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Not My Fault: Explaining the collapse of the coastline south of Centerville Beach

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Time sequence of the bluff near Fleener Creek, 1987 and 2005 from the California Coastal Records Project, 2010 by Dave White, and 2024 by Brandon Rice.

One of my favorite hikes in Humboldt County is just south of Centerville Beach. Fleener Creek trail starts at a parking area about 300 feet above the ocean and zigzags down to the beach. In spring and early summer, it is a riot of flowers. If the tide is low enough, you can walk south to Guthrie Creek, passing spectacular exposures of tilted sedimentary rocks.

Or you could until a week ago Saturday. A massive landslide bit off a chunk of the trail and some of the parking area as well. BLM geologist Sam Flanagan estimates that one to two acres of the former bluff and the 300 feet of rock below it tumbled into the ocean in the early morning hours of February 24th. Fortunately, no one was there at the time and, other than the parking lot, no homes or infrastructure directly impacted.

For anyone who has lives on the North Coast, this is no surprise. Landslides are common throughout the region but are far more frequent in some areas than in others. The coastal bluffs west of Ferndale and just south of Centerville Beach offer spectacular coastal views but are particularly vulnerable to slope failure.

Landslides reflect nature's battle between uplift and gravity. If earth weren't a dynamic planet, gravity would have won the battle eons ago, leveling our surface to a low lying plain. Plate tectonics keeps uplifting the surface and creating new opportunities for the dance to continue.

Slopes fails when the gravitational pull exceeds the strength of the rock. Gravitational force depends on elevation and slope angle. Rock strength and resistance to pull depends on several factors: chemical makeup and how tightly grains are held together, planes of weakness such as joints, faults and bedding surfaces, and fluids. Ground water can increase both the weight of the rock and increase pore pressures, pushing against the frictional forces that help keep the rock mass intact. Just like people, time changes rock strength. Weathering processes often weaken rock making it more vulnerable to landslides.

Almost all the rocks on the North Coast are sedimentary in origin, formed by deposition of rock fragments and the remains of microfauna onto the sea floor. Over time, the fragments are buried and consolidated, until geologic forces bring them to the surface. The first step in geologic mapping is identifying the type of rock and dividing them into manageable units.

The basic unit of sedimentary geology is the "formation," a series of rock layers that are distinct from the strata above and below it. Based on mineralogy, texture, and the presence of or absence of fossils, a formation represents a period of time when the depositional environment was roughly the same. A number of formations with similar characteristics are classified as a 'group.' Most geologists are introduced to stratigraphy at the Grand Canyon where the different formations create the color variations and distinctive stair step topography. The horizontal formations that make up the middle and top of the canyon are in one group, and the tilted sedimentary rocks below it are in another.

The story at Centerville Beach is similar to the Grand Canyon but on a much smaller scale. Walking along the beach it's clear that these rocks are made up of sediments. Unlike much of the North Coast bedrock, these units are relatively weak, and the bedding surfaces are easy to see. First recognized in the late 19th century, their extent has been mapped throughout the Humboldt Bay region and are called the Wildcat Group.

The Wildcat is relatively young by North Coast standards ranging in age from about 7 million years at their base to 500,000 years at the top. The rocks exposed below Fleener Creek are part of the Rio Dell Formation, the thickest unit within the Wildcat. The distinctive light gray beds are composed primarily of silt to fine sand and were deposited horizontally on the continental shelf and adjacent deeper waters. The rock is only weakly lithified, it is easy to scratch the surface.

Compressional forces caused by subduction and the northern migration of the Mendocino triple junction slowly warped the rocks in the Wildcat Group into a broad syncline, a gentle trough-like fold down in the middle. The Fleener Creek hike was a terrific place to see evidence of this folding, the once horizontal Rio Dell Formation sand beds now tilted up at angles of more than 30°.

The environment has been hard on the Rio Dell Formation. The warping produced joints, near vertical planes of weakness. Ocean waves constantly batter the base, slowly eroding the bluff support. Wet winters and dry summers change pore pressures. Viewing historic imagery of the bluff near Fleener Creek either on Google Earth or California's Coastal Records Project (https://www.californiacoastline.org/) shows a constantly changing cliff face.

There is one more factor that adds to the Rio Dell Formation fragility – earthquakes. Earthquakes impact slope stability in several ways. The added accelerations can boost gravity's pull, fault rupture can change pore pressures and fluid motions, and the shaking produces new cracks and grow older ones.

Every significant earthquake on the North Coast has triggered slope failures in the minutes afterwards. Numerous landslides occurred in Wildcat rocks after the 1992 M7.2 Cape

Mendocino earthquakes, including one in the Fleener Creek bluffs. I found a photograph of a huge slide near Centerville Beach taken by Ferndale photographer Edna Garrett after the 1906 earthquake. One of the largest earthquake costs to county government is dealing with road slip outs and clearing landslides post-quake.

But earthquakes don't just cause landslides during shaking. The Fleener Creek failure may have been initiated 14 months earlier in the December 20, 2022, M6.4 Ferndale earthquake. The earthquake fault rupture was only two miles from Fleener Creek and post-earthquake field investigations noted a number of cracks in the ground near the Fleener trail parking lot soon after the earthquake. The cracks had grown sufficiently large by January 2024 that BLM had closed the trail.

Something similar happened in 2010. The M6.5 Eureka earthquake occurred on January 9, 2010, centered about 22 miles offshore of the Fleener Creek bluff. We saw a number of cracks in the ground near the Fleener trail parking lot a few days afterwards. Eleven months later, that section of the bluff collapsed.

Our ground can fail at any time. Earthquakes exacerbate the vulnerability, and that failure might come weeks to months later.

Note: thanks to Bob McPherson, Andre Lehre, the late Ken Aalto, Gary Carver, and many other colleagues and students who know far more about the Wildcat and landslides than I do – any mistakes are mine and not theirs.

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