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Hydroshearing for Geothermal Energy

AltaRock utilizes high-pressure multi-stage pumps engineered specifically for stimulation to induce hydroshearing and increase permeability in both traditional hydrothermal and EGS wells.

A Seattle-based company is banking on a process similar to hydraulic fracturing to unlock a vast resource of potential energy—geothermal heat that could produce steam in abundance for electricity generation.

AltaRock Energy Inc. continues work in 2014 on the Newberry Volcano EGS Demonstration project in Oregon, where the company is using so-called "hydroshearing" to crack apart rocks to enhance the transfer of heat to injected water to produce steam that powers a turbine generating electricity on the surface. The ultimate goal of the enhanced geothermal system, or EGS, project is to develop an economically competitive resource for additional power generation nationally, says AltaRock spokesman David Stowe.

In the popular mindset, geothermal energy often is associated with natural hydrothermal systems in which heated groundwater flows to the surface from geysers and hot springs, which are rare outside national parks.

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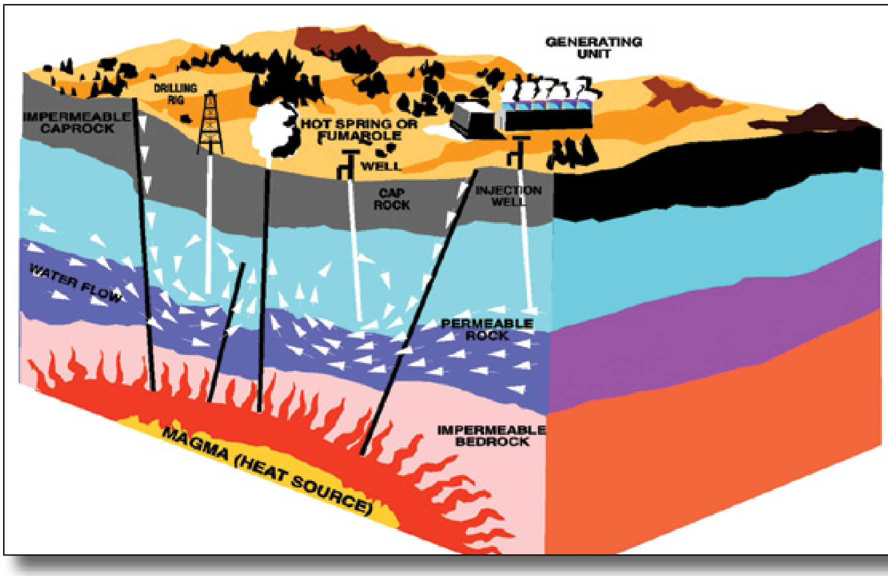
In 2008, Davenport Newberry LLC drilled two 10,000-foot directional geothermal wells on the flanks of the Newberry volcano in hopes of exploiting a natural hydrothermal system for steam to produce electricity, says Stowe. However, two miles below the surface, Davenport encountered temperatures greater that 600˚F but no fluids in largely impermeable rock.

AltaRock and Davenport formed a partnership, and AltaRock proposed using one dry geothermal well for an EGS demonstration project in which cold water would be injected downhole and heated into steam. In 2010, the U.S. Department of Energy awarded a matching grant of $21.5 million to help fund the project.

Harsh weather prevents work on the project during winter, but in summer AltaRock began casing work on the initial test injector well to correct weaknesses identified in earlier stimulation efforts, Stowe explains. Water injected down the well will be captured by a production well planned for next year to channel steam to the surface.

"This year we also plan to put in new stimulation zones at depth to make a larger reservoir," Stowe says. The well is cased to about 6,300 feet and has a total depth of about 10,000 feet, with hydroshearing being used in open



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hole below the casing where rock temperatures are hotter. Surface hole diameter is about 30 inches, narrowing to 8 inches at deeper depths, Stowe says.

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While hydroshearing is similar to hydraulic fracturing, there are key differences, he points out. Fracturing is done at high pressures to produce tensile fractures held open by proppant to allow as much natural gas or oil as possible to flow into the wellbore from shale and other tight rock. But hydroshearing cracks apart rocks largely using water without proppant injected at lower pressures, ranging from 1,500 psi to around 2,300 psi.

"Around the 2,100 psi range is where most of the shearing has taken place," Stowe relates.

The process slightly pries open existing cracks in the rock, to around 1 millimeter. The cracks effectively slip open to create additional permeability, with the surface of the cracks slightly offset and uneven from the slippage, which prevents closure. Large cracks and excessive permeability would allow water to pass through the system too quickly and prevent adequate water heating.

"The process squeezes open, by high pressure, water joints that would slip anyway and the slippage doesn't have to be by much," says Jefferson Tester, Croll Professor of Sustainable Energy Systems in the School of Chemical and Biomolecular Engineering at Cornell University. "Because the rocks have rough surfaces, the cracks are propped open naturally and don't close on top of each other when pressure goes back to least principal stress."

The stimulations are done for both injector and producer wells, with producer wells sited to best intercept fracture planes opened up by the stimulations, explains Stowe.

AltaRock is incorporating another technique from fracturing by performing the hydroshearing method in stages. While multi-zone stimulation can utilize mechanical devices to isolate zones, AltaRock uses a patented thermally degradable polymer to seal off zones after stimulation. Hydroshearing is then done in zones, or fracture planes, uphole. After the zones are stimulated, the heated water eventually dissolves the polymer, largely into carbon dioxide and water, Stowe says.

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"Since you are pumping cold water with pressure, the water is cool enough to not degrade the material while you are performing additional stimulations, but it's still pretty warm down there," he observes. "As you go deeper it gets hotter, but we have different formulas of the diverter for higher temperature ranges."

Multi-stage stimulation can increase reservoir size and energy production, he says.

"With these multi-zones, you are basically stacking up stimulation zones on top of each other in a single well, and you can multiply the amount of power you produce on the surface from the additional steam," he relates. "With two more injector wells on a pad and six or more producers, we should be able to produce anywhere from 35 to 50 megawatts of power from that pad. We would go from about 5 megawatts from a single-zone EGS to 35 to 50 with very similar capital expense. With multi-zone stimulation, it reduces the price of the power because you can produce more of it. If you spend $50 million and you get 50 megawatts, that's better than spending $30 million and getting six megawatts."

The company plans to develop a model to demonstrate the economic feasibility of EGS projects, especially in the western United States where heat below ground is closer to the surface.

Geothermal currently provides about 1 percent of U.S. energy, says Stowe, but making the resource economical would allow it to become a more significant part of the U.S. energy mix.

If the resource can be made economical in the competition with coal and natural gas for boiler fuel, its broad power generation potential could, over the long-term, range from 500 gigawatts to more than 5,000 gigawatts, which is about five times the consumption of the United States, Stowe believes.

While there is no technological issue that prevents EGS development, proving commercial viability is a major challenge, Tester says.

"This has been successfully done at a number of sites around the world, but the question is now you have to make it big enough to flow fast enough for a long enough period of time to make it economical," Tester relates. "In a sense, a lot of the early feasibility ideas of being able to open up permeability between an injector and producer well were done quite a while ago, but the central issue is that you must have the appropriate productivity of that system. You could view in terms of well pairs or a well field that has to produce a certain amount of fluid based on the investment in order to make this thing competitive in today's energy markets. This is without subsidy or anything like that. That's a pretty tall order. It depends a lot on prices for competing fuels for generating electric power."

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Getting the most out of geothermal could eventually mean somehow combining traditional geothermal systems that provide heat with power distribution systems, he says, although district heating systems could be impractical in more remote portions of the western United States.

In the meantime, further development of geothermal for power generation requires additional, consistent funding, something that has not been the case, Tester says.

"The Department of Energy and predecessor agencies have lumped all alternative energy programs together under one umbrella and that's made it very tough for them to appreciate the kind of contingency and risks associated with geothermal development," Tester states. "Government funding has gone up and down, but you can't effectively fund this on a year-to-year basis. Funding planning needs to be more long-term. We have a situation where we can develop EGS for our own good. Even if you are not a climate change person, we need to look at alternative energy sources as we consume fossil fuels so quickly and consider energy supplies for future generations."

EGS won't solve our energy problems or provide enough to offset other sources of energy, but it's definitely a start.