Beach Front Property: The Make-up of Point Reyes

by Jeff Scattini

35 miles north of San Francisco is a very large rock known as Point Reyes. Like most Bay Area residents, Point Reyes is not a native: it settled in this area more than 330,000 years ago. Walking along the coastline of this transplanted shore, you notice things; a high ridge of hills, red, sandy rocks, and a series of steps cut into the landscape, as if a giant had wanted to make an easier path to the top of the ridge. Walking farther, you notice that a hole has been dug in one of these steps. You climb up about 50 feet to the first of these odd flat planes. Stepping closer and peering into the hole, you see what you had expected—dirt—but also two things you hadn't expected at all: old beach sand and a geologist.

The sand is dry and brittle and has been in that hole for the past 80,000 years. The geologist has been in the hole since seven o'clock that morning. Her name is Karen Grove, Ph.D., and she is a professor at San Francisco State University. You help her out of the hole, and, as she brushes the sand of the ages from her clothes into a carefully labeled specimen jar, she begins to explain.

Grove first noticed the peculiarities of the Point Reyes coastline during a 1993 sediment survey of Point Reyes, looking for evidence of seismic activity over the past 100,000 years. She was struck by the terraces on the flank of the peninsula. Marine terraces are formed when the ocean cuts away at the land, explains Grove. Slowly, over thousands of years, the ocean forms a flat plane in the landscape. This flat plane is the beachfront where, today, people come and relax and play. Then, perhaps every thousand years or so, an earthquake lifts the land up above sea level. As this happens, the sea level recedes. When the sea level rises again, it starts to cut into the land again. Since the previous ground level is now above sea level, the ocean must start fresh. Once again, over thousands of years, the ocean creates a flat plane in the landscape. Again, an earthquake raises the land above the ocean's reach, and then the ocean, again, must begin leveling the beach. This continual leveling and raising of the beachfront creates the terraces that form the flank of Point Reyes.

How did Grove figure out the age of the coastline? The sediment of the coastline is not like trees where the rings of the trunk will tell how long they've been around. Normally, when geologists want to know the age of a coastline, they try to find seashells that have been thrown up by prehistoric oceans. Scientists can carbon-date the shells, a process in which they count carbon atoms and see how many have decayed. (The more atoms that have decayed, the older the artifact is.)

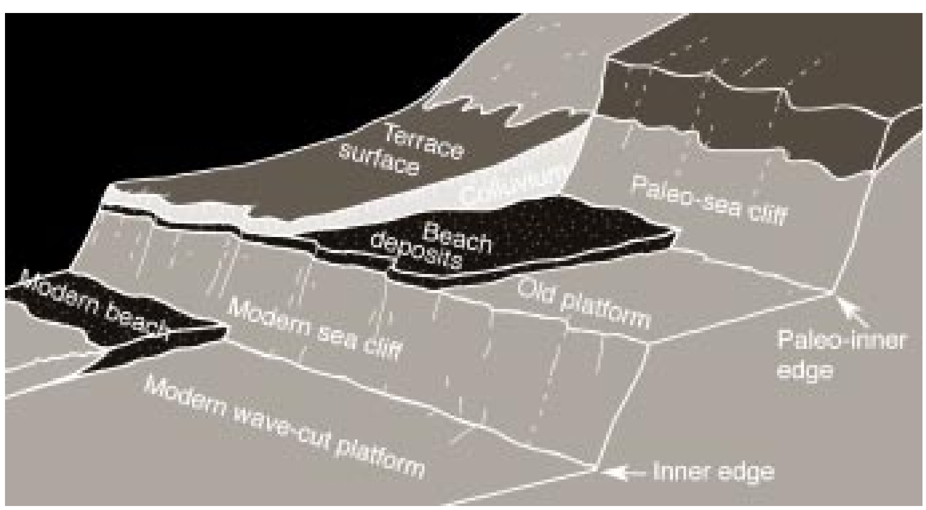
Grove never found any seashells. Instead, she chose another way of dating the Point Reyes coastline, called *luminescence dating.* Luminescence dating, or glow studies, relies on the fact that certain crystals trap the natural radiation of the earth, explains Grove. This radiation is released when the crystals are heated or exposed to sunlight. When these crystals are hidden away from the light, say, buried beneath the topsoil of Point Reyes, the crystals start trapping the natural area radiation. The radiation will build up in the crystal until it is either exposed to sunlight or heated to over 500 degrees Celsius. When scientists take a sample of these crystals and expose it to specific lights and temperatures, the sample will luminesce, or glow, and the amount of light and radiation escaping will tell them how long the crystals have been hidden from the sunlight.

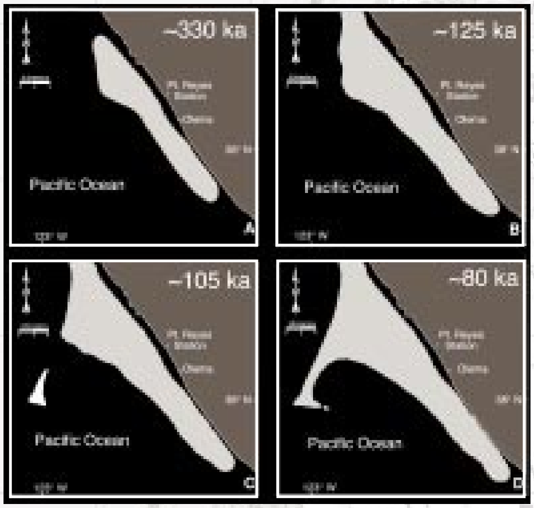
Grove and her team must take care when gathering these samples. Any exposure to light or extreme heat will ruin the samples, so Grove uses thick PVC pipe and an impressive amount of duct tape to secure them during transport. To get the samples from the terrace, she crawls under a large black cloth, hammers a PVC pipe into the cliff face, and then, in the pitch black, wraps them in black plastic and duct tape.

With her prehistoric beach terraces blowing out their ancient birthday candles, Grove must then determine how much uplift has occurred to each terrace. There is nothing better than a Global Positioning System (GPS), which uses satellites to determine the precise longitude, latitude, and elevation of a millennium-old beach terrace. Using a GPS, Grove and her team took over 100 elevation

Karen Grove, Professor
Department of Geosciences

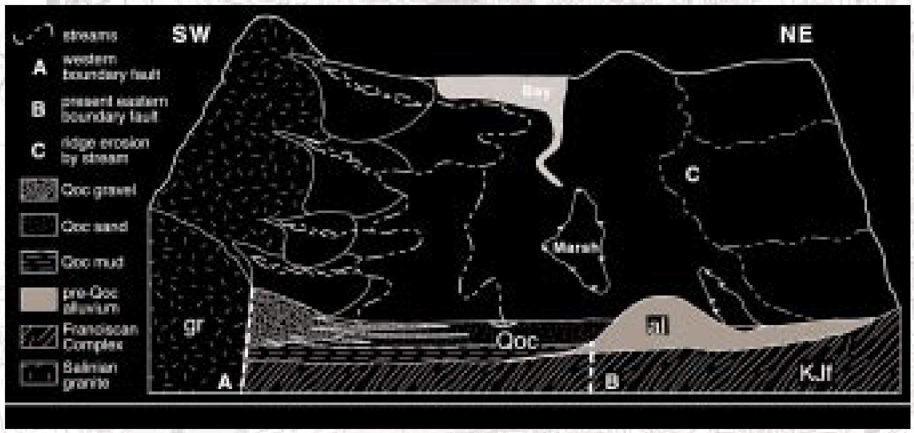
Diagram of marine terraces, which have two components–a platform carved by waves in the surf zone, and sediments that accumulate on top of the platform. Along an uplifting coastline, the platform and sediments get moved vertically upward from the surf zone, so that new platforms are created at lower elevations. The uplift rate of the coastline can be calculated by measuring the elevation of the uplifted platform and dividing by the age when the platform was created. All diagrams courtesy of Dr. Grove





"Point Reyes is like a cupped hand. As uplift occurs, the two ridges get taller and the valley forms."

Above: Marine terraces are used to estimate the rate of vertical uplift of the Point Reyes Peninsula and the timing of its emergence from the sea (ka= thousand years ago). About 330,000 years ago, the Point Reyes Peninsula consisted only of a single small ridge west of the San Andreas Fault. Since then it has been uplifted by faults to become a larger area above water. The white area between the peninsula (shown in darker gray) and the Marin County mainland (shown in gray) is the valley created by the San Andreas Fault.



Schematic diagram of the paleogeography of the San Andreas Fault valley south of Tomales Bay.

gr=Mesozoic granodiorite, Qoc=Pleistocene Olema Creek Formation.

points at three different locations on the most recent terrace. Over time, they emerged with a set of data that detailed the amount of uplift each site on the terrace had experienced in the last 80,000 years. Grove discovered that different areas of Point Reyes are rising at different rates. The three sites, Wittenburg, Glen, and Bolinas, had elevations of 10.2 meters, 28.9 meters, and 84.5 meters above sea level. Grove's calculations show the three different sites uplifting at 0.2 millimeters, 0.4 millimeters, and 1.1 millimeters per year, respectively.

Grove found that uplift has been most responsible for the unique triangle shape of Point Reyes. "Point Reyes is like a cupped hand," Grove explains, holding her own hand out for demonstration. "As uplift occurs, the two ridges get taller and the valley forms." By measuring the height of the different terraces, Grove can estimate the amount of uplift that has occurred to give Point Reyes its distinctive shape. Once she knows the amount of uplift in a given time frame, she can estimate the amount of seismic activity that the area has had in the past 80,000 years.

Listening to this animated woman describe the seismic antics of the landscape, you look out over Point Reyes with new eyes. You envision Point Reyes sliding farther up the coast and becoming Canadian. You ask about the San Andreas Fault, which could cause the earthquakes that make this type of shift. Grove acknowledges the possibility of earthquakes from the fault, which she says is "a major player," but she is more interested in other fault-lines. Other fault-lines? There are smaller faults that allow vertical motion in the Point Reyes region and are responsible for its topography. These smaller faults are considered part of the San Andreas Fault System. The smaller faults' significance is poorly understood, and little is known about how they interact with the overall system. By studying how these fault-lines helped shaped Point Reyes, Grove hopes to investigate faults that have similar characteristics and see how they interact with the major San Andreas Fault.

Along with furthering recognition of hazardous fault-lines, Grove's research will educate people about how the Bay Area landscape has formed. She would like to install three-dimensional animated topographical maps in the Point Reyes ranger station so that every visitor can easily see how the Point Reyes landscape has evolved. She pats the rocks around her, imagining that wealth of information displayed for the public.

As the sun dips lower on the horizon, Grove says goodbye and drops down into her hole to take the last samples of the day. You walk along the coastline and begin noticing the tall ridge, the sandy red rocks, and the surrounding ocean in a whole new light. Placing your hand on the bare earth, you can almost feel the intricate interplay of the shifting fault-lines, their resulting earthquakes, and the rising sea levels, which together have cut into and uplift the landscape, creating terraces, and over thousands of years, formed this remarkable bit of rock.