Point Sal State Beach

National Natural Landmark 1974

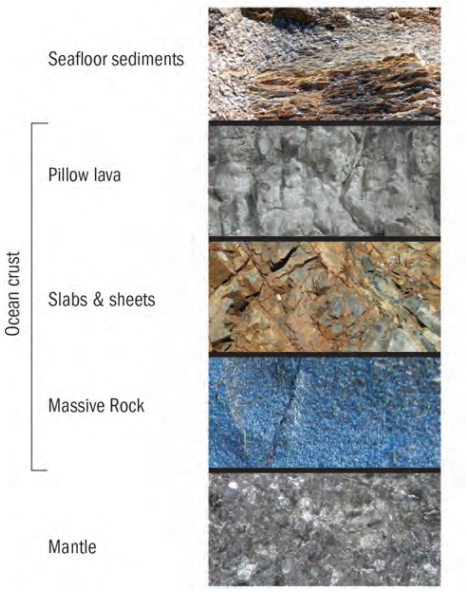
A Window into the Deep Earth

The exposed rocks along the coastline of Point Sal make up what is known as the Point Sal Ophiolite, part of the Coast Range Ophiolite. An ophiolite is a slice across the layers of seafloor (as produced at a mid-oceanic spreading center) from the basement rock to the overlying accumulations of volcanic and sedimentary rocks. At Point Sal and to the south, an approximately three-mile thick section of ophiolite is exposed on land.

Feature/Process:
Petrology of an ophiolite and pillow lava

During ophiolite formation at the spreading center, molten rock (magma) from below the thin oceanic crust penetrates into seafloor fractures and either slowly cools and solidifies below the surface or erupts onto the surface as lava. The lava cools

abruptly when it encounters the oceanic waters and forms rounded blobs. Outcrops of such lava can look like a stack of pillows, called pillow lavas. Molten rock that cools beneath the pillow lava forms as slabs of fine-grained rock. Radiometric dating shows that these volcanic and intrusive rocks formed during the Jurassic Period, about 165 million years ago. At structurally deeper levels of the crust, massive intrusive igneous rocks such as diorite and gabbro are found. Below these igneous intrusions are rocks that represent the upper mantle and consist of dunite and peridotite. These coarse-grained rocks represent the basement of the oceanic crust.

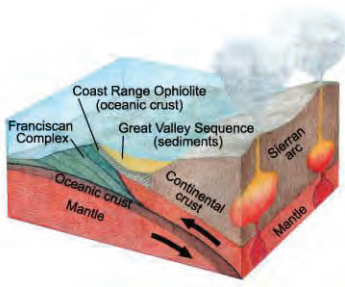


Ophiolite: A layered assemblage of rocks that formed as a section of oceanic crust. The crust forms at rifts in the oceanic crust such that a characteristic sequence of layers is formed. The rate of cooling of molten rock is controlled by the depth below the ocean floor where water quenches the rock. The deeper layers are cooled more slowly while the uppermost layers cool rapidly. Pillow basalts typify the upper layers while intermediate layers develop as vertical slabs and lowermost layers develop as massive rock.

A Journey Across the Ocean

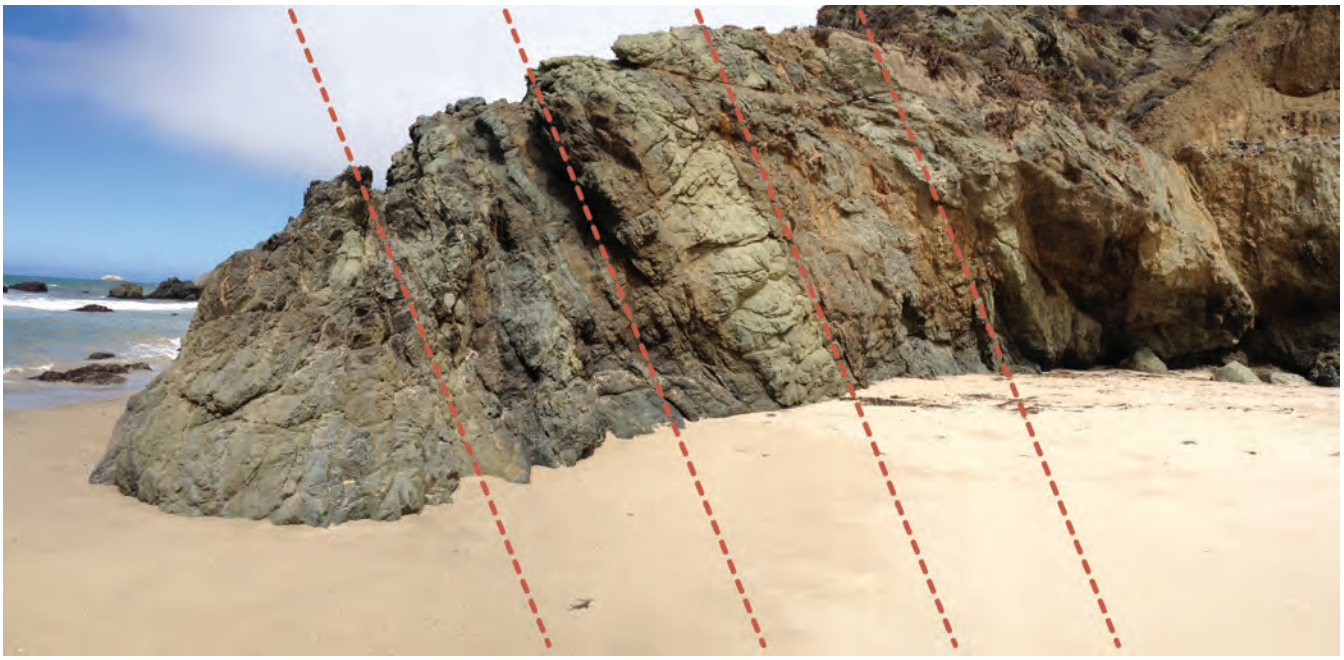
When the lavas erupted, they were located at a mid-ocean spreading center. Geologists have studied the magnetic "signatures" of these lavas and have determined that the mid-ocean spreading center where these rocks formed was near the equator. Rocks found above the pillow basalts tell the story of how the ophiolite migrated from the equator and became attached to the margin of North America. Limestone (formed from the skeletal remains of ancient sea creatures) was the first rock to be deposited on top of the pillow lava. The limestone was most likely deposited in warm tropical waters. As the ophiolite was carried away from the spreading center by plate tectonics, the ocean floor became deeper, too deep in fact, for limestone to form. Bedded chert, a reddish sedimentary rock that is made of the skeletal remains

Why it's important: The rocks that make up Point Sal represent one of the most intact and complete cross sections of oceanic crust visible on land. Oceanic crust comprises 60% of the earth's crust, yet we rarely have opportunities to see it and study its formation. The rocks at the park indicate submarine origin and widespread transport via plate tectonics.



Graphic by Lillie, 2005.

Oceanic crust is produced at ocean spreading centers and consumed in subduction zones. This process recycles oceanic crust and destroys the evidence of its creation. Oceanic crust older than 170 million years is exceptionally rare. Point Sal and outcrops like it have escaped the recycling process and preserve the only evidence of the geologic history of older oceanic crust. Geologists are trying to understand how these fragments of oceanic crust avoided re-cycling and became exposed at their present locations. This history is shared by many of the rocks that make up the Coast Ranges throughout much of Central California.



What you can see: An exposed cross section of ancient seafloor and oceanic plate that traveled (as part of the Pacific plate) from its apparently tropical "birthplace" at an oceanic rift to the central California coast. Layers may appear obscure but upon close examination are evident; red dashed lines clarify the ophiolite component layers.

of small sea creatures called radiolaria, was deposited on top of the limestone. Interbedded with the cherts are layers of volcanic ash, erupted from volcanoes that likely existed along the western margin of North America. Recent studies suggest that this occurred at the latitude of Baja California.

Forming the Coast

The ophiolite is encased within the Franciscan Complex, a chaotic assemblage of rocks scraped off of the subducting Farallon plate as it was thrust beneath the Coast Range Ophiolite (CRO). This wedging of Franciscan Complex materials under the CRO had the effect of uplifting coastal California. To the east, sediments (the Great Valley Sequence) shed off of the margin of North America were deposited on top of the CRO.

The most recent chapter of this story began in the Tertiary epoch (approximately 20 million years ago) as subduction waned and the current tectonic regime of San Andreas-style faulting began.

During these processes, the CRO broke into pieces. Movement along the San Andreas Fault system continues to spread fragments of the ophiolite along the coast.

Photo: 1989, Kenneth and Gabrielle Adelman – Adelman & Adelman.com

Landslides

During the El Nino rainfall events from the mid to late 1990s, landslides and gully erosion caused closure of the access road to Point Sal State Beach. Now the road is passable by foot only. The landslides are extensive in the Miocene-aged sediments that overlap the rocks of the ophiolite. The ocean waves redistribute slide debris that accumulates on the beach maintaining a smooth beach. But the larger waves attack the base of the landslides increasing the instability. Geologically the state beach occupies a narrow strip in an amazingly dynamic environment with highly unstable slopes on one side and the crashing waves of the ocean on the other.

Final Thoughts

Fortunately, plate tectonics has left a largely intact piece of ophiolite at Point Sal, making it one of the premier locations to observe the rocks that record the formation and history of coastal California.

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Photos: Will Harris (except where noted)

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