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Deep in Bedrock, Clean Energy and Quake Fears

By JAMES GLANZ

BASEL, Switzerland — Markus O. Häring, a former oilman, was a hero in this 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, as every schoolchild here learns, had been devastated exactly 650 years before by a quake that sent two steeples of the Münster Cathedral tumbling into the Rhine.

Hastily shut down, Mr. Häring's project was soon forgotten by nearly everyone outside Switzerland. As early as this week, though, an American start-up company, AltaRock Energy, will begin using nearly the same method to drill deep into ground laced with fault lines in an area two hours' drive north of San Francisco.

Residents of the region, which straddles Lake and Sonoma Counties, have already been protesting swarms of smaller earthquakes set off by a less geologically invasive set of energy projects there. AltaRock officials said that they chose the spot in 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, including Kleiner Perkins Caufield & Byers, and Google. AltaRock maintains that it will steer clear of large faults and that 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 down because of the earthquake it caused. AltaRock claimed it was uncertain that the project had caused the quake, even though Swiss government seismologists and officials on the Basel project agreed that it did. Nor did AltaRock mention the thousands of smaller earthquakes induced by the Basel project that continued for months after it shut down.

The California 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 American 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 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 W. 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 have long 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 in California, could be that breakthrough. But because large earthquakes tend to originate at great depths, breaking rock that far down carries more serious risk, seismologists say. Seismologists have long known that 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. Mr. 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 has already approved financing for related projects in Idaho by the University of Utah; in Nevada by Ormat Technologies; and in California by Calpine, just a few miles from AltaRock's project.

Steven E. Koonin, the under secretary for science at the Energy Department, said the earthquake issue was new to him, but added, "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 Mr. 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.

Basel's Big Shock

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

Mr. Häring knew that by its very nature, the technique created earthquakes 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 earthquake 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.

Mr. Häring 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, Mr. Häring 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 are also 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," Mr. 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, some refusing to move until a veteran editor barked at them to go get the story, said Philipp Loser, 28, a reporter there.

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

Eveline Meyer, 44, a receptionist at a maritime exhibition, was on the phone with a friend and thought that her washing machine had, all by itself, started clattering with an unbalanced load. "I was saying to my friend, 'Am I now completely nuts?' " Ms. Meyer recalled. Then, she said, the line went dead.

Mr. Häring was rushed to police headquarters in a squad car so he could explain what had happened. By the time word slipped out that the project had set off the earthquake, Mr. Loser said, outrage was sweeping the

city. The earthquakes, including three more above magnitude 3, 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.

Optimism and Opportunity

In the United States, where the Basel earthquakes 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 Ms. 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 Ms. Petty to found AltaRock and bring in, by Ms. 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 that 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," Professor Rogers said. "It's what every scientist dreams of."

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

The Basel earthquake 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 earthquake risks. Ms. 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, Calif., and Seattle, insist that the company has learned the lessons of Basel and that its own studies indicate the project can be carried out safely. James T. Turner, AltaRock's senior vice president for operations, said the company had applied for roughly 20 patents on ways to improve the method.

Mr. Turner also asserted in a visit to the project 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," Mr. Turner said as he stood next to a rig where the company plans to drill a hole almost two and a half 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 earthquake in a list of temblors near geothermal projects, but the company denied that 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 B.L.M. early in the project,” Mr. Turner said in an e-mail response to questions after the visit.

But Richard Estabrook, a petroleum engineer in the Ukiah, Calif., field office of the land agency who has a lead role in granting the necessary federal permits, gave a different account when asked if he knew that the Basel project had shut down because of earthquakes or that it had induced more than 3,500 quakes.

“I’ll be honest,” he said. “I didn’t know that.”

Mr. 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, speaking of the Basel project’s shutdown, “I wish that had been disclosed.”

Bracing for Tremors

There was a time when Anderson Springs, about two miles from the project site, had few earthquakes — no more than anywhere else in the hills of Northern California. Over cookies and tea in the cabin his family has owned since 1958, Tom Grant and his sister Cynthia Lora reminisced with their spouses over visiting the town, once famous for its mineral baths, in the 1940s and ’50s. “I never felt an earthquake up here,” Mr. Grant said .

Then came a frenzy of drilling for underground steam just to the west at The Geysers, a roughly 30-square-mile patch of wooded hills threaded with huge, curving tubes and squat power plants. The Geysers is the nation’s largest producer of traditional geothermal energy. Government seismologists confirm that earthquakes were far less frequent in the past and that the geothermal project produces as many as 1,000 small earthquakes a year as the ground expands and contracts like an enormous sponge with the extraction of steam and the injection of water to replace it.

These days, Anderson Springs is a mixed community of working class and retired residents, affluent professionals and a smattering of artists. Everyone has a story about earthquakes. There are cats that suddenly leap in terror, guests who have to be warned about tremors, thousands of dollars of repairs to walls and cabinets that just do not want to stay together.

Residents have been fighting for years with California power companies over the earthquakes, occasionally winning modest financial compensation. But the obscure nature of earthquakes always gives the companies an out, says Douglas Bartlett, who works in marketing at Bay Area Rapid Transit in San Francisco, and with his wife, Susan, owns a bungalow in town.

“If they were creating tornadoes, they would be shut down immediately,” Mr. Bartlett said. “But because it’s under the ground, where you can’t see it, and somewhat conjectural, they keep doing it.”

Now, the residents are bracing for more. As David Oppenheimer, a seismologist at the United States Geological Survey in Menlo Park, Calif., explains it, The Geysers is heated by magma welling up from deep in

the earth. Above the magma is a layer of granite-like rock called felsite, which transmits heat to a thick layer of sandstone-like material called graywacke, riddled with fractures and filled with steam.

The steam is what originally drew the power companies here. But the AltaRock project will, for the first time, drill deep into the felsite. Mr. Turner said that AltaRock, which will drill on federal land leased by the Northern California Power Agency, had calculated that the number of earthquakes felt by residents in Anderson Springs and local communities would not noticeably increase.

But many residents are skeptical.

“It’s terrifying,” said Susan Bartlett, who works as a new patient coordinator at the Pacific Fertility Center in San Francisco. “What’s happening to all these rocks that they’re busting into a million pieces?”