

# Geology Discovery Trail

Crystal Cove State Park



**G**eologic processes, including floods, wind and water erosion, volcanic eruptions, landslides, and earthquakes, continuously shape this land. Records of these events await your discovery in the rocks of Crystal Cove State Park.

Beginning 25 million years ago, sediments (sand, silt, clay, and skeletons) slowly accumulated in shallow Pacific Ocean waters and formed the geologic layer known today as the *Vaqueros Formation*, the oldest exposed rock unit in the park.

Over the next several million years, the Crystal Cove area sank deeper into the ocean. Sediments deposited during this time formed the *Topanga Formation* in an oceanic environment deeper than the *Vaqueros*. Composed of units slightly varying in rock characteristics, the *Topanga Formation* is subdivided into three separate “members”. The oldest and lowest member is the *Bommer*, overlain by the *Los Trancos* and *Paularino Members*.

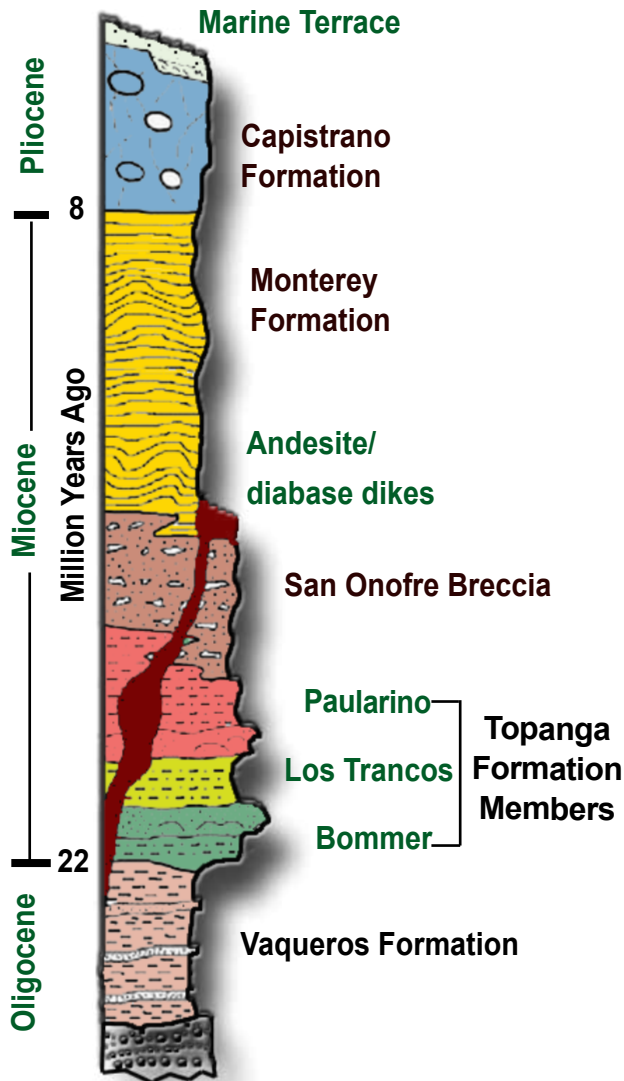
Between 15 and 12 million years ago, sediments forming the *San Onofre Breccia* were deposited from islands offshore as California was torn apart by tectonic forces. *Magma* (molten rock) worked its way up through joints and faults, forming andesite and diabase *dikes* (igneous intrusions cutting across the rock fabric) and *flows*.

**E**xplore 25 million years of the earth’s history at Crystal Cove State Park. Discover the secrets of the rocks shaped by the sea, sand, magma, and ancient life.

Hike through the backcountry and enjoy the ever-changing landscape.

Monterey Formation near trail marker 14.





Layers of the earth's history are revealed at Crystal Cove State Park, a state and national natural landmark.

Between 12 and 8 million years ago, very fine-grained sediments including microscopic plankton accumulated (in water depths up to 1700 meters) to form the *Monterey Formation*. (Elsewhere the *Monterey Formation* ranges from 18 to 8 million years in age).

The last major rock formation deposited was the *Capistrano Formation*, which covered the *Monterey*.

Beginning 4 million years ago and continuing today, the area was uplifted, faulted, and folded while ocean waves carved *marine terraces* at sea level. Terraces can now be seen at various elevations up to 1000 feet above sea level in the surrounding hills.

Geologic processes, some of which are catastrophic, continue today in the park. For example, although the youngest evidence of volcanic activity in the park is about 8 million years old, even the magma could arise again!

*A short walk from the El Moro parking lot, your 8.25 mile journey begins at the first of 14 trail markers.*



## TRAIL MARKER # 1

N33 34.02 W117 49.21 Elevation 194 ft

### Peperite

Your hike starts with this “peperite” boulder (moved here from another site in the park). Composed of angular dark gray volcanic rock fragments in a light-colored, baked clay matrix, this boulder formed when the hot volcanic flow shattered as it contacted cold, wet sediments. Calcite veins (white in color) later filled cracks in the rock. Peperite outcrops occur near trail marker #14 on this hike.



## TRAIL MARKER # 2

N33 34.05 W117 48.95 Elevation 341 ft

### Monterey Formation

After a short, uphill hike on “No Dogs” trail, an outcrop of the tilted, deformed, and highly weathered *Monterey Formation* appears on your left. The light-colored *Monterey* is rich in *silica* — the same chemical formula as window glass — from *diatoms* (microscopic fossil remains of plankton). The rocks here include shale, porcelanite, and chert with yellow-orange iron stains.



## TRAIL MARKER # 3

N33 34.12 W117 48.86 Elevation 406 ft

### Badlands/Columnar Joints

Look down the canyon to see small outcrops of *badlands topography*. Also, dark volcanic rock occurs where the surf meets the cliff under the house at the southern end of Crystal Cove State Park. Inspection from the beach reveals *columnar joints* (prismatic columns) in this volcanic rock. You do not have to travel to Devils Post Pile (near Mammoth, California) to see this popular feature.

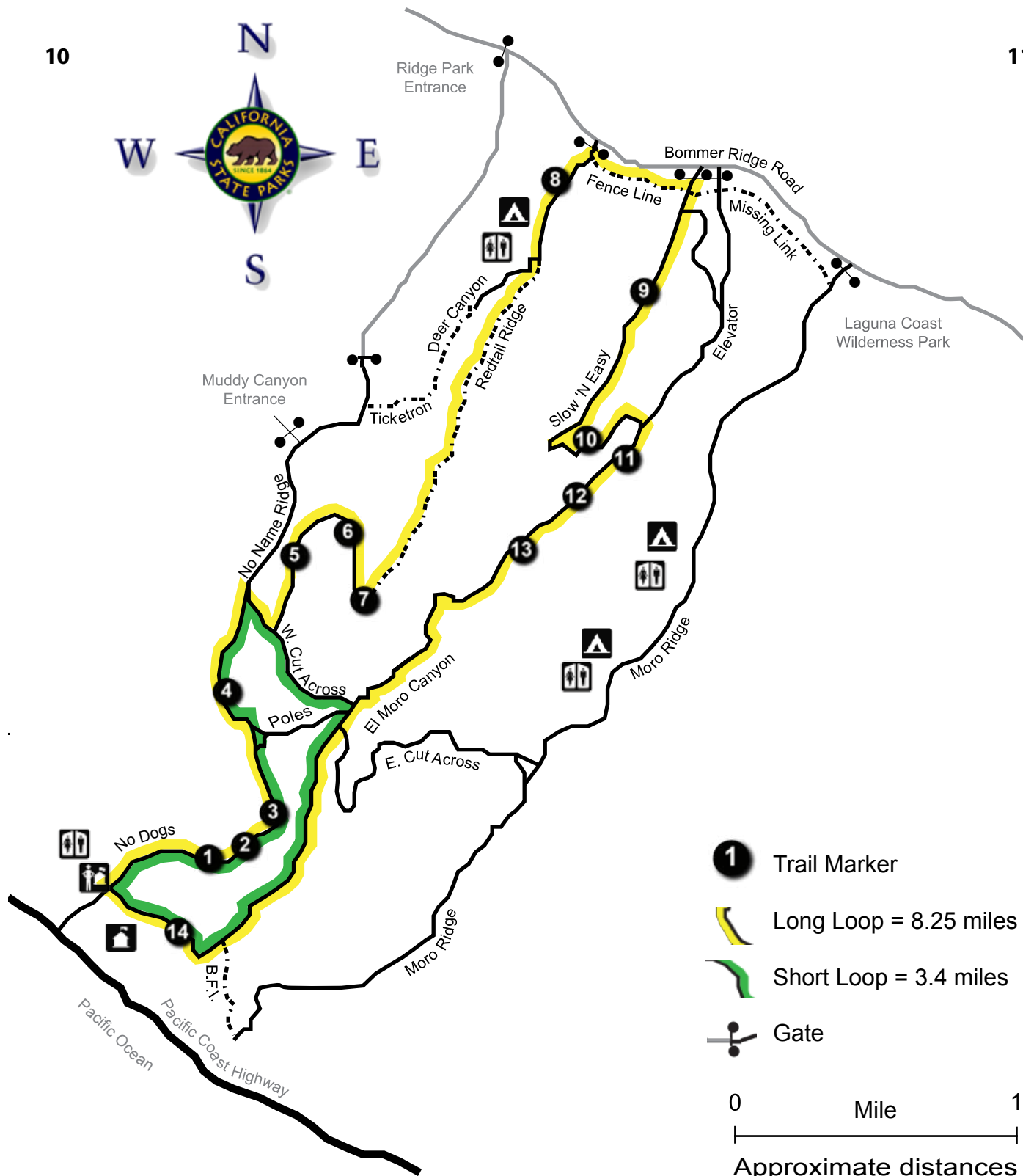


## TRAIL MARKER # 4

N33 34.43 W117 48.89 Elevation 573 ft

### Geology Determines Biology

Notice the abrupt vegetation changes on the hillsides. In many places you see boundaries between coastal sage scrub (commonly on the *Vaqueros Formation*) and grass (commonly on *San Onofre Breccia*). Since rocks differ in their mineral content, porosity, and resistance to erosion, biological species with varying needs live on different rocks. Vegetation also differs where landslides occur: the coastal sage scrub is uprooted and temporarily replaced by rapidly-growing grasses.





## TRAIL MARKER # 5

N33 34.79 W117 48.74 Elevation 417 ft



## TRAIL MARKER # 6

N33 34.87 W117 48.54 Elevation 421 ft

## Landslides

The trail passes over a landslide and is on the mass that was once part of the hill above. The slide left a 30-foot high *head scarp* (vertical cliff) (trail marker #5).

Look below and across the canyon to see numerous scarps and landslides (trail marker #6).

The *hummocky* (extremely irregular) slide material transported down- slope is a triangle of green vegetation (trail marker #7).



## TRAIL MARKER # 7

N33 34.80 W117 48.53 Elevation 492 ft



## TRAIL MARKER # 8

N33 35.94 W117 47.72 Elevation 929 ft

### Veins — Topanga Formation

Zones of crisscrossing faults and veins are common. Erosion-resistant veins stand out from the more easily eroded surrounding formation.

## TRAIL MARKER # 10

N33 35.14 W117 47.66 Elevation 600 ft

### Dipping Beds — Topanga Formation

The thick sandstone beds dip across the opposite slope. As at trail marker #4, different rock types determine the kind of soil and vegetation.



## TRAIL MARKER # 9

N33 35.51 W117 47.55 Elevation 862 ft

### Caves — Topanga Formation

Looking towards Signal Peak across the canyon, outcrops of sandstone are riddled with caves — a prominent feature of this formation.

## TRAIL MARKER # 11

N33 35.11 W117 47.63 Elevation 469 ft

### Small Cave — Topanga Formation

Here weathered, coarse, gravelly sandstone has recently caved in.



## TRAIL MARKER # 12

N33 34.99 W117 47.77 Elevation 417 ft

### Large Cave — Topanga Formation

In this large cave within the *Bommer Member* of the *Topanga Formation*, migrating underwater sand dunes formed *cross beds* (herring bone pattern) seen on the back wall.

The rock of the cave was originally deposited as loose sand and gravel on the sea floor. Look for layers with rounded pebbles which mark times of strong currents on the ocean bottom (as shown on the cover photo of this brochure).



## TRAIL MARKER # 13

N33 34.90 W117 48.00 Elevation 438 ft

### Thick Weathered Sandstone

Look across El Moro Canyon to view thick sandstone outcrops of the *Bommer Member*. Notice the caves, overhangs and “chessman” shapes. Look behind you to see the “bear”. What other imaginary creatures do you see?

## TRAIL MARKER # 14

N33 33.81 W117 49.18 Elevation 101 ft

### Quiz Time

You’ve seen the formation behind trail marker #14 before. What is it? Look behind you just beyond the trail. What is the rock with dark gray angular fragments embedded in clay? See trail marker #1 and #2 for the answers.



*Dramatic exposures of the Monterey Formation also occur along the beaches and within the bluffs at Crystal Cove State Park.*

## To further explore Orange County geology, visit:

**Crystal Cove State Park Calendar**  
[www.crystalcovestatepark.com](http://www.crystalcovestatepark.com)

**Merton Hill, PhD at Saddleback College**  
[www.saddleback.edu/faculty/mhill](http://www.saddleback.edu/faculty/mhill)

**Laguna Canyon Foundation**  
[www.lagunacanyon.org/events.html](http://www.lagunacanyon.org/events.html)

**Irvine Ranch Natural Landmarks**  
[www.irvineranchwildlands.org](http://www.irvineranchwildlands.org)

**This guide was made possible by contributions from:**

Merton Hill, PhD,  
 Saddleback College;

Rick Behl, PhD,  
 California State University, Long Beach; and

Tod Brewster, Eagle Scout,  
 Orange County Troop 567.

Images by:  
 Annlia Hill, PhD; Merton Hill, PhD; and  
 California State Parks.

## Please remember

- Be prepared. Pack plenty of water, snacks, sunscreen, and other backcountry essentials.
- Please protect your park. Enjoy only trails designated by park maps and signs.
- Camping reservations are required.

The following are prohibited:

- collection of rocks, fossils, plants, seeds, animals, or shells.
- smoking or open fire pits in the El Moro backcountry.
- dogs on the beach or in the backcountry.

## Our Mission

The mission of California State Parks is to provide for the health, inspiration and education of the people of California by helping to preserve the state's extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation.



California State Parks supports equal access. Prior to arrival, visitors with disabilities who need assistance should contact Crystal Cove State Park at (949) 494-3539, 711, TTY Relay Service. This publication is available in alternate formats by contacting:

CALIFORNIA STATE PARKS  
Orange Coast District  
3030 Avenida del Presidente  
San Clemente, CA 92672  
(949) 366-8503

**CRYSTAL COVE STATE PARK**  
**8471 Pacific Coast Hwy**  
**Laguna Beach, CA 92651**  
**(949) 494-3539**  
**[www.parks.ca.gov](http://www.parks.ca.gov)**