This brochure is dedicated to the memory of Tom Dibblee and Helmut Ehrenspeck who lived the Forest Service motto: "Caring for the Land and Serving People"

Geologists Tom Dibblee and Helmut Ehrenspeck.

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Check out these geology websites:

http://www.fs.fed.us/r5/lospadres/about/resources/geology

http://www.fs.fed.us/geology/

http://geology.usgs.gov

http://www2.nature.nps.gov/geology/

For kids and teachers:

http://earthquake.usgs.gov/4kids

http://terraweb.wr.usgs.gov/TRS/kids/index.html

http://education.usgs.gov.html

http://www.blm.gov/education.html

Acknowledgements: cover photo of Brian Seneker at Stop 15 taken by Allen King. Original work done by Brian Seneker, with revisions by Christy Till, Lindsay Rae Silva, Ashlee Dere, and Krista Mondelli. Geologic technical support by Allen King and Helmut Ehrenspeck. Original geologic mapping by Thomas W. Dibblee and simplified geologic map by Helmut Ehrenspeck. Graphic production by Kuromiya Design.

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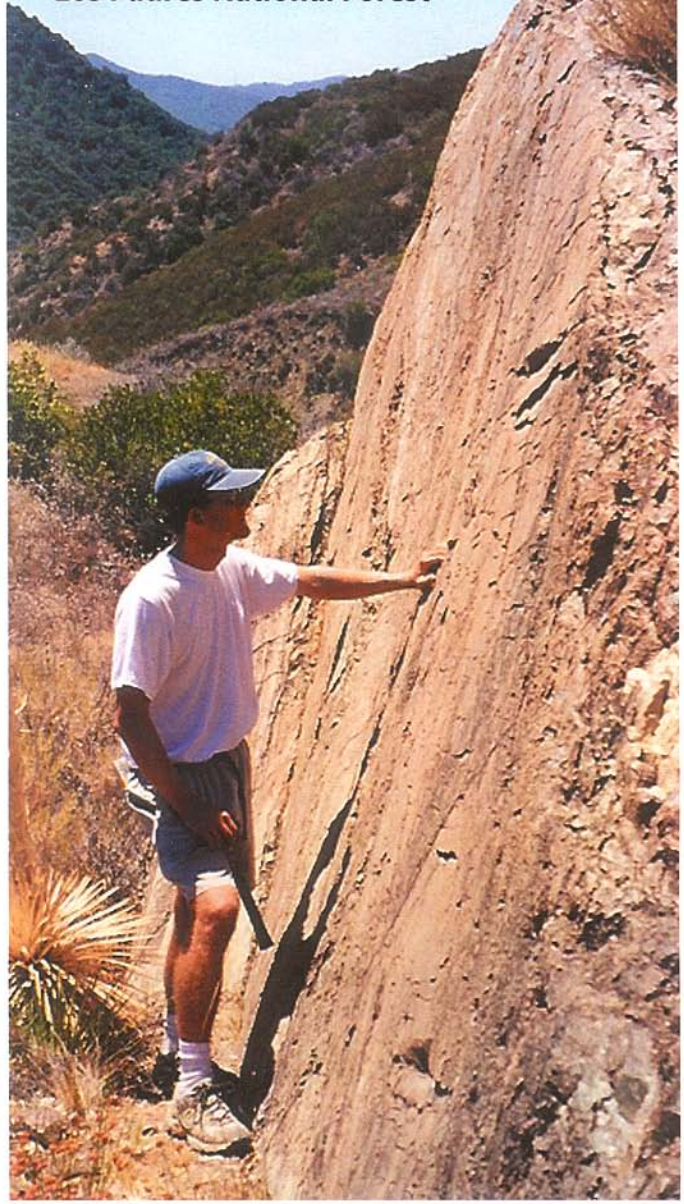
USDA

United States Department of Agriculture
Forest Service, Pacific Southwest Region

Geologic Trail Guide for the Upper Oso Canyon

Santa Barbara Ranger District
Los Padres National Forest



Welcome to Upper Oso Canyon

Millions of Years of Geologic History Preserved in Upper Oso Canyon

This self-guided geologic tour is a journey through the fascinating geologic history preserved in the area. On this trip, you will encounter rocks up to 180 million years old that came from the depths of the earth's interior as well as rocks that were once part of the ocean floor. Ancient earth processes, including mountain-building events, faulting and folding, are also evident in these rocks. However, as an old geology saying goes, "the only constant is change." Modern processes such as landslides, faulting, and stream erosion are continually shaping the rocks and the landscape. The rocks can be thought of as stone tablets that have recorded the earth's geologic history and are constantly being edited and changed by these natural processes.

Why Learn About Geology?

Geologic processes and events are largely responsible for the natural resources, natural disasters, and landscapes of California. While many of these geologic processes go unnoticed, their impacts greatly affect the state's economy, agriculture, water supply, vegetation and land use. Understanding geology is critical in determining how we impact and use our environment.

The National Forest Service is dedicated to meeting public needs for forest products and services while conserving the resources, ecosystems, and aesthetics of the land, all of which are dependent upon past and present geologic processes. In the Los Padres National Forest, Upper Oso Canyon is a great place to see some of the unique geologic features of California. This self-guided trail is 3 miles roundtrip and includes the sixteen numbered stops described in this brochure. The hike begins at the Upper Oso Trailhead in the Upper Oso Campground.

The first 0.5 mile follows the Camuesa – Buckhorn Off Highway Vehicle (OHV) route, so be aware of motorcycles, bicycles, and small all-terrain vehicles (ATVs). **After stop five, the geologic trail branches left at the Santa Cruz Trailhead.** Here you have the option of taking a short detour to Stop 6 by continuing up the road before following the Santa Cruz Trail. The one mile hike from the Santa Cruz Trailhead to Nineteen Oaks follows a gentle single track trail for hikers, mountain bikers and equestrians where motor vehicles are prohibited. This Trail Guide ends at Nineteen Oaks where you may turn around or continue toward Little Pine Mountain.

For Your Safety. Hazards in this area include uneven or slippery walking surfaces, steep cliffs, recreation traffic, poison oak, rattlesnakes and changing water flows within rivers and creeks. Please be careful of all potential hazards and be responsible for your own safety in this wildland environment. **Please, take only pictures and leave only footprints.**

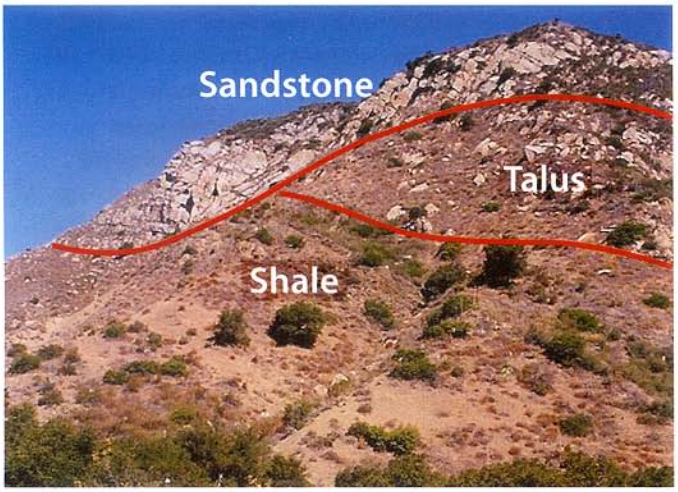
Before you begin, take a moment to observe the flat-lying terrain of the campground area. This is characteristic of an old flood plain where boulders and gravel were deposited due to flooding of Oso Creek over the past several thousand years. These deposits create rich soils that support a healthy oak woodland of native grasses, sycamore trees, and live oaks.

May I Keep This Brochure?

This brochure is yours to keep. If you do not wish to keep it, please return the brochure to the trailhead box. This will allow others to enjoy the guide and conserve resources by recycling.

1 The Shale Here is 60 Million Years Old!

The first geological formation through which you will pass is the Juncal Shale. **Shale** is a type of sedimentary rock formed from cemented clay and silt. The sediments were first deposited as thin layers in an ocean basin millions of years ago. These layers were then compacted and cemented into shale approximately 60 million years ago during a time geologists call the Eocene Epoch (see map legend on page 10). Shale is highly erosive, often creating gently sloping, vegetated hillsides rather than rock outcrops. The greenish slope to the northwest across the creek and below the steep bluffs is an example of the Juncal Shale. Take note of the difference in vegetation on the slopes along the trail. North-facing slopes generally support Oak Woodland habitats, such as Manzanita, Toyon, and Scrub Oak, while South-facing slopes are home to chaparral, such as chamise, sage, and yucca.



Matilija Sandstone (light colored rock at top of photo) is a resistant, cliff-forming rock that looks different than the gentler, smoother slopes formed by shale (darker rock below), and talus (rocky slope) in between.

2 Beaches Turn to Stone Over Several Million Years

As you approach Stop 2, you can see how the creek has cut down through the rock. This rock, which you will also find at the Stop 2 marker farther up the trail on your right, is called the Matilija Sandstone. **Sandstone** is a type of sedimentary rock formed from cemented sand grains, like those found on a beach. These sand grains were most likely deposited by high-energy waves in a near-shore beach environment, whereas the shale was formed in a quiet, deeper offshore environment. The sandstone is more resistant to erosion than shale and tends to form cliffs rather than rolling hills. The Matilija Sandstone is a younger Eocene Rock, about 50 million years old, formed after the Juncal Shale. The black streaks on the sandstone are the result of water running over the rocks and oxidizing the iron manganese minerals, which changes the surface color of the rock. Sandstone was used by the Chumash for mortars and pestles for grinding nuts and seeds. Sandstone also served as a canvas for the rich pictograph tradition of the Chumash peoples.

3 Can You See the Seafloor in this Rock?

This is also an outcrop of the Matilija Sandstone. Notice how the rock has a slightly different character than the cliff you observed previously. The softer quality comes from layers of siltstone within the sandstone. **Siltstone** is a sedimentary rock composed of particles smaller than sand but larger than mud. It was deposited in a continental shelf environment between the high-energy beach and the deep ocean bottom. Old worm burrows can be seen as small, round holes in the rock, where worms once lived on the calm ocean floor. Presently, similar rock is being formed a few miles off the California coast.

4 Rockslides Change the Landscape

Look to the northwest across the canyon at the large rockslide scarp exposing the tilted layers of the Matilija Siltstone. Each layer or plane, called a **bed** in geologic terms, was deposited slowly over a period of several million years. A period of erosion or change in depositional environment defines the boundary between each bed. The beds on the bottom are the oldest and the top beds are more recent. Siltstone is more susceptible to slope failure than sandstone, which often results in rockslides like the one in front of you. Farther up the trail on the right is a smaller, similar exposure of siltstone with rock debris occasionally falling onto the road.

5 Active Landslides Are a Continual Erosional Process

Ahead on the right is the "toe," or lower edge, of an active **slump/earthflow**. An earthflow is the slow movement of a large mass of earth, and here the material has moved slowly downhill from near the top of the mountain. The earthflow, which moved significantly in 2001, is now much harder to see because new springs formed during the slump have caused riparian vegetation to grown. However, the earthflow continues to move every year, constantly changing the landscape as an active geologic process. This type of geologic process requires Forest Service employees and volunteers to continuously work to keep trails open and clear.

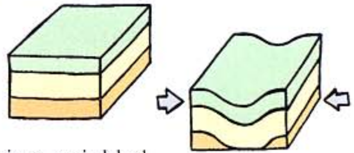
Detour! If you would like to explore more of the bedrock geology, take a short detour to your right past the Santa Cruz Trailhead. Follow the Camuesa-Buckthorn OHV route uphill about 100 yards to Stop 6 where the road switchbacks (see map). To continue on the geologic trail, return to the Santa Cruz Trailhead. Please be cautious of OHVs coming around the corner!

6 *(Detour)* Caution: Mountain Building in Progress!

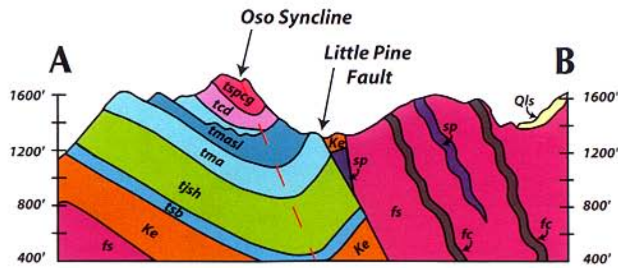
To the northwest is a view of the canyon geology and the Oso Syncline (see map). Notice the rocky cliffs faintly visible along the ridge and how all of the rock layers angle diagonally to the northeast. These beds were originally deposited horizontally, but have since been tilted and uplifted to their current position by folding and faulting within the earth's crust. This began during the Pliocene time about 2-3 million years ago, in an episode that geologists call the Pasadenan orogeny, or mountain building event. The result of folding is the construction of the mountains around you – the Transverse and Coast Ranges.

Can you identify Sycamore trees along the creek? Sycamores are indicator species of ground water.

Although it is hard to see, the Oso Syncline trends northwest to southeast through this area. A **syncline** is an under-lying concave fold in the bedrock layers created when a large block of the earth's crust is squeezed and compressed. The fold of a syncline is similar to the low "valleys" created by the folds in a wrinkled tablecloth. You are standing near the axis, or center, of this syncline (see diagram and map). Return to the Santa Cruz Trailhead and follow the trail to Point 7.



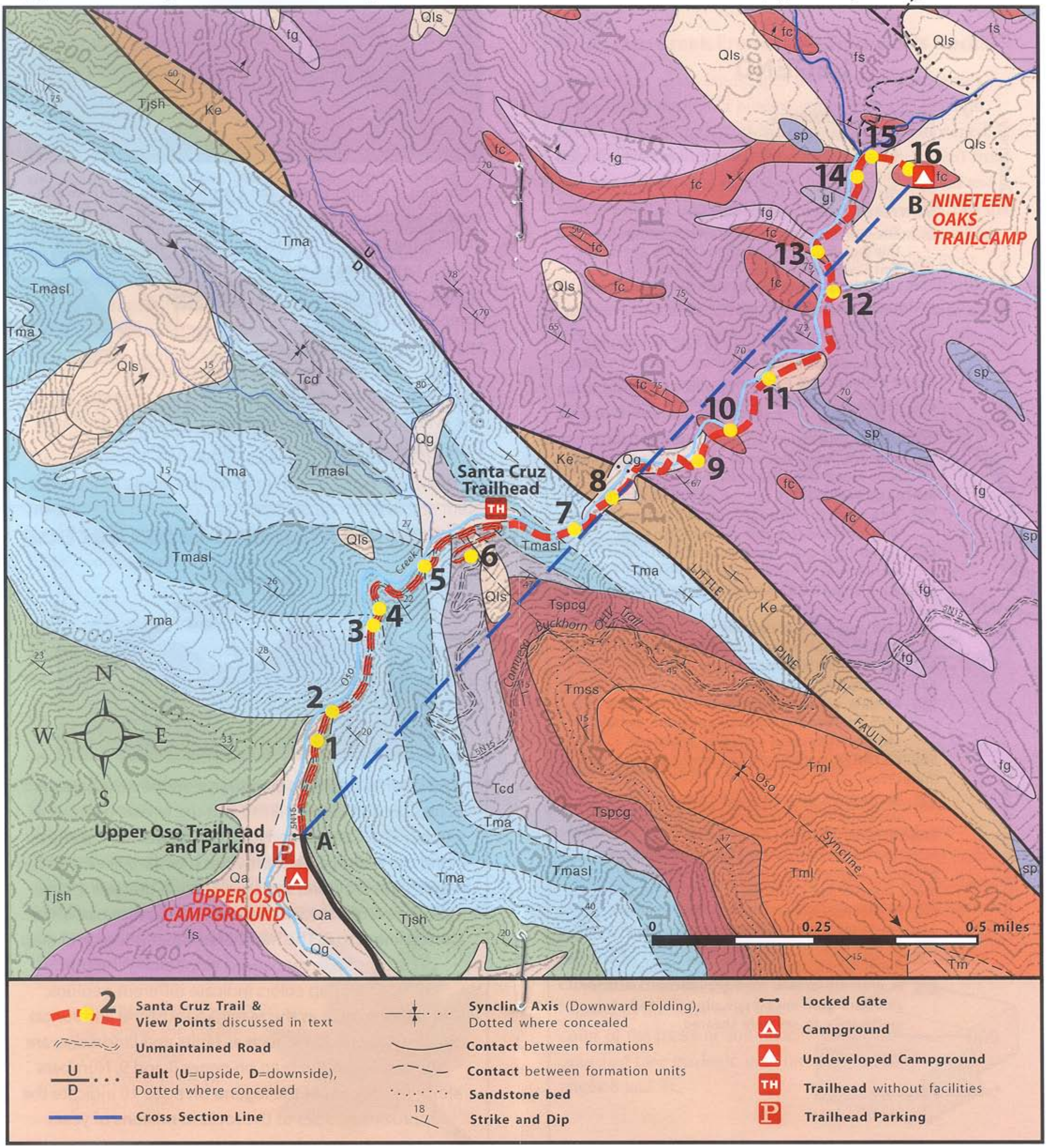
Geologic Map and Cross Section



The colorful geologic map found on the next page and cross section (above) illustrates the overall geology of Upper Oso Canyon and locations of geologic features along the trail. The map provides a bird's-eye view of the area's geology, and the cross section displays a "cake slice" view of the rocks beneath the surface along the dotted line A to B. The numbered descriptions and map correspond to numbered stops along the trail. The various map colors indicate different geologic formations, such as the Matilija Sandstone and Juncal Shale. Other features, such as faults and landslides, are also shown on the map on pages 8 and 9. Numbers along the margin of the legend on page 10 indicate the approximate ages of the rocks in millions of years.

Upper Oso Canyon Points of Geologic Interest

To Little Pine Mountain, approximately 5 miles.



LEGEND

AGE

Quaternary

0*

SURFICIAL SEDIMENTS

- **Qg** stream channel; Quaternary deposits
- **Qa** alluvium: unconsolidated floodplain deposits
- **Qls** landslide debris

5*

Miocene

MONTEREY SHALE *marine; Miocene*

- **Tm** upper shale unit: white-weathering thin-bedded, siliceous shale, locally chert
- **Tml** lower shale unit: white-weathering, clayey shale with minor thin calcareous strata

UNNAMED SANDSTONE *shallow marine; early Miocene*

- **Tmss** light greenish gray to tan, fossiliferous arkasic sandstone

24*

Oligocene

SESPE FORMATION *nonmarine; Oligocene*

- **Tspcg** dark maroon conglomerate and sandstone

34*

Eocene

COZY DELL SHALE *marine; late Eocene*

- **Tcd** gray, argillaceous to silty micaceous shale with minor arkosic sandstone

MATILIJA SANDSTONE *marine; middle to late Eocene*

- **Tma** hard, thick bedded, tan arkosic sandstone with interbedded gray miceaceous shale
- **Tmasl** light gray, massive sandy siltstone, fossiliferous

JUNCAL FORMATION *marine; early to middle Eocene age*

- **Tjsh** dark gray micaceous shale with minor thin interbeds arkosic sandstone

63*

Jurassic & Cretaceous

ESPADA FORMATION *marine; late Jurassic to early and middle Cretaceous*

- **Ke** dark greenish-gray carbonaceous shale with interbedded arkosic sandstone, pebble conglomerate, and dark gray limestone

SERPENTINITE *metamorphosed intrusive rocks; Cretaceous*

- **sp** severely sheared, bluish-green to black serpentinite and serpentinized peridotite

FRANCISCAN ASSEMBLAGE *slightly metamorphosed, pervasively sheared assemblage of marine sedimentary, igneous and metamorphic rocks; Jurassic and Cretaceous*

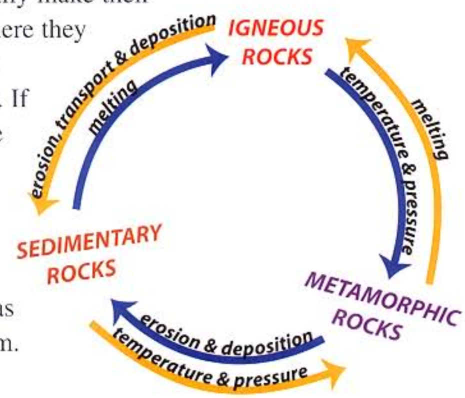
- **fg** greenish-brown to black, fine-grained greenstone, metamorphosed from basalt
- **fc** thin bedded, hard and brittle, varicolored green to red chert
- **fs** greenish-brown, hard graywacke sandstone and dark gray micaceous siltstone and shale, moderately to severely sheared

200*

** millions of years ago*

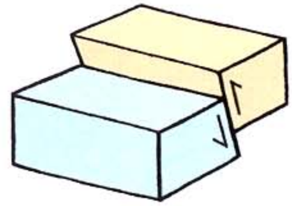
7 Oso Creek Erodes and Transports Rocks

Stream flow alters landscapes and transports materials downstream through a process called erosion. **Erosion** occurs when materials of the earth's crust are loosened, dissolved, or worn away, and simultaneously moved from one place to another by natural agents such as wind and water. You can find rounded boulders in the creek bed that have been transported from Little Pine Mountain, which you can see to the north northeast about 5 miles away. Along the way, they become broken and rounded into smaller materials such as cobbles and gravel. These are moved farther downstream and broken down into even smaller particles such as sand, silt and clay. These particles will eventually make their way to the ocean, where they are eroded further or deposited and buried. If they are buried, these particles could be recemented into a new sedimentary rock, continuing the geologic rock cycle as shown in this diagram.



8 Little Pine Fault Uplifts 180 Million Year Old Rocks to the Surface

A **fault** is a discrete rupture in the earth's surface separating two rock masses that have slid past one another. Here the tan Matilija Sandstone abruptly ends where the Little Pine Fault has uplifted the much older (~180 million year old) olive Espada and gray Franciscan rocks to the surface. The fault runs up the valley on the hillside to your left and is hard to see, but look for a change in the rock type on the hillside to the west or in the color of the rocks or soil under your feet (see geologic map on pages 8 and 9).

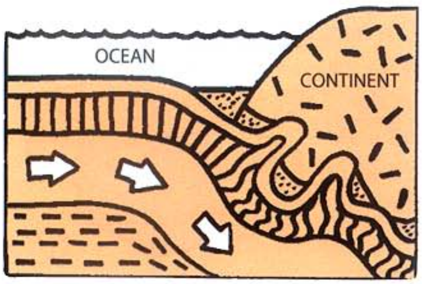


9 See a Fault Contact

Look back along the trail to the southwest where you cross Oso Creek a second time to see the dark outcrop above. This greenish-gray marine shale of late Jurassic to middle Cretaceous age is called the Espada formation. This is also an example of a fault contact where a minor fault separates the Espada shale from the Franciscan rocks around you. This fault parallels the Little Pine Fault, but is much shorter in length (see geologic map on pages 8 and 9). Notice how the layers, which were deposited horizontally, have been folded and faulted to near vertical.

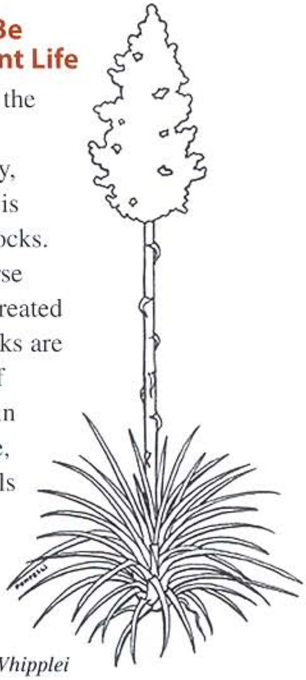
10 Severe Deformation and Metamorphism Ahead!

You have traveled across time and geologic history and are now hiking through the Franciscan Assemblage. The Franciscan rocks are called an assemblage because they are a mixture of many different rock types that once composed the ocean floor off the west coast of North America. These rocks were later thrust onto the continent much like a bulldozer moves rubble. This occurred during subduction, a process by which the ocean floor was scraped against, and piled onto, the continent as lower layers dove below the crust (see diagram). The rocks involved in subduction experienced metamorphism, or extreme deformation, as they were exposed to high temperatures and pressures deep below the earth's surface. The rocks in the Franciscan Assemblage were subducted and consequently **metamorphosed**, permanently changing their chemical structure, mineral composition, and appearance. The rock you see here is greywacke, a mixture of greenish-brown sandstone and greenish-gray siltstone that is severely sheared or shattered. These rocks are the oldest in this area, dating from late Cretaceous to late Jurassic time, or roughly 65-180 million years old.



11 Franciscan Soils Can Be Infertile for Some Plant Life

As you continue to hike, observe the rolling terrain dotted with dark, knobby outcrops. This topography, including landslides and springs, is characteristic of the Franciscan rocks. Notice how the vegetation is sparse and scruffy on the slopes. Soils created by weathering the Franciscan rocks are slightly toxic (from high levels of magnesium), allowing only certain hearty plants, such as yucca, sage, and chaparral brush, to grow. Soils in the canyon also rely on fire to replenish nutrients plants need to grow, with many species dependent on fire to reproduce.



Yucca Whipplei

12 The Surface of Serpentinite Rocks Resembles Lizard or "Serpent" Skin

The streambed is a great place to see some rounded boulders that were formed by the erosive activity of water and sediment movement in the streambed. The dark green boulders are Franciscan serpentinite. **Serpentinite** originally came from rocks deep beneath the ocean crust and was metamorphosed as it rose to the earth's surface. The white streaks, or veins, produce a pattern similar to the crisscross pattern of lizard or snakeskin.

Serpentine is usually green, but may be yellow, brownish red or gray in color.

Folded chert is made from the silica skeletons of tiny marine organisms.

13 How Did These Boulders Become So Folded and Deformed?

Boulders, like the ones in front of you, are examples of folded chert beds, another rock type from the Franciscan Assemblage. **Chert** is a rock made from the silica skeletons of tiny marine organisms. Millions of years passed as these skeletons accumulated on the ocean floor and eventually became beds of chert. The chert was then folded and compressed when water was squeezed from the sedimentary layers by underwater slumping or faulting during or soon after deposition. Look for more of these twisted, varicolored chert boulders along the trail and in the creek bed.

14 Rare Blue Rocks from Earth's Interior Reach the Surface

Located across the stream behind the red-banded chert is a rare boulder of the Franciscan **blueschist**, another metamorphic rock. The denim blue color of this rock comes from the mineral glaucophane, a product of the extreme pressures the rock experienced when it was deep below the earth's surface. These blueschist rocks formed under higher pressures and lower temperatures than the green serpentinite from Stop 12. For a closer view of the blueschist, look for boulders in the stream crossings.

15 Striking Evidence of Faulting

When the trail forks, head to the right toward Nineteen Oaks. Stop 15 is about 100 feet up the trail on the left (there is no numbered marker for this stop). On the face of this chert outcrop is an outstanding example of **slickensides**: linear grooves on a fault surface created when a fault slips and two pieces of rock grind against each other. Look closely and try to determine the direction of movement during the faulting event. Also notice the fault breccia: bits of broken and sheared rock that have been recemented along the fault plane. You can see where the breccia pieces were dragged across the face, leaving a gouge or impression in the chert.

16 You Are Standing on an Old Landslide Deposit (End of Self-Guided Tour)

Nineteen Oaks Trailcamp is the turnaround point for this hike. It is a beautiful, shady spot to take in the views, enjoy lunch, or camp out. The camp is perched on a large, ancient landslide deposit mapped as "Qls" (Quaternary Landslide) on the geologic map. The dark, rocky knobs you see scattered around the "potrero," or meadow, are weathered examples of rocks from the Franciscan Assemblage you learned of during the hike, including serpentinite and chert. From this vista point you can see much of the terrain you passed through to the southwest, including the fault from Stop 8. To the north, the Santa Cruz Trail climbs to Little Pine Mountain through many other interesting geological features. The self-guided tour ends here, but feel free to continue up the trail or return to Upper Oso Campground.