex mass of young sedimentary rocks that have been uplifted, folded, and faulted. It is made up of mostly nonmarine alluvial fan sediments less than 2 million years old. Note the drainage patterns of the streams as they come off the hills and hit the San Andreas Fault. (The dark, very straight line is a fence full of

tumbleweeds, not the fault!) This pressure ridge is in an area where the San Andreas Fault changes direction slightly. It has been tilted and uplifted due to complex interactions along both the San Andreas fault and other faults. There are a series of pressure ridges in this zone along the fault.



BLOCK DIAGRAM SHOWING LANDFORMS PRODUCED ALONG RECENTLY ACTIVE FAULTS

18.1 (0.8) Road cut on right. You can stop and feel the texture of this loosely consolidated sediment which contains small pebbles as well as clay. This is part of the Caliente Formation -- sediments deposited in an ancient river bed 10 million years ago, which has since been uplifted and tilted. Volcanic basalt crops out in these hills as well, farther to the southwest.

18.8 (0.7) Traver block house. The Travers built this house in the 1970s. The paved stretch of road helped keep the dust down in front

of the house. The white house across Soda Lake Road and to the north was the first Traver ranch, built in 1951.

- 19.7 (0.9) **STOP 5.** Concrete-filled gully. Obviously, erosion is at work. The gully was once Soda Lake Road! It has completely washed out to form this deep gully. Realignment of the road to its present route in the 1960s changed the flow dynamics by concentrating runoff and dramatically speeding up erosion. This concrete capping was poured in 1992 to protect a buried AT & T cable where it crosses the gully. Look at the gully walls for clues to older stream deposits. Do you think the gully continues to Soda Lake. Note the vast difference in gully definition from one side of the road to the other.

The road is approaching the San Andreas Fault which lies just ahead along the base of the Elkhorn Hills. Note the large **alluvial fans**, fan-shaped sedimentary deposits, emerging from the stream mouths of the Elkhorn Hills.

- 21.8 (2.1) **STOP 6.** Cattle guard. The geology to the southwest is dominated by the dark red and contrasting white beds of the Caliente Formation in the mountains. Fossil fragments from camels, rhinos, crocodiles and horses indicate this area was once rich with large animals. Dark black rocks on the horizon are 15 million-year-old basalts.

To your left, the San Andreas Fault dominates the topography of the Elkhorn Hills, and is especially visible in late afternoon light. Many offset streams and linear ridges are visible. Can you see any **shutter ridges**, hills that have been moved by the fault to block drainages?

- 22.1 (0.3) As you come to the narrowing of the plain note that saltbush plant communities again are present.

- 23.3 (1.2) Cattle guard. Note large gully to west of road; over the next 1-½ miles note drainages crossing the road and joining this gully.

- 23.9 (0.6) The trees to the southwest are called "trees of heaven," planted by some early homesteader -- a trace of the past. A good example of an offset gully lies to the left.

- 24.3 (0.4) Power lines. Note steepness of gully to the west.

- 24.7 (0.4) **STOP 7.** Examine this gully! More extreme erosion. Note remnants of old road, which was washed out in severe rainstorms of March 1991.
- 25.3 (0.6) Pavement begins.
- 25.7 (0.4) You have reached the limits of the Carrizo Plain drainage basin. From here on, drainage patterns go to the Cuyama Valley and the Santa Maria River. As you continue south to Highway 166 you will be traveling a narrow linear valley created by the San Andreas Fault. The Caliente Range is to your right (west) and Elkhorn Hills to your left.
- 26.4 (0.7) Excellent view of the trace of the San Andreas Fault. Mt. Pinos lies ahead. It and the mountains to the south are part of the Transverse Ranges of California -- a unique geological province because, unlike almost all other mountain ranges in the state, the Transverse Ranges follow an east-west trend. The south end of the Caliente Range runs east-west parallel with the Transverse Ranges, yet to the north it trends northwest parallel with the Coast Ranges. South of Highway 166 the San Andreas fault makes what is known as the "Big Bend" as it veers southeast to Gorman, east of Mt. Pinos.
- 27.1 (0.7) The small basin in the foreground is a **sag pond**. Sag ponds develop where the fault splits into strands, and fault blocks settle to develop hollows. Groundwater may fill the hollows, but this one is dry most of the year.
- 27.4 (0.3) Junction with Elkhorn Rd.
- 28.0 (0.6) Carrizo Plain Natural Area sign. The greenish and brownish shales on the southwestern end of the sag pond are sheared rock that have been chemically altered by groundwater. As you head toward Highway 166, you leave the Coast Ranges behind you.

Erosion, deposition, volcanic eruptions, sudden earthquakes, and slow folding -- the story will continue. Enjoy your trip home.

END OF TOUR #2

REFERENCES

- Author:** Judith Hildinger
- Technical Reviewers:** Bob Wallace, Gene Fritsche, Ramon Arrowsmith, David Chipping, Larry Vredenburg,
- Editors:** Michael Ayers, Nancy Adess, Tony Nelson, Johna Cochran, Jim Lidberg
- Illustrator:** John Iwerks
- Further Reading:** Wallace, R. E., 1990, San Andreas Fault System, California: U. S. Geological Survey Professional Paper 1515, 283 p.

Acknowledgments:

The Wallace Creek map was adapted from K. Sieh & R. E. Wallace, 1987, The SAF at Wallace Creek, Geological Society of America Centennial Field Guide, Cordilleran Section. The photo on the front cover and the fault features block diagram are from USGS Professional Paper 1515. Verbal permission was granted by K. Sieh and R. Wallace for the use of the photo, Wallace Creek map and block diagram.



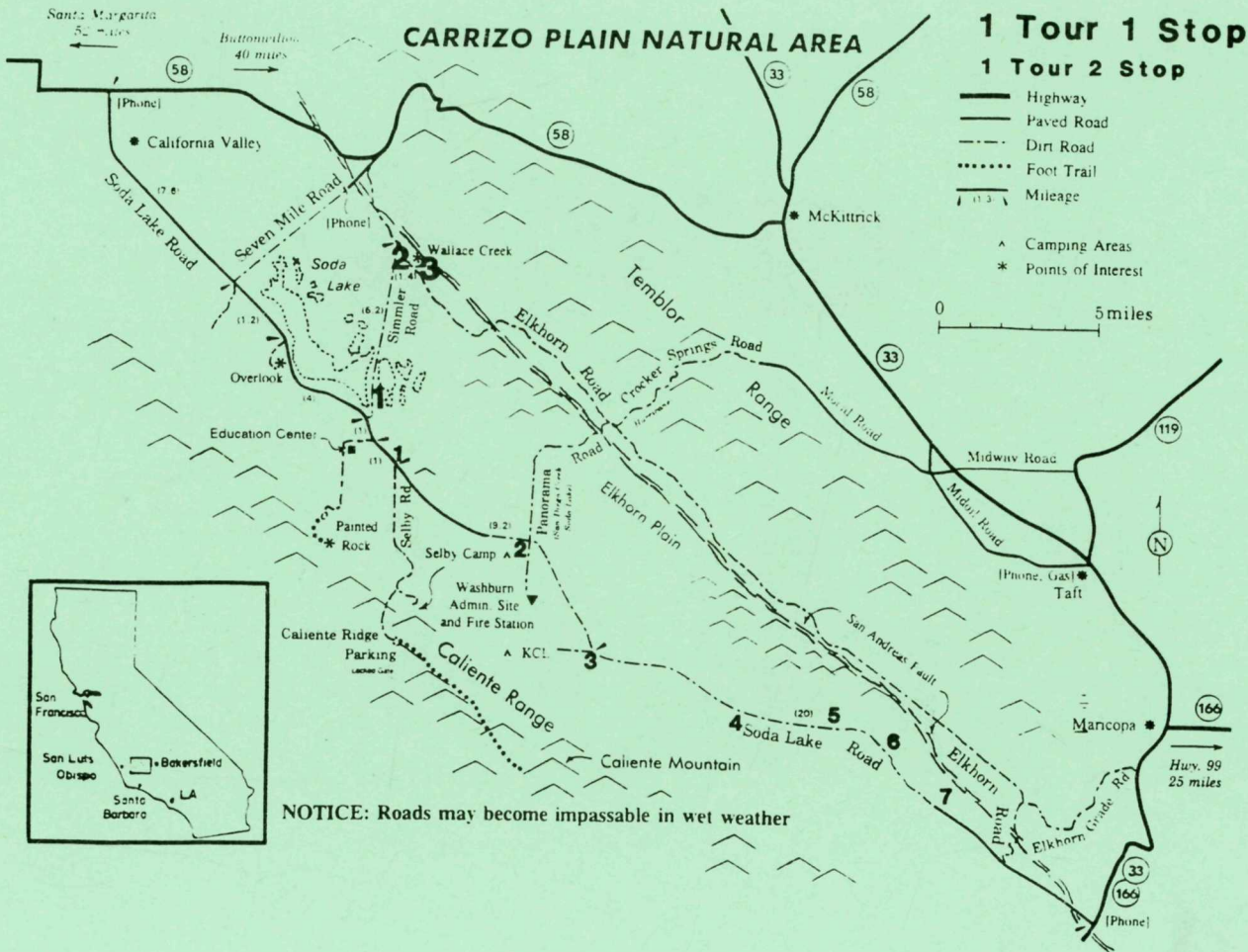
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