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Not My Fault: There's a newly identified earthquake fault in Shively

Lori Dengler for the Times-Standard
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This is the trench across the Shively fault. It was dug in this stairstep way for stability reasons and to give the research team easy access to all of the layers. It's roughly 25 feet across and 15 feet deep. Inset is from the trench wall where the fault is exposed. The fault zone has been colored orange to make it more visible in this photo, black arrows show how the two sides of the fault have moved relative to each other.

I took a very special field trip this week. Colleagues of mine received funding from the National Earthquake Hazards Reduction Program (NEHRP) to study a suspicious bump in the ground near Shively in southern Humboldt County. The team led by Jay Patton of the California Geological Survey and Mark Hemphill-Haley a fellow professor emeritus in the Humboldt Geology Department, have just opened a trench to determine if it is a fault, how active it may be and its potential for producing a major earthquake.

Trenching is a relatively new tool in our arsenal for studying earthquakes. It wasn't until the mid 1970s that Kerry Sieh, then an undergraduate at UC Riverside had the idea of using a backhoe to study faults. Sieh's doctoral work at Pallett Creek in the San Andreas fault zone near Palmdale not only demonstrated the effectiveness of the technique but gave a big push to the discipline of paleoseismolgy, the study of ancient earthquakes.

Paleoseismology took off quickly, and Humboldt professors Gary Carver and Bud Burke applied the new techniques to faults in Humboldt County. The Department initiated a master's program that emphasized tectonics and surface processes. Generations of Humboldt undergrad and grad students learned how to read the landscape to determine the telltale signs of past fault ruptures. Jay and Mark came out of this tradition as did a number of other people involved with the project. The tradition continues as two current undergrads are part of the Shively fault study team.

There are three essential parts to successful fault trenching. The first is picking a good spot. This might not seem too difficult if you know where the fault is located, but no one suspected that the Shively fault existed until a few years ago. Finding faults in Humboldt County is difficult because of terrain and tree cover. It was comparing leveling surveys taken twenty years apart that led to this spot.

Jay Patton has been looking a land level changes for decades in our area. Caltrans periodically surveys its highways and U.S. 101 runs along the Eel River near Shively. One expects to see some deformation over time where a road crosses a fault, but an odd anomaly showed up in the surveys near Shively where no fault had been previously mapped. Scanning air photos and doing a little ground reconnaissance revealed a suspicious berm running through the town and into the timber lands to the east.

Just spotting a good candidate to trench is only the first step in site selection. Access and permission to scrape a large hole in the ground is another. One wants a site with road access and needs property owners willing to allow the operation. Many people are a little wary about a backhoe gouging a chasm into their property and hosting a team of scientists for weeks pouring over what it reveals. The Shively berm runs through the Humboldt Redwood Company property and Jay has built a relationship with them over the years. They not only allowed access, but had the expertise to do the excavation work, and had no concerns about limiting the size of the trench.

Having the ok to excavate doesn't guarantee success. It is not unusual to dig a trench and not find a fault. Earthquake faults are deep, extending many miles into bedrock beneath the surface and trenches typically only sample the near surface. There are many factors that limit how deep you can dig. There is always concern about the stability of the trench and even with shoring to prop up the sides, some materials are prone to collapse. The ground water table and more resistant rock or very weak layers can also limit how far down you can go. Some active faults die out in surface sediments fanning out into a zone of small displacements over a large area. These are known as blind faults and many a paleoseismology trenching project has been thwarted by the lack of measurable offsets.

The Humboldt Redwood Company trench is the widest and deepest I've ever seen. Usual trenching investigations are about three to five feet wide and rarely more than ten feet deep, narrow slots in the ground where the researchers have their noses pressed against the sides to record what they see. The Humboldt Redwood folks gave the Shively fault investigation team the leeway to make it as wide as they wished, opting for a three-tiered hole about 25 feet wide, and 15 feet deep in the center. The design made easy to access to all parts of the trench and no need for shoring as each step wasn't high enough to be unstable. The best news about the trench is that the fault is exposed and even clear enough for even my uneducated eye to pick out.

Once a trench is completed, step two begins, the laborious work of cataloging and recording what it reveals. The goal of trenching is to identify a fault and measure how much it has displaced materials that were originally next to one another. But there wasn't just one earthquake that caused the berm and offset layers. This fault has been around for a long time, and each successive earthquake has displaced the older sediments it cuts through.

Imagine a sloppy cook making a layer cake on an uneven slanting surface. They lay down the first tier and then it cracks, and one side slips down a little. They slather it over with frosting and add a second layer and then whole thing cracks and slides again. The bottom layer will be displaced more than the newer one. Our chef will not be deterred and adds yet another layer and another with periodic cracks and slip events continuing to displace the stack. Each deeper (older) layer is deformed more than the ones above it and only the last layer of frosting on the top that was just added and hasn't experienced a slip event shows no displacement.

It would be easy to see displacements in cake and frosting layers. It's a real art to discern their equivalents in the ground. It requires an understanding of the environment in which the sediments were deposited. There are two types of sediment deposits that are crucial to recognize in the unraveling of this site. The Shively trench site was occupied by the Eel River for many years in the past. As the river evolved, it cut benches into the landscape and deposits sands, silts and gravels. They are called fluvial terraces, think of them as ancient floodplains that were originally flat. As the river system evolves and incises into the landscape, a series of these terraces develop, the youngest closest to the present river channel and the oldest far above. The Shively fault team has identified seven terraces in the area, four of which are exposed in the trench. The terraces are produced by normal river processes and have nothing to do with faulting. They provide surfaces to measure displacement.

The second deposit is directly related to fault movement. When an earthquake occurs and moves the land up, that newly displaced land is likely to slide. These landslide deposits look very different from the river sediments with a jumbled chaotic texture compared to the layered materials deposited by water. We know a lot about them from studying modern earthquakes and the subsequent slides off of the newly offset ground. The Shively team found evidence for four of these fault slip produced landslides, solid evidence that at least four earthquakes produced enough vertical displacement to cause slope instability.

Just observing displaced units and landslides is not enough to tie the story down. The final step is determining the age of the units and when the slides occurred. Dating of geologic materials has experienced a revolution in the past few decades. You may have heard of Carbon-14 dating, where the radioactive isotope of carbon begins decaying as soon as a living organism dies. It's the method still widely used for materials less than 50,000 years old. There were many chunks of charcoal in the Shively trench, a testimony to the prevalence of prehistoric wildfire in the region and many of those samples will be sent to high precision C14 dating laboratories.

The Shively team is also making use of several newer dating techniques that measure when a geologic deposit was last exposed to the sun. Like human skin, sediments react to sunlight. Exposed surfaces experience cosmic radiation and sunlight releases trapped electrons in mineral lattices. When the sediment is buried, these processes stop. Several techniques make use of this "zeroing" of sunlight. Optically Stimulated Luminescence (OSL) calculates sediment burial time by measuring trapped electrons and cosmic ray age dating can yield similar burial estimates by rare isotope concentrations.

It's early stages in the Shively fault study. The team still has two weeks to finish mapping and collecting samples. The trench is not the only part of the study; the team has also used remote sensing, conducted regional mapping, and dug pits in other areas to get a more regional picture of the fault extent. Preliminary results show four likely earthquake events in the past 20,000 years but nailing down timing and magnitude will take much more analysis. A huge shout out to Humboldt Redwood Company the rest of the Shively Fault research team: Jessica Vermeer and Stephen DeLong (USGS), Sophia Garcia and Cadence Ramirez (Cal Poly Humboldt), and Jason Buck and Gary Simpson (SHN).

Learn more about the Shively fault and the trench project at https://earthjay.com/?page_id=12633.

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