Cookie Tectonics

The rocks of the Marin Headlands tell the dramatic story of plate tectonics. A sandwich cookie helps us learn the story!

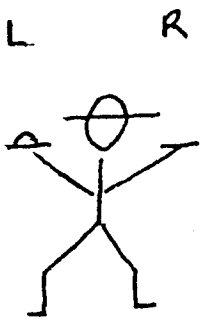
The rocks of the Marin Headlands belong to combination of rocks called the *Franciscan Complex.* These rocks show the formation, migration, and subduction of an oceanic plate at the western edge of North America. The Franciscan Complex is a piece of ancient seafloor that is now exposed on land.

Three main rocks are found in the Headlands landscape:

1. **basalt**, an igneous rock, often formed in pillow shapes, 1 meter long, and often altered (metamorphosed) by seawater to *greenstone.*

2. **chert**, a sedimentary rock composed of silica (quartz), often formed in layers 4 to 12 cm thick, which are often bent in wavy patterns.

3. **graywacke**, a sandstone composed of sharp sand grains of different sizes and colors.



This activity works best with sandwich cookies warmed to room temperature. Low-fat varieties don't work as well!

The Origin of These Rocks

Take a sandwich cookie. No munching yet! Carefully separate the 2 halves of the cookie so they don't break.

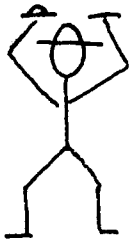
Hold the cookie with the most frosting in your **left** hand. Hold the cookie with the least amount

of frosting in your **right** hand. Keep your hands about shoulder-width apart. The cookie in your left hand represents the oceanic plate. The cookie in your right hand is the North American plate.

As the hot lava comes into contact with cold seawater, it quickly hardens to form a blob, or "pillow" As more lava erupts under the blob, another blob forms. The lava inside the blob will cool more slowly than the outer "shell" of the blob. The blobs are shaped like 3 foot-long jelly beans.

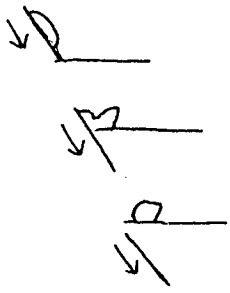
Now move your oceanic cookie (left hand) slowly towards your North American cookie. The oceanic plate is being carried towards North America as if it's riding on a conveyor belt. It's moving slowly, about 5 cm per year!

The oceanic cookie is made up of three layers. The bottom layer is **basalt**, which erupted from underwater vents and volcanoes in the middle of the ocean, about 5,000 km southwest of here. The middle layer is **chert**, which is made up of the silica skeletons of billions of microscopic organisms called radiolarians. When the radiolarians died, their skeletons were deposited on top of the basalt. The top layer is **graywacke**, a sandstone made of sediments from the continent that were carried by wind or coastal currents and then deposited on top of the chert.



Eventually, your oceanic cookie comes into contact with the continental cookie. Since oceanic plate material is denser (heavier) than continental material, the oceanic cookie will be pulled under the continental cookie. This is called **subduction**.

During subduction, most oceanic plate rocks are crushed, melted, and recycled back to the mantle under the Earth's crust. Some of the rocks may be scraped off along the continent's edge, forming a new coastline.

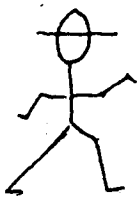


A frosting mound-building event.

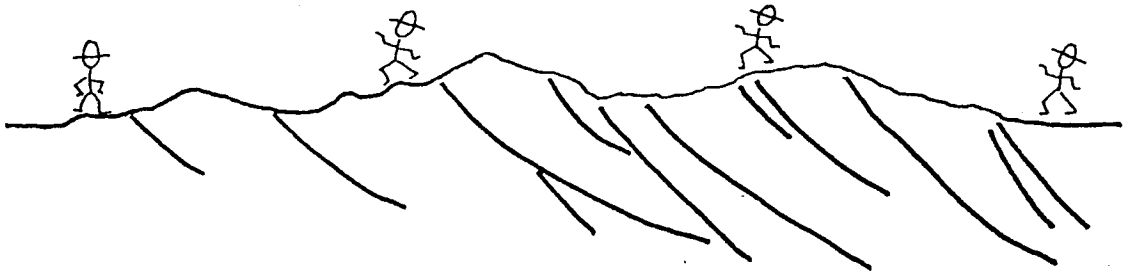
As your oceanic cookie is subducted beneath the continental cookie, scrape off the frosting on the oceanic cookie into a big mound on the edge of your continental cookie. Careful! Too much force may fracture a tectonic plate!

You're walking on the frosting!

The mound of frosting on your continental cookie represents the scraped-off seafloor rocks of the oceanic plate. That's what you walk on in the Marin Headlands!



As you can see, the rocks of the Marin Headlands (and many other parts of the Bay Area) made quite a journey! Where are they going now?



This particular way of using a sandwich cookie to demonstrate plate movements was developed by Roxi Farwell, after many field tests!