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## Reading the Geologic History of Doheny State Beach

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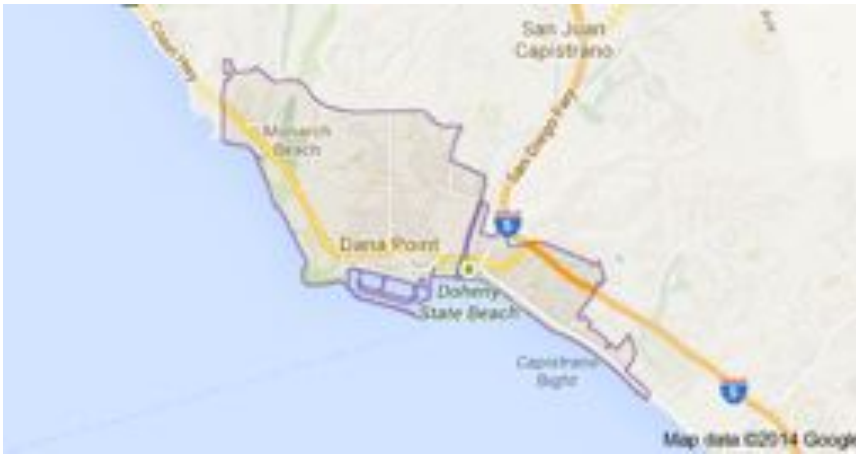
**LAYERS** of sediment and rock are like a book. Formations make up chapters and individual layers are the pages.




The earth's crust is made of many layers of sediment and rock. Since most geologic layers are underground much of the data comes from mining excavations and drilling information from oil, gas and water wells. Geologists also use surface mapping in areas that have been uplifted and are exposed. They gather as many sources of information as they can to help explain the geologic history of an area, along with information from adjacent areas. They analyze it all and attempt to correlate it to where it makes sense.

**LET'S TAKE A TOUR** of the "book" that makes up Doheny, the Dana Point Headlands and Capistrano Valley coastlines. We'll begin our tour back into geologic time by walking down Doheny's beach to where the ocean meets San Juan Creek by the Lifeguard Headquarters.

You are standing at the edge of the ocean and dry land. Now look up stream towards the highway. The mountains you see in the distance are the Santa Ana Mountains. You are standing on a sedimentary layer of "recently" deposited sand washed in from the ocean or down San Juan Creek, or eroded from the sandstone bluffs along Pacific Coast Highway and surrounding most of Dana Point Harbor. Below this layer of sand on which your feet rest are more layers of sedimentary deposits, laid down over millions of years. The sand layers beneath you and those of the cliffs makeup the Capistrano Formation.

**THE BLUFFS** to your right heading south towards San Clemente are a beautiful example of the

Capistrano Formation and were once much closer the ocean's lapping waves. They were cut back away from the ocean in the late 1880s to make room for the Santa Fe Railroad to go from the newly established town of San Juan-by-the-Sea (now Capistrano Beach) to Oceanside. In the 1920s, the bluffs were cut back even farther to make room for the Pacific Coast Highway heading towards San Clemente (first construction there in 1925 and incorporated in 1928) and beyond.

The sandstone bluffs to your left that wrap into the

Dana Point Harbor are also part of the Capistrano Formation. Large portions of this bluff were also cut back from the ocean to make room for Dana Point Harbor in the mid-1960s.

Far down at the west end of the harbor near the small fishing pier and the outside breakwater is a different type of bluff made of very different types of sedimentary deposit: clay and rocks. This is the San Onofre Breccia Formation, one that is much older than the Capistrano Formation. Since it is an older formation, it should be underneath the Capistrano Formation, not next to it. Hmmm… we will figure this formation conundrum out later.

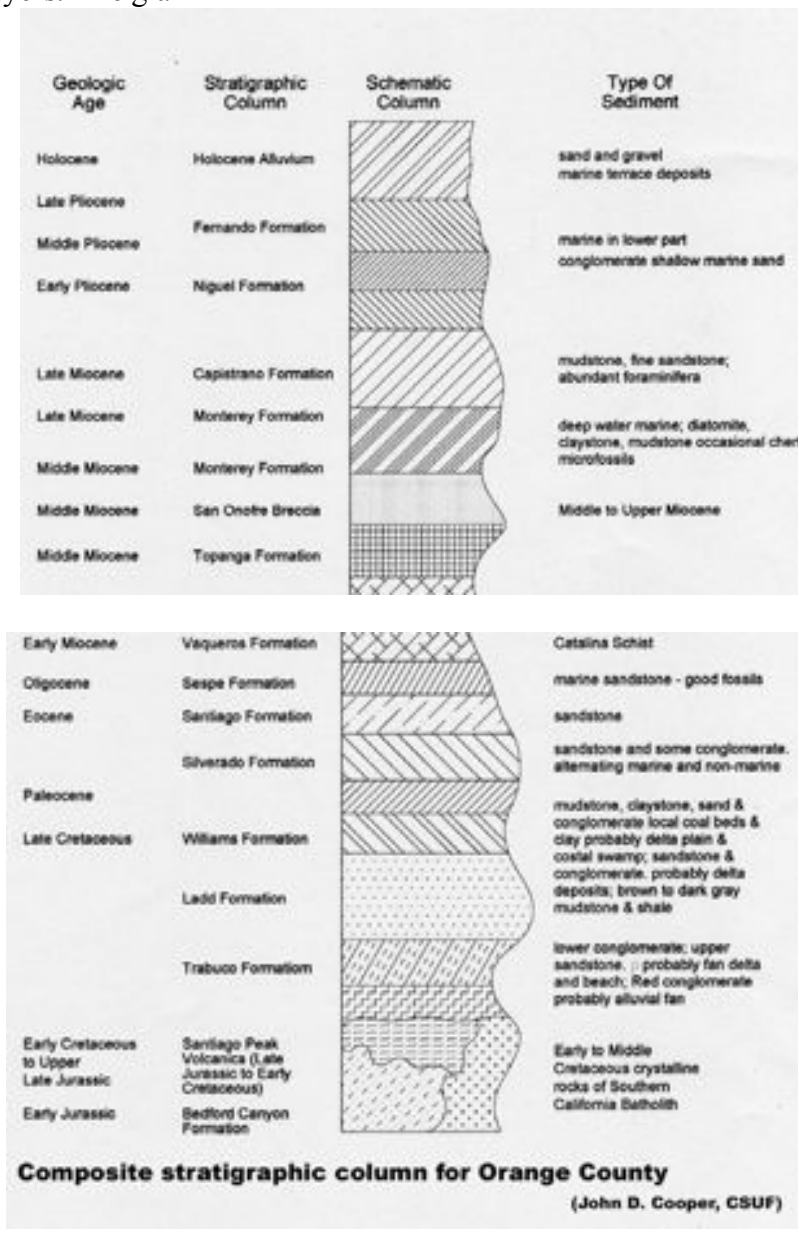
*Capistrano formation in Dana Point Harbor*

**MOST OF SOUTH ORANGE COUNTY,** and especially Dana Point, Capistrano Valley and the area of Doheny State Beach were once covered with thousands of feet of ocean. Geologists using index fossils found in the sediment, such as plankton, (which is food for the gray and other baleen whales), seashells, whalebones, shark teeth, trees and other material to help estimate the geologic date of sedimentary layers. The grain size of sediment is used to help estimate the depths of the ocean where the sediments were deposited. Remember that dirt (sediment) is heavier than water and that the finer (smaller) the sediment, the lighter it is and the longer it will float and drift before it will settle to the bottom.

*Breccia clay, rock and uplift*

**THE SEDIMENTS** that make up the Capistrano Formation were deposited in the ocean during the geologic Pliocene through the Miocene Epochs that occurred approximately 4 to 10 million years ago. (We are currently in the Holocene Epoch, which began about 11,000 years ago. As you can see, the geologic clock makes the likelihood of you or I living long enough to see the end of the Holocene Epoch pretty slim.)

**GEOLOGISTS** estimate that the Capistrano sediments had settled to the bottom of an ocean that was approximately 1,000 to 3,000 feet deep and the seashore was located near the base of today's Santa Ana Mountains. Scientists determined this great ocean depth because the Capistrano Formation is composed mostly of very fine (small) grained clay, silt and sand. The Santa Ana Mountains were the major source of this material for the Capistrano Formation, which is approximately 2,000 feet thick. You can see



why it took millions of years to form with such small pieces of building material. Today, you could come down to Doheny State Beach everyday, or every year, or every decade for that matter, and never see much real change.

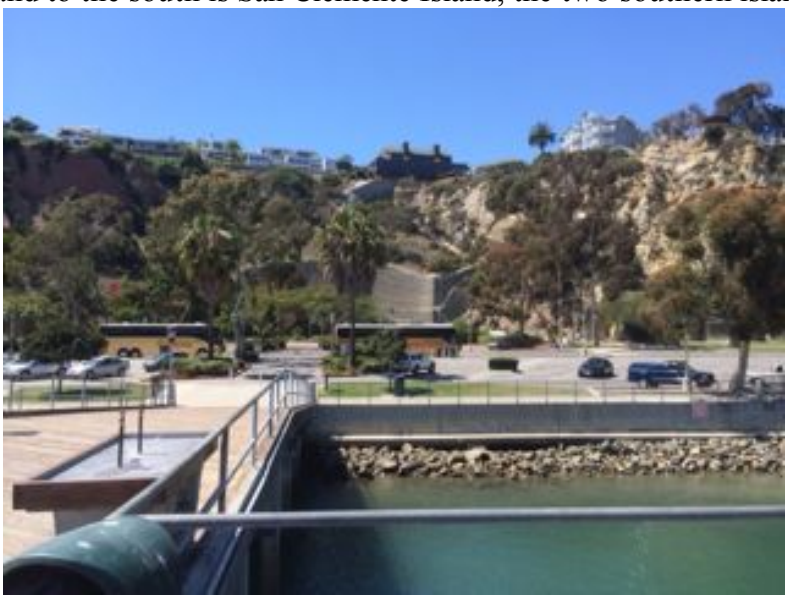
**BELOW** the Capistrano Formation is the Monterey Formation, which is older than the Capistrano by a few million years. It was deposited during the middle Miocene to late Miocene Epoch and is about 500 to 600 feet thick. This formation is **not** exposed at the surface near Doheny State Beach, but can be seen north of us at Crystal Cove and the beaches at Corona del Mar.

Below the Monterey Formation is the San Onofre Breccia Formation that was deposited during the lower and middle Miocene Epoch and is about 1,000 feet thick. This formation, even though it is older than the Monterey Formation and the Capistrano Formation by a few more million years **is** exposed near Doheny State Beach. How did that happen?

Take a hike to the west end of the harbor near the Ocean Institute and walk out onto the fishing pier, then look back at the bluffs. The bluffs to your left are the San Onofre Breccia. They look much different from the Capistrano Formation on your right. San Onofre Breccia has a red colored sandy clay matrix "cement" with large angular grain sizes from sand size up to large boulders. This is where the "breccia" name comes from. The grain sizes are much larger and more angular than the material that makes up the Capistrano Formation. This means that the source material was completely different and the larger more angular *San Onofre Breccia at the Dana Point Headlands* grain sizes means that the source was closer to its place of deposit.

**NOW** how did the Capistrano Formation and the San Onofre Breccia end up being right next to each other rather than the younger Capistrano being on top of the older San Onofre (ah… it's a geological mystery book)?

On a clear day, you can look out to the west and easily see Santa Catalina Island, and further out and to the south is San Clemente Island, the two southern islands of the Channel Island chain that



includes Anacapa, Santa Cruz, Santa Rosa and others off the southern and central California coast. Scientists believe that just as we are on the large Pacific tectonic plate that is moving north and west, the Channel Islands are on a smaller, separate plate also moving north, but rotating counter clockwise to the Pacific Plate and being overridden by it, a process called subduction. Much of these islands are made of the breccia formation material. It is the

theory that an ancient island or sea mound of this chain "crashed" into and broke off onto the Capistrano Formation of Dana Point (and of Palos Verdes Peninsula to our north).

*Crash Site: Where Breccia and Capistrano Formation meet*

Like the pages in our geological book, when we squeezed the pages together, they bend into high and low spots. With enough force, our pages may even tear causing a fault. This is where the San Onofre Breccia Formation and the Capistrano Formation join. Out on the pier, if you look at the bluff, you can see that tear. The Dana Point Fault is located across the parking lot from the pier, going up the cliff below Cannons Restaurant (notice all the reinforcement that was needed under Cannons). It continues to run both inland and out to sea, under where you are standing and into the ocean far beyond. The fault must be younger than the San Onofre Breccia and the Capistrano Formation because it forced these two formations next to each other. The San Onofre Breccia was moved and lifted up by great geologic forces and pushed into the Capistrano Formation over millions of years. Look at the Breccia formations and you will see layers that were laid down level at their creation are now tilted, pushed upwards diagonally and against the Capistrano Formation. Fortunately for the homes and restaurants on top of the bluffs (except for Cannons), the Dana Point Fault hasn't been active in at least 2 million years.

**ALL RIGHT THEN**, how did all of this area get to be above sea level? About a million years ago during the Pleistocene Epoch (our last Ice Age) the ocean depths were becoming shallower and the seashore was moving westward on its tectonic plate. This activity was due to the uplift of the Santa Ana Mountains via earthquake forces. As the mountains raised and the seashore moved westward, the increased erosion cut deeper streams, which formed (among numerous others) San Juan Creek and also was the beginning of the landslide problems for this area. Then gradually during the last 10,000 to 11,000 years this landscape began looking more like it does today.

But come back to Doheny State Beach in 10,000 years and it is a sure bet that the landscape will look quite different again!


*Photo from the City of Dana Point Website*

| EON | ERA | PERIOD | | EPOCH | PIVOTAL EVENTS |
|---|---|---|---|---|---|
| **Phanerozoic Eon**<br>**"Visible Life"**<br>Organisms with skeletons or hard shells.<br>540 million years ago (mya) to today | Cenozoic Era<br>"The Age of Mammals"<br>65 mya to today | Quaternary Period<br>"The Age of Man"<br>1.8 mya to today | | Holocene<br>11,000 ya to today | Human Civilization |
| | | | | Pleistocene<br>The Last Ice Age<br>1.8 - .11 mya | The first humas (Homo sapiens) evolve. Mammoths, mastodons, saber-toothed cats, giant ground sloths. |
| | | Tertiary Period<br>65 - 1.8 mya | Neogene<br>24 - 1.8 mya | Pliocene<br>5 - 1.8 mya | First hominids. Modern forms of whales. Megalodon swam the seas. |
| | | | | Miocene<br>24 - 5 mya | More mammals, including the horses, dogs and bears. Modern birds. South American monkeys, apes in southern Europe. |
| | | | Paleogene<br>65 - 24 mya | Oligocene<br>38 - 24 years | Many new mammals (pigs, deer, cats, rhinos, tapirs, appear). Grasses common. |
| | | | | Eocene<br>54 - 38 mya | Mammals abound. Rodents appear. Primitive whales appear. |
| | | | | Paleocene<br>65 - 54 mya | First large mammals and primitive primates, plesiadapiforms. |
| | Mesozoic Era<br>"The Age of Reptiles"<br>248 to 65 mya | Cretaceous Period<br>146 to 65 mya | | Upper<br>98 - 65 mya | High tectonic and volcanic activity. Primitive marsupials develop. Continents have a modern-day look. Ended with large extinction of dinosaurs. |
| | | | | Lower<br>146 - 98 mya | The heyday of the dinosaurs. The first crocodilians, and feathered dinosaurs appear. The earliest-known butterflies appear, as well as the earliest-known snakes, ants, and bees. |
| | | Jurassic Period<br>208 to 146 mya | | | Many dinosaurs, including the giant Sauropods. The first birds appear. The first flowering plants evolve. |
| | | Triassic Period<br>248 to 208 mya | | | The first dinosaurs and mammals appear. Mollusks are the dominant invertebrate. Many reptiles, for example, turtles. True flies appear. |
| | Paleozoic Era<br>540 to 248 mya | Permian Period<br>"The Age of Amphibians"<br>280 to 248 mya | | | "The Age of the Amphibians" The continents merge into a single super-continent, Pangaea. Phytoplankton and plants oxygenate the Earth's atmosphere to close to modern levels. True bugs and beetles. Trilobites go extinct. |
| | | Carboniferous<br>Wide-spread coal swamps and corals. Amphibians become more common.<br>360 to 280 mya | | Pennsylvania Period<br>325 to 280 mya | First reptiles. Many ferns. The first mayflies and cockroaches apper. |
| | | | | Mississippian Period<br>360 to 325 mya | First winged insects |
| | | Devonian Period<br>"The Age of Fishes"<br>408 to 360 mya | | | Fish and land plants become abundant and diverse. First Amphibians appear. First sharks, bony fish, and ammonoids. |
| | | Silurian Period<br>438 to 408 mya | | | The first jawed fishes and insects, centipedes and millipedes appeared during the Silurian. |
| | | Ordovician Period<br>505 to 438 mya | | | Primitive plants appear on land. First corals. Primitive fishes, seaweed and fungi. North America under shallow seas. |
| | | Cambrian Period<br>"The Age of Trilobites"<br>540 to 500 mya | | | "Age of Trilobites" - The Cambrian Explosion of life occurs. Many marine invertebrates (marine animals with mineralized shells: shell-fish, echinoderms, trilobites, brachiopods, mollusks). First vertebrates. Earliest primitive fish. |
| **Proterozoic Eon**<br>2.5 billion years ago (bya) to 540 mya | | Vendian/Ediacaran Period<br>600 to 540 mya | | | Multi-celled animals appear, including sponges. |
| | | | | | First multicellular life: colonial algae and soft-bodied invertebrates appear. |
| **Archeozoic Eon** (Archean)<br>3.9 to 2.5 bya | | | | | "Ancient Life" - The first life forms evolve - one celled organisms. Blue-green algae. |
| **Hadean Eon**<br>4.6 to 3.9 bya | | | | | "Rockless Eon" - The solidifying of the Earth's continental and oceanic crusts. |