Geothermal Powerhouse

The subducting Farallon plate gives the Pacific Northwest its volcanoes and a reservoir of untapped geothermal potential. Scientists have only now begun to evaluate its vast energy-producing prospects.


Oregon State Department of Geology and Mineral Industries

Newberry Crater, Deschutes National Forest, Ore., is a recreation area and a hot geothermal prospect as well.

By ALLAN CHEN

Among the many residents of Washington, Oregon, northern California and southwestern British Columbia are a few old-timers addressed only by surname who keep silent, brooding watch over the land. Of those, Mt. Lassen, Mt. Shasta, Mt. Mazama (Crater Lake), Mt. Rainier, Mt. Hood, Mt. Baker and Mt. Meager generally hold their peace. At least one, Mt. St. Helens, is famous in recent years for repeatedly losing its fiery temper and causing all manner of trouble for its mortal neighbors.

Mt. St. Helens's outbursts had at least one good effect. They helped focus attention on the Pacific Northwest's reserves of geothermal energy. A few scientists believe that these reservoirs are so large they would make the Pacific Northwest the largest geothermal resource area in the world. Other scientists hold more modest opinions but still say that in spite of currently depressed world oil prices, there are enough possible high-quality geothermal source areas to make exploration worthwhile. And even as scientists, state officials and the energy industry eye the area's geothermal possibilities with interest, environmentalists wonder out loud what effect geothermal energy development might have on the Pacific Northwest's fabled forests and other natural wonders.

The most sought-after geothermal sources are the high-temperature ones that are hot enough to turn the turbines of electrical generators — areas where the water is at least 180°C and preferably hotter than 200°C. Even better are the hot dry steam sources that can generate power directly with no need to convert hot water to steam first, but they are the rarest form of geothermal energy.

Geothermal power is already being produced at the Geysers Field, 75 miles north of San Francisco, and at the Salton Sea and Brawley plants in southern California. The Geysers plant is the only facility that currently harnesses steam for power generation in the United States. This mid-California geothermal field has been producing power since 1960 when Pacific Gas and Electric Co. established an 11-megawatt power station there. Operated jointly with Union Oil Co., the field now produces 1,137 megawatts of power, or about enough to satisfy the energy needs of more than one million people. This is enough to serve San Francisco and Oakland combined.

The Geysers field was recognized early on as a convenient, usable energy source at a time when no one was scrambling for alternatives to fossil fuels. The great volcanoes to the north had to wait for oil price hikes, two important geothermal finds and recognition by geologists of their significance.

No one, however, has yet made any plans to build plants in the Pacific Northwest, although interest in further exploration by the energy industry and among scientists is high. Pinpointing the most promising geothermal sources is not easy. Some possibilities, like Crater Lake, Mt. Lassen and Mt. St. Helens, are protected areas (national parks, monuments or Indian reservations) and, as such, unavailable for exploration. Other areas, which might be too low in temperature to generate steam for electricity, contain warm water that could be used in homes and offices for hot water space heating systems.

John W. Hook, a consulting geologist in Salem, Ore., and one of the region's biggest geothermal advocates, says, "We have a chain of volcanoes from Mt. Meager [British Columbia] to Mt. Pleasant in California 700 miles long. This is one of the largest potential sources of energy in the world." In spite of this, there are only four areas that have been tested.

Two of these areas have yielded important finds. One is Mt. Meager in British Columbia, where B.C. Hydro drilled shallow "thermal gradient boreholes" to measure the change in temperature as a function of depth. They found dry steam of more than 200°C at the relatively shallow depth of 370 meters. B.C. Hydro has since decided to do deep drilling to evaluate their find's energy-producing potential. They are now reviewing these results, and a company spokesman said they might have an announcement within a few weeks on whether they will go ahead with Canada's first geothermal power plant.

The second site is Newberry Crater in Oregon. There, in 1981, the U.S. Geological Survey found dry steam of between 270°C and 300°C at 3,100 feet. The find has attracted the eyes of U.S. energy companies and has already begun to stir an environmental debate. Several energy companies, including Sunedco and Union Oil, have acquired or are interested in acquiring leases in the area, according to Hook. Newberry Crater is not really a crater but a caldera, a volcanic collapse depression shaped like a cirque or a round basin. It probably formed during an eruption of an ancient volcano, when the walls of the volcano's cone collapsed. The volcano became inactive and the caldera filled with water, but magma bodies probably still reside at depth and furnish the area's high heat flow and hot springs.

The Newberry Crater is an attractive searching ground because, like Crater Lake, it is the site of geologically recent volcanism. Geologists have made several estimates of how much power the area could produce. The U.S. Geological Survey calculated possible output at 740 megawatts (enough to supply 800,000 people with electricity) for 30 years. Using the heat flow data along with other measurements of the magma body beneath the caldera, Jerry Black of Oregon's Department of Geology estimates about twice that figure — 1,316 to 1,843 megawatts for 30 years. Even higher estimates are possible, depending on how conservatively the geologists have estimated the magma's volume. The 30-year figure is an approximate rule of thumb for the life of a producing geothermal borehole. "Nobody really knows what happens after 30 years," says Black, although they might only have to drill a new borehole some distance away to tap into an unused part of the reservoir.

But drilling in itself can present problems. The geothermal energy of the earth is in principle inexhaustible, since the earth's mantle and core contain so much heat that the rocks below the crust are fluid. A commercial geothermal field fueled by magma or rock that is hotter than surrounding rocks might not cool for millennia. But the drillhole might degrade a portion of the reservoir where it surrounds the hole by fracturing sidewall rocks and depleting them of the hydrothermal fluids that carry the heat. Geothermal plants have not been operating long enough for geologists to understand the effect, but they don't see it as a serious short-term obstacle to geothermal development.

The long-term depletion of geothermal boreholes is not a factor at present, especially when there are so many areas that have yet to be explored for geothermal energy. Geologists believe that Oregon holds the most promising source areas, followed by California, which possesses the Medicine Lakes caldera. In Washington, outside of protected areas like Mt. St. Helens, the best target is Mt. Baker, according to geologist Mike Korosec of the state's Department of Natural Resources. Seattle City Lights, the public utility company, is planning to buy leases for exploration there.

No one really knows why Washington seems geothermally less promising than Oregon, but one man who may have an answer to this question and to others concerning the Northwest's heat sources is David Blackwell of Southern Methodist University in Dallas, Tex. Blackwell and his colleagues have been studying heat flow and volcanism in northern Oregon, especially the northern Cascade Range. Measurements show that heat flow increases from the Western Cascade Range to a maximum in the High Cascade Range in the east. The Cascades are divided into these two provinces by an irregular boundary that separates younger rocks in the higher elevations of the High Cascades from older, lower units in the Western Cascades. The entire range began to form in Oligocene times (38 million years ago) and has continued forming up to the present.

The Cascades may be rich in geothermal sources because of the plate tectonic processes that caused their birth. They probably formed as the once-mighty Farallon Plate, an oceanic slab of rock eight to eleven kilometers thick, forced itself (subducted) beneath the North American continental plate and melted as it went deeper into the earth's mantle, the fluid zone just below the crust. The whole Pacific coast was once a subduction zone where the Farallon Plate and others that no longer exist were subducted into oblivion by the less dense, overriding North American plate. The Pacific Plate, these older plates' present-day successor, slides horizontally by the North American Plate, forming the San Andreas Fault, except off the coast of the Pacific Northwest where the last remnant of the Farallon Plate is going under. As it does, it melts, and some of the less dense magma from the melting plate rises to the surface, burning holes through the North American Plate and forming volcanoes. Oregon's Cascades, says Blackwell, are a volcanic arc whose formation is related to the Farallon Plate's subduction.

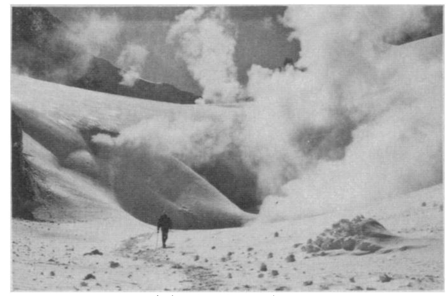
From heat flow measurements and other kinds of data, Blackwell and his colleagues have drawn a controversial conclusion about the Cascades: that there is a vast and relatively shallow "hot, low-density region about 60 km [long] in the crust below 7 to 10 km."

"People previously had the idea the magma chambers were under volcanoes. Our results suggest that the whole area is very high-temperature at very shallow depth," says Blackwell, referring to the 30 by 60 square kilometers of the Cascades.

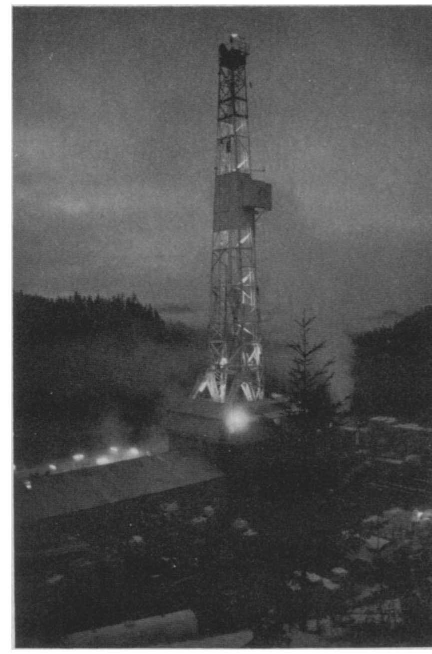
If this were true, and if there were hot water circulating just above the high temperature zones at 10,000 to 12,000 feet, then almost any part of the Cascades might supply geothermal energy, and the range would be the world's largest known geothermal resource. Blackwell adds he believes that if this high temperature zone extends any farther north into Washington, it is probably not as shallow or as hot.

Some scientists greet these results with skepticism. Korosec, for one says: "Where they have put down holes near volcanoes, of course they have found high heat flow. The question is, is there any high heat flow in between these areas?" He also believes that if this zone is underneath Oregon, it is also underneath Washington. "But someone has to give me proof that it's there at all."

If the Cascades are a geothermal powerhouse, there might one day be dozens of power plants nestled snugly among its hills, turbines churning and power lines crackling with renewable electricity for northwestern habitations. Yet the image is probably unrealistic. Abundant as geothermal sources are, they are hard to locate. Loosely compacted volcanic sediments disperse heat and give incorrectly low values for heat that might lie below. Moreover, drill crews searching for a geothermal reservoir are likely to hit the water table instead. This shallow feature, source of many a farmer's well water, causes two problems. It masks, by dispersion, heat flowing up from deeper levels, and, if the crew drills more deeply after hitting it, this water might pour down the hole, contaminate and destroy steam sources that lie below. Consequently, drilling has to be done slowly, carefully and in geographically deeper areas such as valleys or depressions that are below the regional water table.


U. S. Geological Survey, Tacoma, Wash.

Fumaroles at Mt. Baker, Wash., hint at powerful geothermal sources beneath.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A geothermal test well at Breitenbush Hot Springs, Ore.

Drilling endangers more than the reservoir itself. It has environmental effects as well, and the severity of those effects depends on how much drilling and development an operator expects to do. The adverse environmental effects of drilling include noise, traffic, hydrogen sulfide odor (the rotten egg smell from dissolved gases in geothermal fluids) and the possible disruption of wildlife habitats and migration routes from the construction of access roads. Environmentalists — primarily the Sierra Club—in the Pacific Northwest gen-

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erally welcome geothermal development as an alternative to its more environmentally destructive relatives, fossil fuels and nuclear power, but they have made it clear that in the coming months they will be watching the leasing agencies—the Forest Service and the Bureau of Land Management (BLM)—and energy companies like hawks to ensure that exploration is carried on with minimal environmental effects. Fred Hersh, Geothermal Coordinator for the Club's Oregon chapter, explains: "The key issue is how much right to development goes to the operator when the lease is issued."

The fact that such leasing requires no environmental impact statement after exploration but before construction of a plant alarms Hersh because the Geothermal Leasing Act of 1970 does not clearly establish what rights go along with leasing. According to Hersh, Union Oil has argued that once the lease is issued, it carries an unconditional right to develop the source. Moreover, geothermal leases do not expire after a set time period if no sources are found on the property, as they do with oil and gas leasing. The Forest Service dropped a so-called Conditional Development Stipulation from its lease arrangements — no development to be allowed if the environmental impact is too great — because of industry's objections. Spokesmen for Union Oil had no comment on the geothermal leasing process when contacted by SCIENCE NEWS.

The Sierra Club has already lost two administrative appeals within the Forest Service to block leases for the Fort Rock Ranger District in central Oregon and the Clackamas Geothermal Block in Mt. Hood National Forest. They are currently waiting on appeals to block leasing in the non-wilderness area part of Oregon's Willamette Forest, and the Mt. Hood Geothermal Block of Mt. Hood National Forest. Sierra Club officials say they are not planning any legal actions on these appeals.

A second hazy area in the leasing process concerns the national wilderness areas. According to Hersh, all wilderness areas created before 1970, when the Geothermal Leasing Act was passed, will not be open for leasing. However, in the opinion of Interior Department's Solicitor William Coldiron, those created after 1970 can legally be leased. The Forest Service has thus far held back on leasing present wilderness areas or those under consideration for wilderness status while BLM has offered similar lands under its control for leasing if the operators restore the areas after they are through.

The Solicitor's opinion puts into question the leasing of the Northwest's hottest geothermal gem: Newberry Crater. A post-1970 wilderness area, it boasts two lakes as well as fishing and hunting grounds. The Forest Service has issued a proposal that would open the outer flanks of the caldera to leasing and leave its interior, including its lakeside portions, untouched. The comment period on this proposal is now over, says Greg McClarren of the Forest Service's regional office at the Deschutes National Forest where Newberry is located. He believes the Forest Service will decide early next year at the latest if they will go with this plan.

A second geothermal prize under a cloud of uncertainty is Mt. Lassen National Forest, Calif. Although the national park of the same name is off-limits, the surrounding national forest is available for leasing, according to Hamilton Hess, Geothermal Coordinator in the National Energy Committee of the Sierra Club. He feels that development in the buffer zone of the national forest could adversely affect conditions within the park itself, and that parts of the forest and hotsprings, fumaroles and natural geothermal features in the park's southwestern corner are endangered by drilling.

Their fears that geothermal exploration might endanger hot springs, geysers and related phenomena may not be groundless, in the view of some geologists. The geyser field near Beowawe, Nev., was active and healthy until exploratory drilling in the early 1970s depleted its underground steam reservoirs. Although some springs remain, the geysers there are now dead.

No one can yet say just how much the environmentalists have to fear from geothermal development in these sensitive areas. Oil prices are low and geothermal power is not competitive just now. But, says Hook, "there is a surplus of energy that I think is momentary." Geothermal power is easier to work with than nuclear power, since utilities have to predict power demand 10 or more years ahead to determine if they want a large nuclear plant, while a geothermal plant can be brought on-line quickly: "If we make a discovery ... there are off-the-shelf systems that can be mounted in a four-month period," says Hook. The number of small 10-megawatt plants like these could be increased as demand grows. "Geothermal is something that you could bring on in small increments of power," Hook says. "You can bring those plants on-line as they're needed."

Black predicts a rosy future for geothermal. Although no more than 50 megawatts should be on-line in Oregon before 1995, he says that "in the long run geothermal could supply a significant amount of energy in Oregon." But, he cautions, "unless oil prices skyrocket, geothermal development will slow down."

Commercial development of geothermal energy might even be worthwhile in spite of the economy if, as Hook believes, it could reduce U.S. dependence on foreign sources: "These are resources that are available in significant enough quantities to make some kind of impact on energy supplies in the U.S." □

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