

Times Standard

Not My Fault: North Coast's unique geologic history is exposed on the beach

Lori Dengler for the Times-Standard

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Two very different North Coast beaches that are only two miles apart are shown. On the left is the beach at Houda Point just north of Moonstone. Note that Camel Rock and numerous sea stacks are exposed near the beach. On the right is Clam Beach near the northern access trail with no sea stacks to be seen anywhere. Trinidad Head is seen faintly in the distance and the author's dog, Pip, is shown for scale

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The North Coast landscape is very old, very new, and everything in between. It is the product of events that happened over 100 million years ago and processes happening now, some in the past days and hours. We are fortunate to have this extraordinary backdrop beneath us. Beaches are the easiest introduction to North Coast geology for the simple reason that rocks are exposed and not obscured by forest. The light, shifting sands, and everchanging sculpture garden of logs brought in by winter storms make it a special experience.

None of this coast existed 100 million years ago. Reconstructing our edge of the continent requires geologic sleuthing. The broad outlines are clear, the exact details obscure. What we now call the Gorda and Juan de Fuca plates were part of a much larger plate that floored much of the Pacific basin. It was created along a complex spreading center that extended from where the Aleutians are today to latitudes as far south as southern Chile. Geologists call it the Farallon plate, a sort of misnomer because its namesake, the Farallon Islands, are in the Pacific plate and were never a part of the Farallon plate.

All oceanic plates have remarkably similar compositions, at least in contrast to the far more heterogeneous rock types that make up continents. At the surface, just beneath the seafloor sediments, lies a layer of basalt roughly a half mile thick. This basalt was created by nearly constant volcanic eruptions along the ridge, quickly quenched by the cold ocean waters creating the characteristic pillow shapes of submarine eruptions. Beneath the basalt are igneous rocks that cooled more slowly, a complex of dikes (feeder tubes where molten rock cut vertically through other layers) and more uniform gabbro, the remnant of the slowly cooling magma

chambers that once fed the sea floor eruptions. Spreading of the plate away from the ridge carried this package of rock away from the ridge axis.

The ocean above the sea floor is teeming with plankton, small and larger life forms adrift on the ocean currents, their remains continuously raining down onto the seabed creating a biogenic ooze. Diatoms and radiolarians have tests (shells) made of silica that is preserved even in the deepest oceans. Microscopic in size, their vast numbers deposit more than 150 million metric tons of ooze in global oceans each year. Over time, the ooze crystalizes into a rock called chert.

As plate motion brings this rock package closer to the coast, terrestrial sediments from the continent are reach the sea floor. These sediments are carried by rivers accumulating on the continental shelf and, when thick enough, slide down submarine canyons in turbidity currents, fluid-rich submarine landslides that is the primary way continental fragments are transported onto the deeper abyssal planes. As the turbidity current spreads out and slows down, the larger sand particles settle out first with silts and clays settling last, creating a characteristic graded sequence from coarse to fine typically several inches and occasionally over a foot thick.

All of the ingredients that will make up our coastal bedrock are now assembled and ready for “baking.” Sediments, chert, basalts, dikes, and gabbro are slowly compressed as they near the subduction zone and are pulled beneath the continent. Some of the material is scraped off and added to the continental margin, undergoing relatively little compositional change. Some is pulled deeper into the crust where higher temperatures and pressures cause the rock to recrystallize into a new suite of minerals stable at higher temperatures and pressures. These new metamorphic rock assemblages precisely earmark the temperature and pressure conditions that they experienced. And some of the subducted plate continues to move downward forever entombed deep within the mantle.

We don't know exactly what happens in the great maw of a subduction zone, but our coast is a testament that some of the rock returns to the surface and reflect the processes that metamorphose the rocks, cooking some only a little and others at extremely high pressures and mix them into a *mélange*, a rock pudding with disparate blocks of harder rock types in a sheared matrix of weaker materials. This complex amalgamation makes up the Franciscan Formation (also called Complex), a massive jumble of very different rock types that is the bedrock of much California coast ranges, extending as far south as Santa Barbara and north into southern Oregon.

Trinidad Beach is the perfect place to view Franciscan rocks. The Franciscan bedrock is nearly at the surface. Wave erosion has winnowed away the weaker units, exposing the more resistant rock types as sea stacks of varying sizes, shapes, and composition. Humboldt's introductory geology course always featured a field trip to Trinidad beach because it exposed students to an amazing variety of rock types, all within a stone's throw from one another.

The sea stacks and rock blocks are mainly of three types: graywacke sandstone, greenstone, and chert. They are easy to distinguish if you know what to look for. Graywacke is dark grey in color and shows no clear layering on first glance. Look for a freshly exposed rock surface and you can see small sand grains. Graywackes are the remains of thick offshore terrestrial sediments that have been cemented together in the subduction zone. A really good eye may find the

characteristic larger to smaller grain-size sequence of the turbidity current that originally deposited them.

Greenstones are a dull greenish tan in color and also show no bedding planes. Greenstone blocks are nearly as abundant as graywackes on Trinidad beach. They are the remnant of the oceanic crust that has only been lightly cooked in the subduction zone, just enough to metamorphose some of the basalt minerals to chlorite, giving it the characteristic olive-green color. In some places you can still see the pillow structures of the original submarine eruptions.

The easiest Trinidad Beach rock to identify is chert. Now contorted into spectacular bends and folds, the half to an inch thick layers are extremely hard, separated by very thin layer of shale. Don't let color fool you. Cherts can be black, red, green, or even white, the color caused by small amounts of impurities incorporated into the very tiny quartz grains that make up the hard layers. I call chert a tombstone as it is the final resting spot of untold numbers of microscopic lifeforms.

There's much more variety if you look at the rocks in more details. Look closely and you will find a few glittering blueish rocks. The glitter is caused by micas and the blue color by glaucophane, a rare mineral formed only by the combination of extremely high pressures but relatively low temperature. These blueschists are now recognized as a hallmark of subduction zones, the only places where high pressures aren't associated with high heat. At the north end of the beach, look closely for a glittering green rock. It's brighter than greenstone and also contains micas that cause the glitter. The green color is caused by chlorite, but this rock was baked at higher temperatures than greenstone, so the crystals grew larger. Peer in really closely and you will find a few gold spots. Don't get too excited – it's pyrite or fool's gold and a common indicator of greenschist rocks.

You'll find other unusual rocks at Trinidad Beach. There are highly sheared fragments that become "blue goo" when wet, one outcrop that is unmetamorphosed basalt, and the bright yellow, red, and blue 'Psychedelic Rock' (see the link to Ken Aalto's field guide below for pictures.) What about Trinidad Head? It's large size and roundish shape differs from the sharply pointed smaller sea stacks near the beach, but it is just another more resistant block in the Franciscan, composed primarily of greenstone and gabbro.

Sea stacks define the beaches from Sue-Meg State Park (formerly Patrick's Point) to Moonstone. Cross the Little River on 101 heading south, and the landscape suddenly changes and there's not a sea stack to be found until south of Ferndale. Why the abrupt change? Tectonic processes over the last few million years have faulted and folded the ancient Franciscan rocks, bringing some sections closer to the surface and burying other stretches beneath thick blankets of sand. The Little River location is no accident. It sits very close to the trace of the Trinidad fault, separating the uplifted rocks to the north from the much deeper bedrock to the south.

Please enjoy your own geologic explorations on North Coast beaches but never turn your back on the ocean as sneaker waves can happen at any time of year.

Note: No one knew the geology of the North Coast better than my colleague Ken Aalto. Ken was a sedimentologist who specialized in the northern Franciscan. He wrote a short summary

of the rocks and processes near Trinidad Beach at
<https://scholarworks.calstate.edu/downloads/05741v05b>.

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