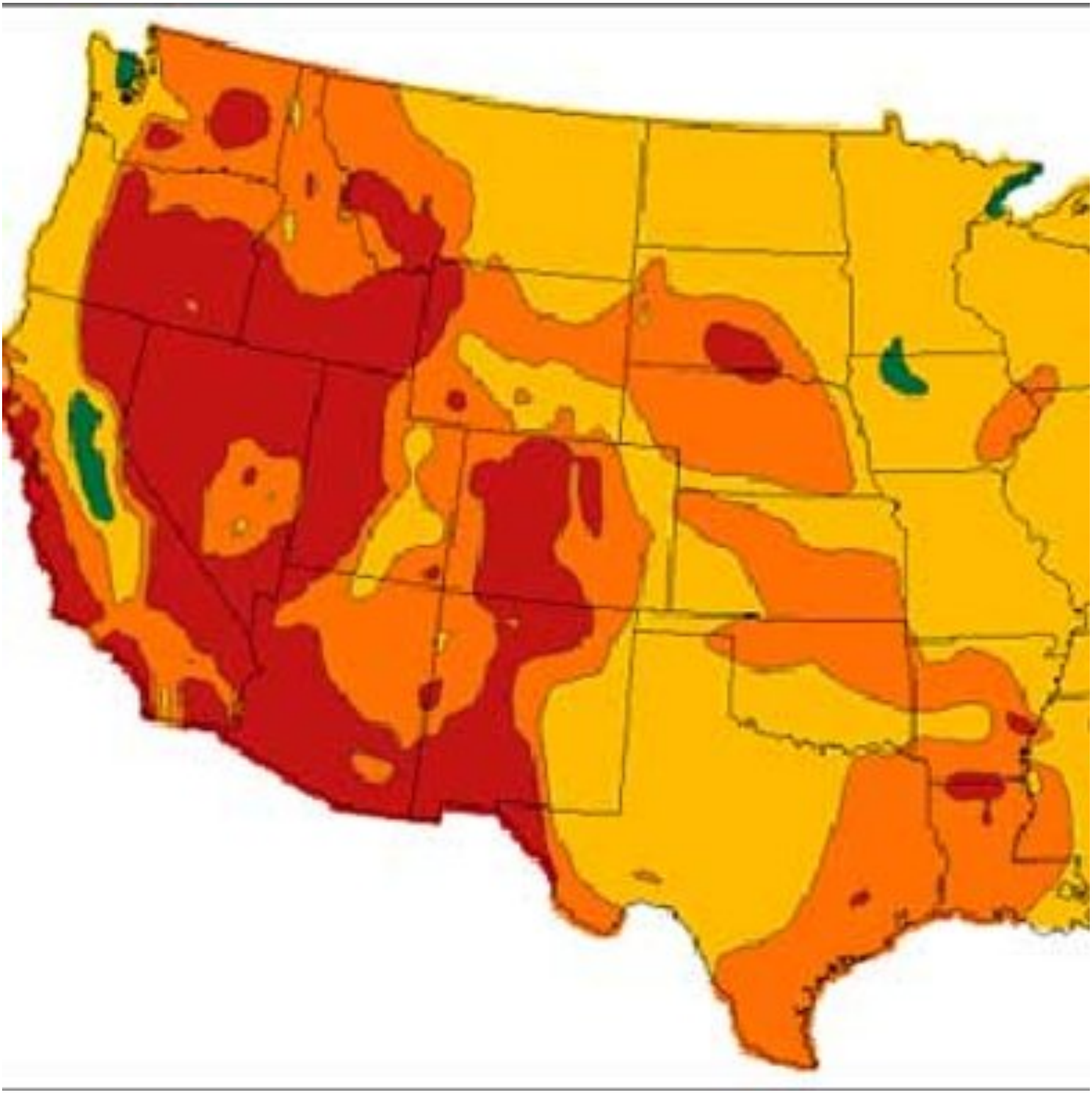
SUSTAINABILITY

How Does Geothermal Drilling Trigger Earthquakes?

People living near a geothermal drilling project in fault-riddled northern California are worried about more earthquakes after a

similar project triggered a major jolt in Switzerland. A seismologist explains the forces at work

By Katherine Harmon on June 29, 2009



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Despite the promise of cheap, clean power, geothermal energy development may be on shaky ground. There have been rumblings from residents and scientists alike that drilling deep to tap naturally

occurring heat could cause bigger earthquakes.

Already on edge about temblors, northern California locals are eying an expansive new geothermal project proposed by a company called AltaRock that's going to be boring down more than two miles (3.2 kilometers). The area near the town of Anderson Springs—about 90 miles (150 kilometers) north of San Francisco—is home to natural geothermal vents (nicknamed The Geysers by early visitors who saw the steam vents there) and has been exploited for its natural energy-generating capacity for the better part of the last century. Starting in the 1970s, as technology improved, engineers started to crank up the production levels. Small earthquakes began shortly thereafter.

Just a few years ago, a now-infamous geothermal project in Basel, Switzerland, which drilled three miles (4.8 kilometers) into Earth's crust, set off a magnitude 3.4 earthquake, rocking the town and shutting the operation down entirely, *The New York Times* recalled recently.

Drilling has even been fingered as the cause of a massive 2006 mud volcano in Java, which displaced more than 30,000 people after a gas exploration project went awry. "We are more certain than ever that the Lusi mud volcano is an unnatural disaster," Richard Davies of the Center for Research into Earth Energy Systems at Durham University in England said in a statement after investigating the incident.

The U.S. Department of Energy has already chipped in $36 million for AltaRock's project, and in an effort to drive down the price of renewable energy Google has anted up $6.25 million, the *Times* reported.

But will these deep holes—and deep-pocketed investors—trigger the next big one? To find out, we spoke with U.S. Geological Survey Earthquake Hazards Team seismologist David Oppenheimer, who is based in Menlo Park, Calif., just a couple hours south of the area.

[An edited transcript of the interview follows.]

How does geothermal drilling work?

The traditional geothermal drilling process has been to drill into the sandstone that has water in its pore spaces. When they drill into the rock, there's a surge of steam—just like popping a lid off a soda

bottle—then the steam rises and spins a turbine.

At The Geysers, they have been condensing 25 percent of the steam and introducing it back into the reservoir to keep the water levels up.

About a million years ago, there was a magmatic intrusion (protovolcano) that didn't make it to the surface. Under the surface is a rock called felsite—you can think of it like granite; it's the heat source for the sandstone.

The new project is going to exploit the felsite directly. But there's no water in the felsite, so they drill, then they pipe water under strong pressure and flow rate, to fracture the rock. They'll be using earthquake-monitoring equipment and will send cameras down the hole to see which direction the fractures were occurring. Then they drill a second hole to intersect the new fracture.

So the potential is to extract much more heat, but you have to create your own fractures and you have to introduce water.

If the new fractures are triggering earthquakes, how do they control them?
What they need to do, from an engineering perspective, is keep the size of the fractures small. So they will control the [water] flow rates and pressures to make sure it doesn't become a runaway earthquake.

We've been monitoring [The Geysers] since 1975. All the earthquakes we see there are [human] induced. When they move production into a new area, earthquakes start there, and when they stop production, the earthquakes stop.

They've been inducing earthquakes since the 1960s, and the largest has been less than a [magnitude] 4.5. Earthquakes are occurring in many, many fractures. So that's very different than if you go south to the Bay Area with the San Andreas Fault. For earthquakes larger than 6.0 to happen, you need a big fault. Therefore, it's unlikely they'll intersect a large fault and trigger a larger earthquake.

The threshold goal for the earthquakes is 2.0 or lower. They don't want a repeat of Basel, Switzerland.

How is geothermal drilling different from other energy projects like natural gas or oil?

There are some similarities to oil fields. In oil fields for secondary recovery, they inject water into the ground to try to force more oil out. Frequently, though, oil fields aren't located in tectonically active areas.

So why don't they do geothermal drilling somewhere that isn't prone to earthquakes?
In Texas, you don't have the heat source. If you drill all the way to the outer core, there will be molten rock. But nobody knows how to do that. In tectonically active areas, you have more heat sources (from failed volcanoes and the like).

There is some geothermal potential all over the country if we're talking about geothermal for heating —but not necessarily for spinning large turbines.

Do these little earthquakes help relieve any building pressure to help stave off larger quakes?
Unfortunately that's a myth.

Does deeper drilling mean stronger earthquakes?
The more important issue is how big a fracture is—how big an earthquake are they generating. If they intersect an existing fracture, and it's ready to go, they can trigger a bigger earthquake.

For the residents of Anderson Springs, [the lack of] depth *is* a problem. The reason they feel so many earthquakes is because they're so close to the fractures—about 1.2 miles (two kilometers) above [the fracture]. The farther away or deeper the drilling [is], the less likely they are to feel them.

What are the chances this deep geothermal drilling near The Geysers could set off one of the larger faults, like the San Andreas?
Here's what we know: You can think about The Geysers—the upper three miles (4.8 kilometers) of crust—as a sponge, and the sponge is wet. Now we're taking fluid out of the sponge, and we're taking heat out of the sponge. When you dry out a sponge, it contracts. The Geysers is contracting. From the data, we can see it pulling in, which means that it's changing the stress field around it.

Surrounding the field are some active faults, which have the capacity for some larger earthquakes. So one day one of the tectonic faults is going to move. People are going to ask the question: Did the shrinkage of The Geysers cause the movement of the fault? If that's the case then we have a larger

issue.

Are there concerns about other, long-term impacts of these deep-drilling projects?
I think the primary undesirable factor is the earthquakes. We have 35-plus years of information, and it hasn't been benign, but they haven't triggered any real damage. But look at hydropower dams and coal power plants—they all have their advantages and disadvantages. Here, they've been able to control emissions of sulfur and radon. I think the downside is pretty small—except if you live in Anderson Springs.

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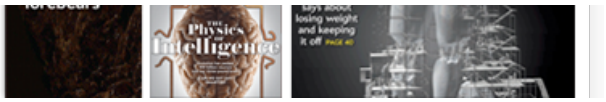

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