# San Onofre State Beach

## Frontline in the Battle of Land and Sea

**Feature/Process:**
Seismic and coastal geologic hazards, with landslides and barrancas

The coastline represents the cutting edge of the ocean where it attacks the edge of the continent. As the waves advance, the shoreline is said to retreat. The cutting of the land forms sea cliffs and landslides and produces great quantities of sand to form the broad beach. Softer rocks are cut away more easily than harder materials. Much of the geologic formations at San Onofre State Beach are relatively soft and easily eroded sedimentary rocks. This soft material was deposited 20 million years ago, when this entire region was part of the seafloor. Then the continental margin was many miles to the east. The older sediments that ultimately became these rocks were deposited in deep marine basins and subsequently uplifted to form a large bay. Sediments



**What you can see:** Dramatic exposure of the Cristianitos fault (between San Onofre Nuclear Generating Station and Echo Arch); the Echo Arch landslide; and gigantic gullies (barrancas) that cut through the flat-lying terrace deposits.

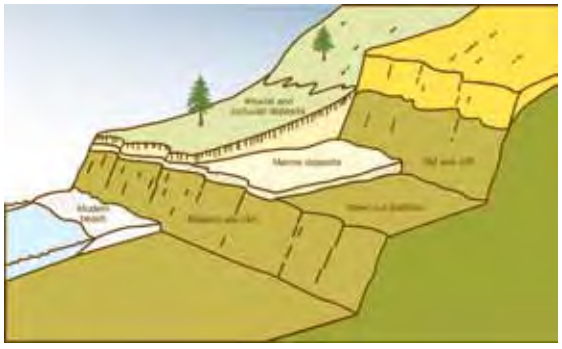
accumulated in the bay. Wave action planed off the surface creating the relatively flat terraces. Continued uplift (averaging about three inches every thousand years) elevated the terraces and the sedimentary rocks to their present position where waves attack the base of the soft slopes.

Although erosion and shoreline retreat are rapid due to the softness of the rock, other factors such as land-use and climate also play important roles. For example, during especially wet periods with intense rainfall, landslides are very common along these slopes. Portions of the bluffs are retreating at a rate of six feet per year. Another conspicuous example of the role of land-use on geology is the development of widespread erosion caused by changes in the natural drainage patterns that resulted from road construction. Along the edge of the dominant terrace, extensive, deep gullies known as barrancas developed. Pre-existing drainages deepened and new drainages formed at the outlets of drainage devices along the interstate.

**Why it's important:** San Onofre State Beach exemplifies the joys and challenges of living on the fragile coast. The scenic beauty derives from the panoply of geologic processes, many of which can be hazardous and difficult to manage. Landslides, massive erosion, and earthquakes are the results of a long geologic history that is readily on display within the park.

## Marine Terraces

San Onofre State Beach is an excellent place to view the dynamics of a migrating coastline. The 12 marine terraces record the relative rise and fall and lateral migration of the coastline. Just in the last 125,000 years, the location of the coastline has been as far east as the back edge of the broad, dominant marine terrace. In fact, the highest terrace records the easternmost extent during the Pleistocene. Conversely, during the lowest sea level, when water was trapped in glaciers worldwide, the shoreline was far to the west. The lowest recognized terrace occurs 250 feet below sea level; while the highest is 1,250 feet above sea level. Each terrace formed at a different relative sea level.



**Marine terraces** consist of a wave-cut bedrock platform (bench) with a thin, discontinuous blanket of marine and younger non-marine deposits. The origins of the terraces are tied to changes in climate and associated fluctuations in eustatic (worldwide) sea level during the Pleistocene epoch 11,000-1.1 million years ago. Modified from Weber and Allwardt, 2001.

Echo Arch Campground is a great observation area to appreciate the significance of landslides and a cross-section of the former terrace. North of the Echo Arch campground, one can observe the sharp contrast in color along the bluff approximately 40 feet above the beach. The pale yellow-brown rock exposed on the bottom of the cliff face and the dark reddish-brown material on top have very different ages. In fact, the light rock was deposited on the ocean floor in the Early Pliocene Epoch (approximately five million years ago). Those sediments were buried, compressed and

lithified. Then the rocks that we now call the San Mateo Formation were uplifted to near sea level approximately 125,000 years ago—based on fossil evidence. If one looks closely, a layer of boulders—the interface of the two layers—is apparent. This layer represents the sand and gravel deposited on the beach as the waves eroded the San Mateo Formation.

## Landslides

The Echo Arch landslide is approximately 1,000 feet wide, measured along the coastline. Along the three mile long Bluffs Trail, approximately 80% of the bluffs show evidence of such landslides—both a natural process that replenishes the beach and a serious hazard.

## Earthquakes—Another Geologic Hazard

The Newport-Rose Canyon Fault system lies approximately ten miles offshore and is considered active and capable of producing strong earthquakes. In the park, another fault—the Cristianitos Fault—is well displayed, well-studied, and deemed inactive.

The intense shaking produced during earthquakes can liquefy saturated sediments. Recent excavations atop the neighboring marine terraces have revealed widespread evidence of liquefaction such as sand dikes and sand blows. Some of these features disturbed archeological sites whose ages are well-constrained. The causative earthquake(s) likely occurred within the last several thousand years, possibly during historic time. Could the offshore Newport-Rose Canyon Fault system be responsible?

A strong offshore earthquake presents a real threat of tsunamis. Evidence of past tsunamis is found up to 300 feet above sea level in nearby coastal lagoons and estuaries.

## Final Thoughts

San Onofre State Beach owes its dramatic scenery to being in the battleground between land and sea. Barrancas, landslides, faults, tsunami deposits, and liquefaction features are the battle scars in the never-ending contest.

*Written by Jeremy Lancaster and Mike Fuller, California Geological Survey*
*Photos: Mike Fuller (except where noted)*

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