

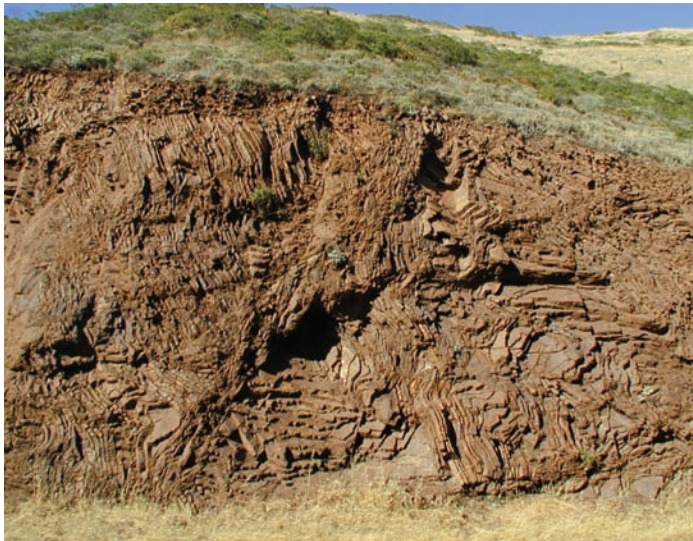
*How do I recognize geologic change in my environment?
What is the tectonic journey of this rock?*



Radiolarian Ribbon Chert

Classification: sedimentary

Environment of formation: deep ocean floor



Folded layers of chert in the Marin Headlands

This rock contains billions of microscopic fossils. The fossils are skeletons of single-celled plankton, called radiolaria. These plankton are most common in nutrient-rich ocean waters. Like quartz, radiolarian skeletons are made of silica.

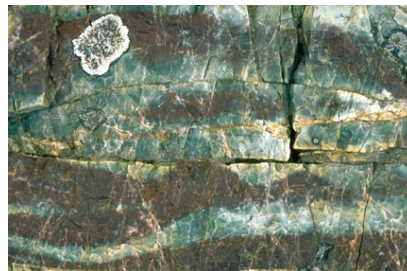
From a distance, radiolarian chert appears red-brown. A closer look reveals many colors. The colors are evidence of different amounts of minerals and oxygen in the sea water when the rock formed.

Radiolarian chert is very hard, and often feels smooth. Indigenous people made spear points from this glassy rock. The Army crushed chert to make roads. Pieces of chert often have a **blocky** shape.

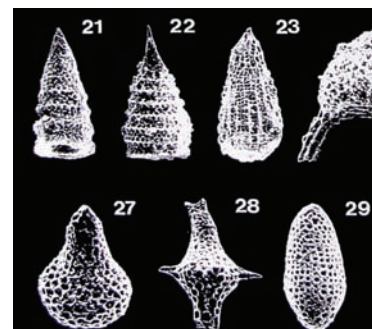
When radiolaria die, their tiny skeletons fall to the ocean floor, forming an ooze. This ooze eventually hardens into rock. The chert forms horizontal layers about 5 -15 cm thick. It took about 1,000 years for a 1 mm thickness of chert to form! When the flat layers of rock are carried on a tectonic plate, they may collide with the edge of a continent. This slow collision will bend and fold the layers.



Chert in Crissy Field riprap



Close-up of red and green chert



Magnified radiolaria skeletons

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Pillow Basalt

Classification: igneous (extrusive)

Environment of formation: underwater volcano



Pillow basalt stack at Point Bonita Lighthouse

Basalt is the most common igneous rock on the planet. When hot basalt erupts from an underwater volcano, cold seawater hardens lava into "pillows," or **jelly bean-shaped blobs**, each about one meter long. As the volcano continues to erupt, stacks of pillow lavas form, with the newest pillow on top of the stack. The pillows start out black, gray or green. If they are exposed to rain, the iron in the basalt will oxidize. Weathered pillow basalt looks **rusty** and crumbly.

Geologists sometimes call Franciscan pillow basalt "greenstone." The green color seen in the basalt comes from an interaction between the basalt and hot, mineral-rich seawater.

Pieces of basalt you find on the beach may look like they have "polka dots." The white dots on the rock are minerals that filled in the gas bubbles in the lava. Pillow basalt with polka dots erupted at a shallower depth. In very deep water, such as at a seafloor spreading center, the weight of the water squeezes out the gas in the lava, and the basalt that forms has no vesicles (gas bubble holes). Most of the basalt in the park has no holes or polka dots, but at Point Bonita, and in some Crissy Field riprap rocks, you will see pieces of basalt with white dots. What does this tell you about its environment of formation?



Basalt rock at Crissy Field
riprap



Pillow lava forming underwater
near Hawaii



Weathered pillow basalt at
Point Bonita

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Franciscan Mélange

Environment of formation: oceanic trench near a subduction zone



Mélange on Baker Beach near Fort Point containing graywacke, shale and serpentinite

Mélange isn't really a type of rock. Rather, it is a mashed-up mixture of Franciscan rocks, mixed and crushed in the subduction zone. Dr. David Alt and Dr. Donald Hyndman, from the University of Montana, call *mélange* "a chaotic mess of rocks swept together within an ocean trench." Sometimes the rock material in *mélange* is so sheared and crushed, it is hard for a geologist to identify what is there.

Often, zones of *mélange* in the park are also areas where landslides occur.



Road in a Marin Headlands *mélange* zone being slowly destroyed as the land slides from under it

Mélange is a French word meaning "mixture."



Rockslide containing blocks from a *mélange* zone at Black Sand Beach, Marin Headlands

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Graywacke Sandstone

Classification: sedimentary

Environment of formation: near subduction zones



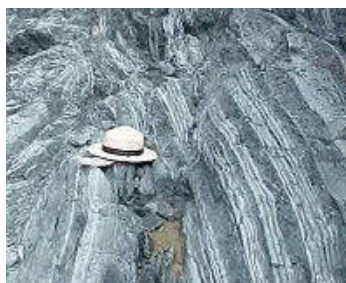
Graywacke sandstone at Baker Beach, San Francisco

Graywacke (GRAY-wak-ee) sandstone is a coarse-grained sedimentary rock that is mostly composed of quartz (silica), but also contains abundant feldspar, volcanic rock fragments and silt. Since the sand and silt grains making up graywacke are all different sizes and shapes (poorly sorted), geologists call it a "dirty" sandstone. This sandstone appears dark gray, brown or green. It looks tan or rusty when weathered, because many of the rock fragments contain iron. The "poor sorting" is a clue that the material that formed this rock was transported and deposited rapidly. Graywacke sandstone forms near subduction zones where mountain-building provides much sediment and earthquakes produce underwater landslides that carry sand out into the deep ocean. Graywacke feels very **gritty**, like sandpaper.

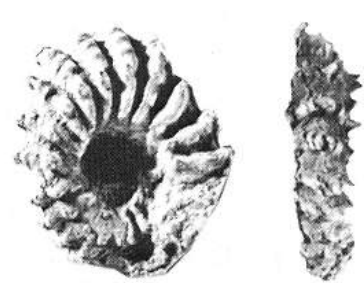
The name, graywacke, comes from an 18th century German mining term, *grauwacke*, meaning "gray gravel."



Sandstone (at right) and shale (at left) in Crissy Field riprap



Tan sandstone with layers of dark shale at Baker Beach



Fossil ammonite from Baker Beach sandstone

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Diabase

Classification: igneous (intrusive)

Environments of formation: in the vicinity of basalt eruptions and divergent plate boundaries



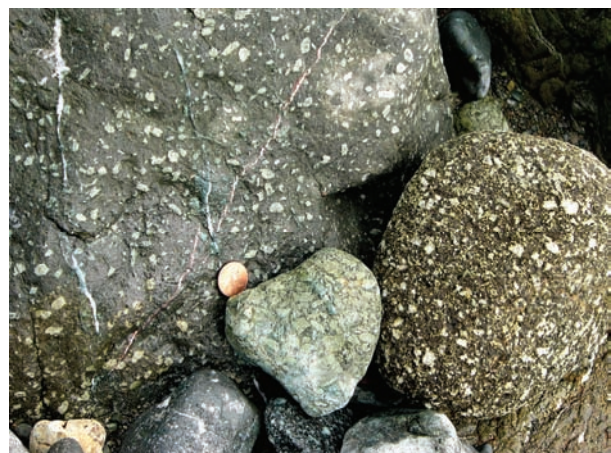
A sheet of diabase forms the cliff along the right side of the Point Bonita trail as you approach the tunnel

Diabase is an intrusive igneous rock. In Franciscan rocks, diabase formed from magma (molten rock) that didn't erupt into seawater. Instead, the basaltic magma cooled slowly in fractures under the seafloor. When molten rock cools slowly, crystals can form. The slower the cooling, the larger the crystals. The same molten rock material can form both pillow basalt and diabase. If it erupts underwater, pillow lavas form. If it cools more slowly beneath the seafloor, it can form diabase.

Diabase in Franciscan rocks has light-colored crystals that are easy to see within its green-gray matrix.



Don't expect to find jelly bean shapes in diabase



Diabase appears speckled, since the crystals are easy to see

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Serpentinite

Classification: metamorphic

Environments of formation: upper mantle at subduction zones and other plate boundaries



Blue-green serpentinite at Baker Beach bluff, San Francisco

We have never been to Earth's mantle, but the mantle comes to us in the form of serpentinite! This is the state rock of California. It is usually blue-green, flaky, slick and soapy. It feels like a snake, thus its name. The mixing of seawater with upper mantle rock produces serpentine minerals, such as chrysotile (asbestos) and talc, which are rich in magnesium and iron, but poor in potassium and calcium. This means that soils produced from serpentinite contain few nutrients that plants need to grow. Some plants, however, have adapted to serpentine soils. Several of these plants are unique to California, for, while serpentinite is abundant in the California Coast Ranges, it is rare in many other places. Look for serpentinite in areas where great tectonic movements occurred in the past, such as ancient, folded mountain ranges.

Sometimes pieces of talc-rich serpentinite are less flaky, and make good carving stone. Then you may hear it called *soapstone*.

The Chinese character for serpentinite contains the symbol for "dragon." Can you guess why?



North Baker Beach serpentinite



Serpentinite, Crissy Field riprap



Close-up of serpentinite, showing white asbestos veins