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## TAPPING THE GEYSERS

# Clean energy vs. quake fears

**New drilling project could bring renewable energy, but does chance of triggering earthquakes make it too risky?**

By JAMES GLANZ  
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BASEL, Switzerland -- Markus Haering, a former oilman, was a hero in Basel, a city of medieval cathedrals and intense environmental passion three years ago, all because he had drilled a hole three miles deep near the corner of Neuhaus Street and Shafer Lane.

He was prospecting for a vast source of clean, renewable energy that seemed straight out of a Jules Verne novel: The heat simmering within the Earth's bedrock.

All seemed to be going well until Dec. 8, 2006, when the project set off an earthquake, shaking and damaging buildings and terrifying many in a city that had been devastated exactly 650 years before by a quake that sent two steeples of the Muenster Cathedral tumbling into the Rhine.

Hastily shut down, Haering's project was soon forgotten by nearly everyone outside Switzerland. As early as this week, though, a U.S. startup company, AltaRock Energy, will begin using nearly the same method to drill deep into ground laced with fault lines in The Geysers area of Sonoma County.

Residents near The Geysers, which straddles Lake and Sonoma counties, already have protested swarms of smaller earthquakes set off by a less geologically invasive set of energy projects. AltaRock officials said they chose The Geysers in



JIM WILSON / New York Times

A drillbit is prepared at AltaRock Energy's geothermal project in Anderson Springs on May 30. The project has raised fears of earthquakes.

part because the history of mostly small quakes reassured them that the risks were limited.

Like the effort in Basel, the new project will tap geothermal energy by fracturing hard rock more than two miles deep to extract its heat. AltaRock, founded by Susan Petty, a veteran geothermal researcher, has secured more than \$36 million from the Energy Department, several large venture-capital firms and Google. AltaRock maintains it will steer clear of large faults and it can operate safely.

But in a report on seismic impact that AltaRock was required to file, the company failed to mention that the Basel program was shut because of the earthquake it caused. AltaRock said it was uncertain the project had caused the quake, even though Swiss government seismologists and officials on the Basel project agreed it did. Nor did AltaRock mention the thousands of smaller quakes induced by the Basel project that continued for months after it was stopped.

The Geysers project is the first of dozens that could be operating in the United States in the next several years, driven by a push to cut emissions of heat-trapping gases and the Obama administration's support for renewable energy.

Geothermal's potential as a clean energy source has raised huge hopes, and its advocates believe it could put a significant dent in U.S. dependence on fossil fuels, potentially supplying roughly 15 percent of the nation's electricity by 2030, according to one estimate by Google.

The Earth's heat is always there waiting to be tapped, unlike wind and solar power, which are intermittent and thus more fickle. According to a 2007 geothermal report financed by the Energy Department, advanced geothermal power could in theory produce as much as 60,000 times the nation's annual energy usage.

President Barack Obama, in a news conference Tuesday, cited geothermal power as part of the "clean energy transformation" that a climate bill now before Congress could bring about.

Dan Reicher, an assistant energy secretary in the Clinton administration who is now director of climate change and energy at Google's investment and philanthropic arm, said geothermal energy had "the potential to deliver vast amounts of power almost anywhere in the world, 24/7."

Power companies long have produced limited amounts of geothermal energy by tapping shallow steam beds, often beneath geysers or vents, called fumaroles. Even those projects can induce earthquakes, although most are small.

But for geothermal energy to be used more widely, engineers need to find a way to draw on the heat at deeper levels percolating in the Earth's core.

Some geothermal advocates believe the method used in Basel, and to be tried at The Geysers, could be that breakthrough. But because large quakes tend to originate at great depths, breaking rock that far down carries more serious risk, seismologists say.

Seismologists long have known human activities can trigger quakes, but they say the science is not developed enough to say for certain what will or will not set off a major temblor.

Even so, there is no shortage of money for testing the idea.

Reicher has overseen a \$6.25 million investment by Google in AltaRock, and with more than \$200 million in new federal money for geothermal, the Energy Department already has approved financing for related projects in Idaho by the University of Utah, in Nevada by Ormat Technologies and at The Geysers by Calpine, just a few miles from AltaRock's project.

Steven Koonin, undersecretary for science at the Energy Department, said the quake issue was new to him, but "we're committed to doing things in a factual and rigorous way, and if there is a problem, we will attend to it."

The tone is more urgent in Europe.

"This was my main question to the experts: Can you exclude that there is a major earthquake triggered by this man-made activity?" said Rudolf Braun, chairman of the project team that the city of Basel created to study the risks of resuming the project.

"I was quite surprised that all of them said: 'No, we can't. We can't exclude it,'" said Braun, whose study is due this year.

"It would be just unfortunate if, in the United States, you rush ahead and don't take into account what happened here," he said.

By the time people were getting off work amid rain squalls Dec. 8, 2006, in Basel, Haering's problems had already begun. His incision into the ground was setting off small quakes that people were starting to feel around the city.

Haering knew that by its very nature, the technique created quakes because it requires injecting water at great pressure down drilled holes to fracture the deep bedrock. The opening of each fracture is, literally, a tiny quake in which subterranean stresses rip apart a weak vein, crack or fault in the rock. The high-pressure water can be thought of loosely as a lubricant that makes it easier for those forces to slide the earth along the weak points, creating a web or network of fractures.

Haering planned to use that network as the ultimate teapot, circulating water through the fractures and hoping it emerged as steam. But what surprised him

that afternoon was the intensity of the quakes because advocates of the method believe they can pull off a delicate balancing act, tearing the rock without creating larger earthquakes.

Alarmed, Haering and other company officials decided to release all pressure in the well to try to halt the fracturing. But as they stood a few miles from the drill site, giving the orders by speakerphone to workers atop the hole, a much bigger jolt shook the room.

"I think that was us," said one stunned official.

Analysis of seismic data proved him correct. The quake measured 3.4 — modest in some parts of the world. But triggered quakes tend to be shallower than natural ones, and residents generally describe them as a single, explosive bang or jolt — often out of proportion to the magnitude — rather than a rumble.

Triggered quakes also are frequently accompanied by an "air shock," a loud tearing or roaring noise.

The noise "made me feel it was some sort of supersonic aircraft going overhead," said Heinrich Schwendener, who, as president of Geopower Basel, the consortium that includes Geothermal Explorers and the utility companies, was standing next to the borehole.

"It took me maybe half a minute to realize, hey, this is not a supersonic plane, this is my well," Schwendener said.

By that time, much of the city was in an uproar. In the newsroom of the city's main paper, Basler Zeitung, reporters dived under tables and desks.

Aysel Mermer, 25, a waitress at the Restaurant Schiff near the Rhine River, said she thought a bomb had gone off.

Haering was rushed to police headquarters in a squad car so he could explain what happened. By the time word slipped out that the project had set off the quake, Loser said, outrage was sweeping the city. The quakes, including three more of more than magnitude 3.0, rattled on for about a year — more than 3,500 in all, according to the company's sensors.

Although no serious injuries were reported, Geothermal Explorers' insurance company ultimately paid more than \$8 million in mostly minor damage claims to the owners of thousands of houses in Switzerland and in neighboring Germany and France.

In the United States, where the Basel quakes received little news coverage, the fortunes of geothermal energy were already on a dizzying rise. The optimistic conclusions of the Energy Department's geothermal report began driving interest from investors, as word trickled out before its official release. In fall 2006, after

some of the findings were presented at a trade meeting, Trae Vassallo, a partner at the firm Kleiner Perkins, phoned Petty, the geothermal researcher who was one of 18 authors on the report, according to e-mail messages from both women. That call eventually led Petty to found AltaRock and bring in, by Petty's tally, another six of the authors as consultants to the company or in other roles.

J. David Rogers, a professor and geological engineer at the Missouri University of Science and Technology who was not involved in the report, said such overlap of research and commercial interests was common in science and engineering but added it might be perceived as a conflict of interest.

"It's very, very satisfying to see something go from theory to application to actually making money and being accepted by society," Rogers said. "It's what every scientist dreams of."

Petty said her first "serious discussions" with Vassallo about forming a company did not come until the report was officially released in late January 2007. That June, Petty founded AltaRock with \$4 million from Kleiner Perkins and Khosla Ventures, an investment firm based in California.

The Basel quake hit more than a month before the Energy Department's report came out, but no reference to it was included in the report's spare and reassuring references to quake risks. Petty said the document had already been at the printer by the fall, "so there was no way we could have included the Basel event in the report."

Officials at AltaRock, with offices in Sausalito and Seattle, insist the company has learned the lessons of Basel and its own studies indicate the project can be carried out safely. James Turner, AltaRock's senior vice president for operations, said the company had applied for roughly 20 patents on ways to improve the method.

Turner also asserted in a visit to The Geysers site last month that AltaRock's monitoring and fail-safe systems were superior to those used in Basel.

"We think it's going to be pretty neat," Turner said as he stood next to a rig where the company plans to drill a hole almost 2½ miles deep. "And when it's successful, we'll have a good-news story that says we can extend geothermal energy."

AltaRock, in its seismic activity report, included the Basel quake in a list of temblors near geothermal projects, but the company denied it had left out crucial details of the quake in seeking approval for the project in California. So far, the company has received its permit from the federal Bureau of Land Management to drill its first hole on land leased to the Northern California Power Agency, but still awaits a second permit to fracture rock.

"We did discuss Basel, in particular, the 3.4 event, with the BLM early in the project," Turner said in an e-mail response to questions after the visit.

But Richard Estabrook, a petroleum engineer in the BLM's Ukiah field office who has a lead role in granting the necessary federal permits, gave a different account when asked if he knew the Basel project had closed because of quakes or it had induced more than 3,500 quakes.

"I'll be honest," he said. "I didn't know that."

Estabrook said he was still leaning toward giving approval if the company agreed to controls that could stop the work if it set off earthquakes above a certain intensity.

But, he said of the Basel project's shutdown, "I wish that had been disclosed."

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