Cascadia
News and information from the Oregon Department of Geology & Mineral Industries
Volume 5, Number 1 www.OregonGeology.com Spring 2007

# Geothermal energy in Oregon

*Renewable energy is hot. On May 23, 2007, passage of Senate Bill 838 in the Oregon State House of Representatives established a Renewable Energy Standard that 25 percent of Oregon's electricity come from renewable sources by 2025.*

*"That puts geothermal energy back in the mix as a viable energy source," says Dr. Vicki McConnell, State Geologist for the Oregon Department of Geology and Mineral Industries (DOGAMI). "Geothermal resources are available in many areas and are suitable for many different types of uses. In fact, these resources are being used for small applications across the state."*

*A 2003 U.S. Interior Department report identified seven sites in Oregon as among the 35 "highest potential" geothermal regions in the country. The sites include Newberry Crater near Bend — the location of past geothermal exploration — and the Klamath Falls, Lakeview, Crump Lake, Summer Lake, Malheur River, and Vale areas of southern and eastern Oregon.*

*"Because DOGAMI is the state agency responsible for regulation of geothermal exploration and production, we're ready to help in any way," notes Robert Houston, Natural Resource Specialist who oversees the oil, gas, and geothermal program for DOGAMI. "Our oversight includes supervision of drilling, abandonment, and reclamation of geothermal wells. We make sure, from the state's point of view, that geothermal development is done right."*

*Oregon does not currently generate commercial electricity from geothermal energy, but a report in the Renewable Energy Atlas of the West (2002) lists potential power generation from geothermal energy at 17 million megawatts per hour per year (MWh/y) — about one third of the state's total current energy output.*

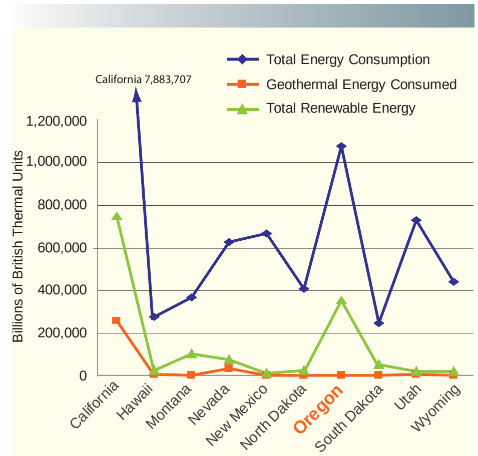
*"We have 40 years worth of geothermal studies in Oregon, so DOGAMI is ready to act when the opportunity arises," says McConnell.*

*Find out why Oregon's renewable geothermal resources are hot in this issue of* Cascadia.

The city of Klamath Falls, Oregon, has its own geothermal district heating system. The Downtown Streetscape Urban Redevelopment Projects expanded the use of the geothermal sidewalk snowmelt system for many businesses along Main Street, including the nation's only geothermally heated passenger transfer area and bus stop area. Above: Laying snow melt tubing. Below: Winter sidewalks are hot enough to fry an egg! Actually, the snow melt system was designed to maintain a slab surface temperature of 3°C (38°F). (Photos: above, Geo-Heat Center; below, City of Klamath Falls Public Works.)

***In this issue:***






Source: http://database.nationalpriorities.org/, 2001 data

**Oregon is a leader in developing renewable resources in the west, but given the state's abundant geothermal resources, much more could be done.**

# Notes from your State Geologist

## —*Interest in geothermal energy heats up*

*by Vicki S. McConnell, Oregon State Geologist*

Making renewable energy available for Oregon's increasing electrical power needs is an ongoing challenge. Governor Ted Kulongoski urged the Legislature to take the road forward and support Senate Bill 373 (SB 373), which establishes Renewable Portfolio Standards (RPS). The RPS uses an energy program and policies to help drive the diversification of the state's energy portfolio.

SB 373 was replaced by SB 838, and a version of SB 838 was passed by the Senate April 10, 2007. An amended version of SB 838 was passed by the State House of Representatives May 23, 2007. To learn more about path of the RPS for Oregon, visit http://www.oregon.gov/ENERGY/RENEW/RPS_home.shtml.

An RPS fosters market demand and essentially makes the state's utilities meet a specific renewable capacity requirement. Its purpose is to play a role in developing an emerging market for a renewable resource mix, "green" power, with a power generation capacity of 25 percent by 2025. Oregon won't be alone if it adopts RPS. In fact, 23 other states have enacted their own RPS, each requiring some portion of the state's energy supply be met with new renewable energy sources.

According to the Renewable Energy Atlas of the West (http://www.energyatlas.org/PDFs/atlas_final.pdf), our state, which currently does not generate any electricity from commercial geothermal power plants, has the potential to yield 17-million MWh/yr (potential megawatt hours generated per year) of new electric power. The resource is plentiful in the Cascade Range and throughout the southern portions of the state (see the geothermal resources map on pages 6-7 and zones for geothermal development on page 9). Our geothermal resource offers the opportunity to obtain a clean electric supply, providing reliable and predictable base-load power and peak-load power. That is why harnessing geothermal energy as a power source for electrical generation is important to Oregon's renewable energy mix. Additionally, geothermal also presents the ever-increasing opportunity for direct-use applications within specific geographic areas. Some geothermal resource uses and projects are shown on page 4.

DOGAMI, the Bureau of Land Management, and the U.S. Forest Service have worked together since 1975 to facilitate geothermal development in Oregon. Projects including heat flow and exploratory drill holes throughout the state and the Newberry Project in central Oregon have resulted in a better understanding of Oregon's geothermal potential.

The main obstacle to generating electricity using geothermal resources is that currently it costs more to develop geothermal resources than other sources of electricity. Financial incentives, such as those available for wind-generated electricity, could help both individual consumers and commercial power suppliers develop geothermal assets. Some incentives are described on page 8.

The Oregon Renewable Energy Action Plan (http://www.oregon.gov/ENERGY/RENEW/docs/FinalREAP.pdf), prepared by the Oregon Department of Energy for Governor Ted Kulongoski, provides the following instructions for DOGAMI.

To promote direct use, DOGAMI, in cooperation with the Departments of Energy, Forestry, and State Lands, will:

- Work with the GeoHeat Center and others to provide copies of existing maps detailing the geothermal resource potential of Oregon and incorporate additional information into the database as new information becomes available.
- Periodically publish updated geothermal resource maps of Oregon as additional data availability and demand require.

Further, to promote generation of electricity, DOGAMI will sample and analyze waters from wells and springs throughout the state to develop a statewide database useful to the geothermal industry, state and federal agencies, and research institutions as a valuable component in geothermal resource target evaluation in Oregon, provided funding can be obtained. (This has been done in Nevada with positive results.) Funding support will be sought from a number of sources, including the state and U.S. Department of Energy grants.

The geothermal regulatory program at DOGAMI is similar to that of the oil and gas program. Geothermal accomplishments are like those of oil and gas and have been successfully handled by the program. In the case of geothermal activity, care is given to work closely between public and private interests due to the sensitivity of where certain geothermal activity has occurred.

For more information on DOGAMI's Geothermal Regulatory Program, contact:

Bob Houston
Natural Resource Specialist
Mineral Land Regulation and Reclamation Program
229 Broadalbin Street SW
Albany, OR 97321
phone (541) 967-2080
email: robert.a.houston@mlrr.oregongeology.com

# What is geothermal energy?

The word "geothermal" is derived from the Greek "geo," meaning earth, and "therine," meaning heat. Geothermal energy means the natural heat of the Earth that flows out from the Earth's interior.

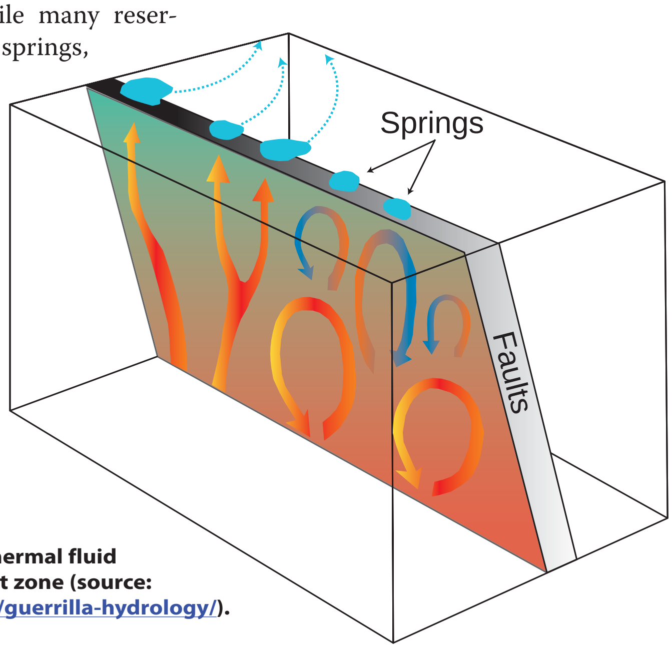
A geothermal system is made up of three elements — a heat source, a reservoir, and a fluid — that constitute a geothermal resource. Geothermal resources are found in regions where the Earth's crust is thin or fractured and where magma bodies are close to the surface — all of which are present in Oregon. Pressurized water that makes its way through faults, rock fractures, and pores to an underground heat source turns into boiling water or even steam. Hot springs, geysers, and steam vents (fumaroles) are naturally occurring examples of geothermal water traveling to the surface.

Those who want to use geothermal energy focus on finding a resource or natural geothermal reservoirs accessible to drilling; the shallower the areas of hot rock and water, the better. A "reservoir" is an area where steam and hot (boiling) water are naturally heated and then trapped. Geothermal reservoirs are generally found in areas of past volcanic activity and in mountain ranges, each bordered by underground faults. While many reservoirs are marked by hot springs, geysers, and steam vents, others exhibit no surface signs.

Today, we drill wells into geothermal reservoirs to bring the hot water to the surface. Geologists, geochemists, drillers, and engineers explore and test to locate underground areas that contain geothermal water. When hot water and/or steam are found, they can be used to generate electricity in geothermal power plants or for energy-saving nonelectrical purposes.

Geothermal fluids can be classified into three categories:

- High-temperature, magma-related, resources that usually have temperatures of 200°–350°C (392°–662°F) at economically drillable depth.
- Moderate- to low-temperature resources of nonmagmatic origin, usually associated with deep faults. Maximum temperatures at drillable depth do not exceed 140°C (284°F) and are often less. These resources are more widespread than the high-temperature resources.
- Very low temperature resources, which are widespread but close to or higher than the ambient temperature of 20°C (68°F).




**Conceptual model of geothermal fluid circulation in an active fault zone (source: http://www.sci.uidaho.edu/guerrilla-hydrology/).**

*Cascadia* is published by the Oregon Department of Geology and Mineral Industries
800 NE Oregon Street, #28,
Suite 965, Portland, OR 97232
(971) 673-1555 FAX (971) 673-1562



State Geologist - Vicki S. McConnell
Assistant Director - Don Lewis
*Cascadia* Editor - Deb Schueller
Special contributor to this issue - Clark Niewendorp

Mineral Land Regulation and Reclamation Program:
229 Broadalbin Street, SW, Albany, OR 97321
(541) 967-2039, FAX (541) 967-2075
Gary W. Lynch, Assistant Director

Baker City Field Office:
1510 Campbell Street, Baker City, OR 97814
(541) 523-3133, FAX (541) 523-5992
Mark L. Ferns, Regional Geologist

Coastal Field Office:
313 SW 2nd Street, Suite D
Newport, OR 97365
(541) 574-6642, FAX (541) 265-5241
Jonathan C. Allan, Coastal Team Leader

Grants Pass Field Office:
5375 Monument Drive
Grants Pass, OR 97526
(541) 476-2496, FAX (541) 474-3158
Thomas J. Wiley, Regional Geologist

The Nature of the Northwest Information Center:
800 NE Oregon Street, Suite 177
Portland, OR 97232-2162
(503) 872-2750, FAX (971) 673-1562
Donald J. Haines, Manager
Internet: http://www.NatureNW.org

For a free copy of this and past issues of *Cascadia*, visit www.OregonGeology.com or call (971) 673-1555

PRINTED ON RECYCLED PAPER

# Geothermal resource uses

| low temperature less than 90°C (194°F) | moderate temperature 90°C-140°C (194-284°F) | high temperature greater than 140°C (284°F) |
|---|---|---|

*Uses for low- and moderate-temperature resources can be divided into two categories: ground-source heat pumps and direct use.*

***Ground-source heat pumps*** use the earth or groundwater as a heat source in winter and a heat sink in summer. Using resource temperatures of 4°C (40°F) to 38°C (100°F), a heat pump transfers heat from the soil to the building in winter and from the building to the soil in summer.

***Direct use*** involves using the heat in the water directly, without a heat pump or power plant. Direct use projects generally use resource temperatures between 38°C (100°F) and 149°C (300°F). Current U.S. installed capacity of direct use systems totals 470 MW, or enough to heat 40,000 average-sized houses.

Low-temperature water produced from wells found throughout Oregon offers opportunities for direct-use applications. Direct-use applications are typically composed of the same three components common to geothermal power plants (see facing page). Instead of a turbine turning an electrical generator, a direct-use application uses a mechanical system—piping, heat exchanger, and controls—that delivers heat to the space or process.

Geothermal heat sources in several Oregon counties supply heat for direct-use applications. These applications include district heating and industrial process heating such as commercial greenhouse heating and temperature control of water for bathing and swimming and for fish farming.

In the early 1980s, Klamath Falls developed a district heating system, which provides hot-water heating to government buildings, 20 commercial buildings, a seeding greenhouse; the system even de-ices sidewalks and bridges. The City's system has since been complemented by geothermal heating of the County's justice and health complex. A direct-heating system also heats 11 buildings at the Oregon Institute of Technology. Outside Klamath Falls, a greenhouse/aquaculture farm, hot springs spa/resort, and hundreds of individual hot-water heating systems tap into the underground hot-water resource.

The new Oregon Correctional Department's state prison in Lakeview is the latest facility to use geothermal heating. The city's swimming pool is heated in this way, too. Also tapped for geothermal heat are a greenhouse, corn drier, and a slaughter house near Vale. A mushroom plant along with nearby homes and a swimming pool use the same Vale-area hot-water source.

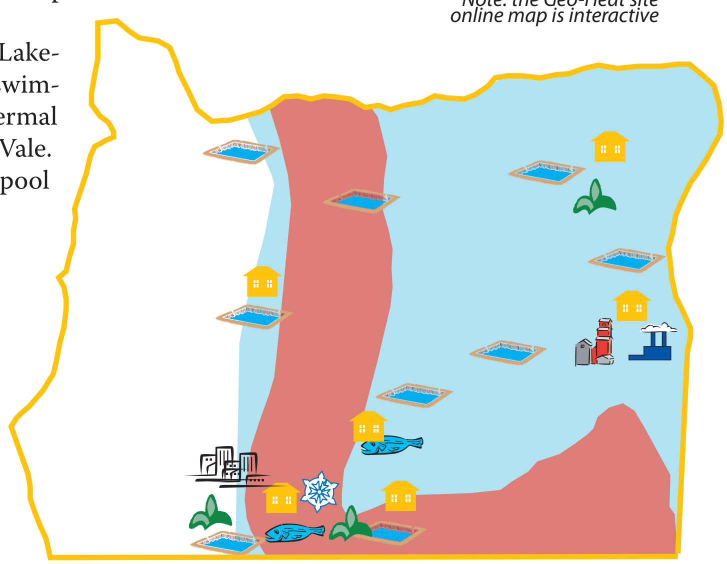
***Electric power generation*** is the main use for high-temperature resources. Current U.S. geothermal electric power generation totals approximately 2200 MW or about the same as four large nuclear power plants.

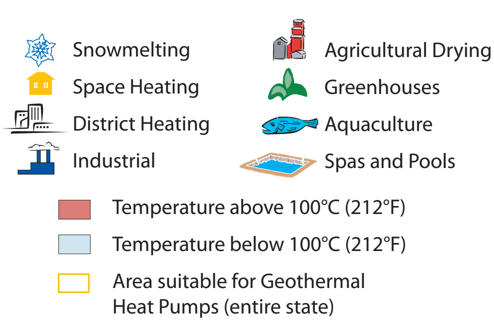
Oregon currently has no geothermal power plants, but Nevada Geothermal Power, Inc. (http://www.nevadageothermal.com), Davenport Power, LLC (http://www.davenportpower.com), and U.S. Geothermal, Inc. (http://www.usgeothermal.com) are looking in the state. Their respective areas of interest are Warner Valley (Crump Geyser, Lake County), Newberry Crater area (Deschutes County), and Neal Hot Springs (Malheur County).

## Oregon geothermal projects

map modified from
http://geoheat.oit.edu/state/or/or.htm

*Note: the Geo-Heat site online map is interactive*





# How does a geothermal power plant work?

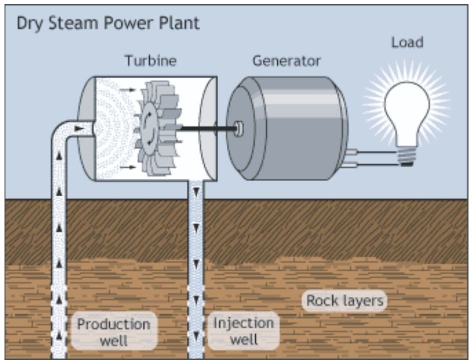
Commercial power plants need steam to generate electricity. Even nuclear power plants run on steam. A geothermal power plant is no exception — a turbine is driven by steam, which then drives a generator to produce electricity. Steam can be supplied in three ways: directly as dry steam, as flash steam, or as binary-cycle power units.

All geothermal power plants share three basic components:

- A production system — a production well brings hot water or natural steam to the surface, where the fluid is piped to the power plant.
- A power system — hot, pressured geothermal fluid (natural steam or flashed steam) or a secondary working fluid (hence "binary") drives the turbines and generates electricity.
- A disposal system — an injection well returns the spent (cooled) water to the geothermal reservoir, where the water is reheated so it can be used again.

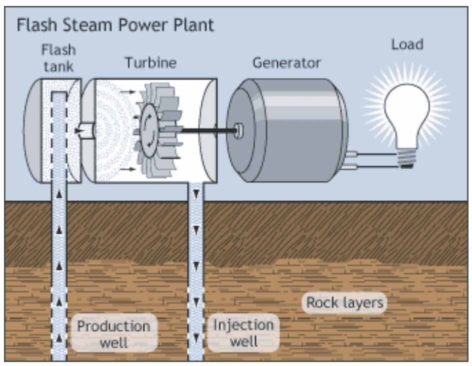
Another approach, called an Enhanced Geothermal System (EGS), is still in the experimental stage. In this technology, heat is extracted by means of circulating water from a deep surface well (probably to depths of 1.5 to 10 km (about 1 to 6 miles), through fractured rocks that have been stimulated to let water flow through (an artificial heat exchanger), with the superheated water returning to surface through a second well. This technology, or heat mining, may be a means of tapping into the enormous thermal energy stored in the Earth's crust. You can read more about EGS in a new study sponsored by the U.S. Department of Energy (DOE) and led by the Massachusetts Institute of Technology (http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf). The report finds that within 50 years development of geothermal resources, such as EGS, could potentially generate 100,000 megawatts of power, or roughly one tenth of the total generating capacity that exists in the United States today.

*Geothermal systems have a small footprint and virtually no emissions — not even carbon dioxide.*



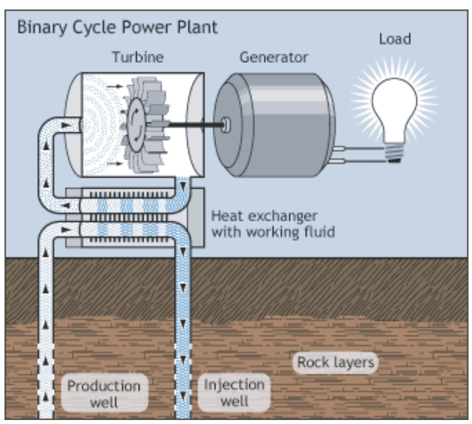

### *Dry steam power plant*

*Pipes carry natural steam from the production wells to the plant, where steam directly powers the turbine generator to make electricity. The steam is condensed by evaporation in the cooling tower, and the cooled water is pumped down an injection well to sustain production.*




### *Flash steam power plant*

*Flash-steam technology is generally employed when the temperature of a geothermal fluid system is 177°–182°C (350°–360°F) and the fluid is in liquid form rather than stream. In order to "flash" or vaporize the fluid into steam, the fluid is pumped to the surface in a pressurized well and sprayed into a tank held at a much lower pressure. The steam then drives a turbine coupled to a generator to produce electricity. A more complex flash-system plant utilizes a second tank that can extract 20–30% more power from the remaining fluid.*




### *Binary-cycle power plant*

*The binary-cycle power plant employs a heat exchanger that contains a binary fluid, usually an organic fluid, such as iso-pentane or even refrigerant (R-134a) that has a boiling point lower than water's. Heat from the geothermal water is transferred to the heat exchanger and causes the binary fluid to "flash" and vaporize. The vapor (steam) is routed to the turbine and expands, driving an electric generator, then cools back into a liquid form and is passed over the geothermal water repeatedly in a closed-loop cycle. Likewise, the used geothermal water is in a closed-loop cycle and is injected back into the geothermal reservoir.*

Source: U.S. Department of Energy
http://www1.eere.energy.gov/geothermal/powerplants.html

***Did you know?*** The Oregon Institute of Technology (OIT) has submitted proposals to drill a geothermal well (1525 m, or 5,000 ft) to tap the Klamath Falls known geothermal resource for a geothermal power plant for OIT. OIT's plan is to use the geothermal resource to generate OIT's own source of electricity. The plant would also function as a teaching tool for geothermal developers.

Oregon Institute of Technology

# Oregon's Geothermal Resources

## Geothermal Categories

- Greenhouse
- Space heating
- District heating
- Aquaculture
- Spa/Resort/Recreation site

- Well >50˚C
- Spring >50˚C
- Well ≥20 and ≤50˚C
- Spring ≥20 and ≤50˚C

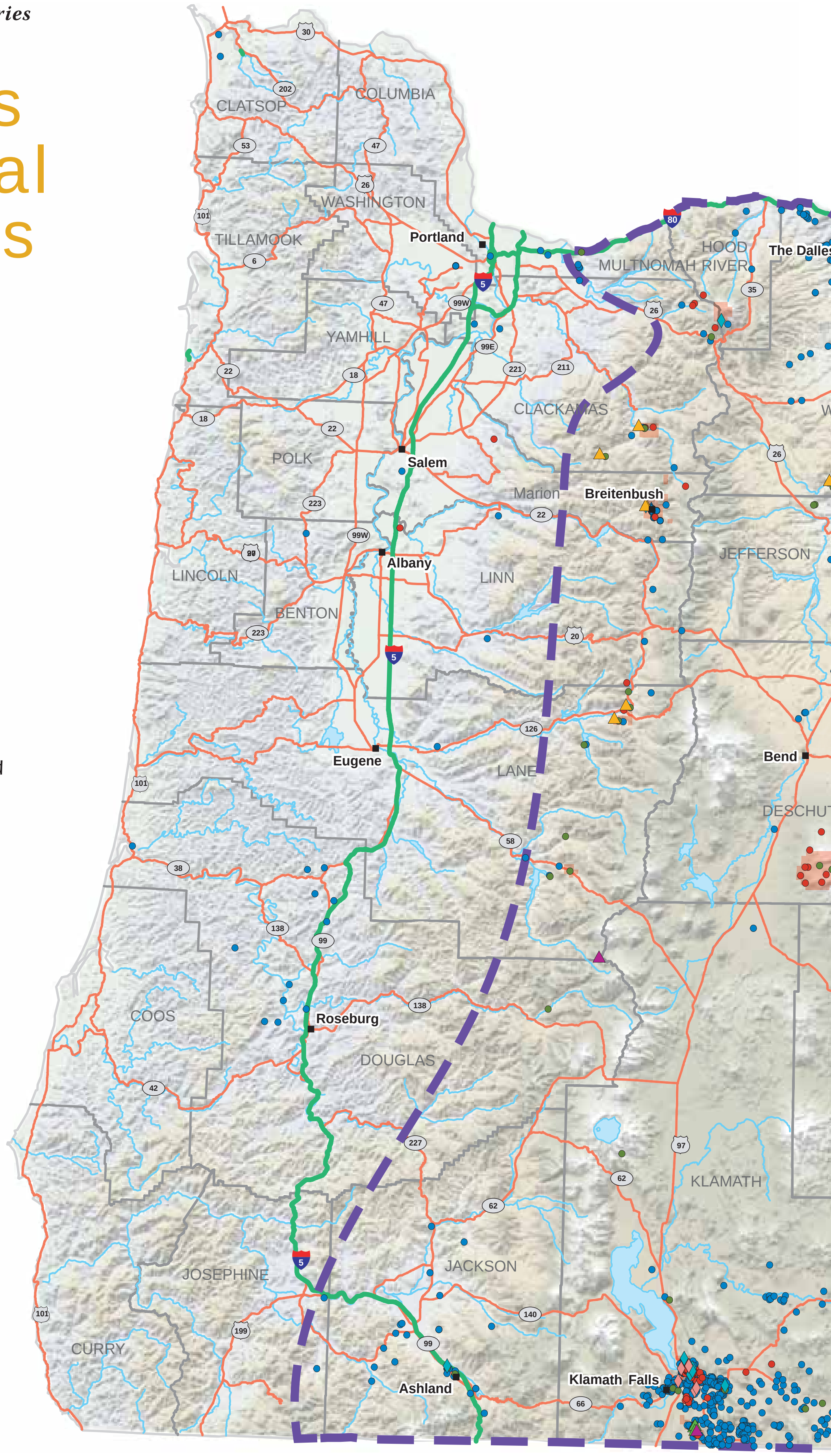
U.S. Geological Survey designated Known Geothermal Resource Area (KGRA)

Extent of known geothermal resource potential

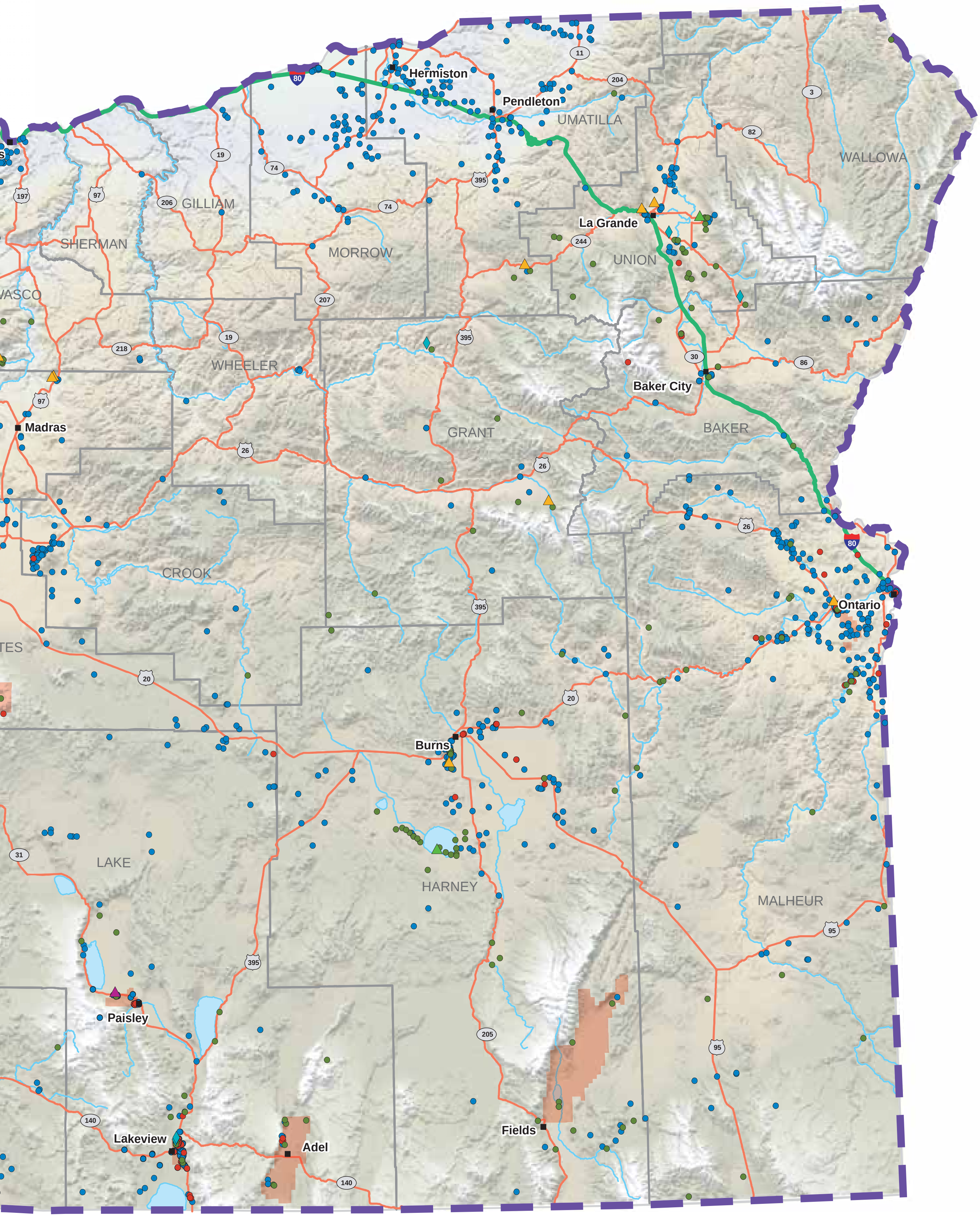
## Other Symbols

- City/Town
- County boundary
- River
- Lake/Reservoir

- Interstate freeway
- U.S. highway
- State highway




Modified from Oregon Geothermal Resources map, INEEL/MIS-2002-1621 Rev. 1 (Nov. 2003).
You can view the original map online at
http://geothermal.id.doe.gov/maps/or.pdf


Hermiston
Pendleton
UMATILLA
WALLOWA
GILLIAM
SHERMAN
MORROW
La Grande
UNION
WASCO
WHEELER
Baker City
BAKER
Madras
GRANT
CROOK
Ontario
Burns
LAKE
HARNEY
MALHEUR
Paisley
Fields
Lakeview
Adel

# Cash incentives for geothermal development

## Oregon Energy Loan Program

The Energy Loan Program (also known as SELP) promotes energy conservation and renewable energy resource development by offering low-interest loans for projects that produce energy from renewable resources such as geothermal. SELP loans to individuals, businesses, schools, cities, counties, special districts, state and federal agencies, public corporations, cooperatives, tribes, and non-profits. Limited funds are available for energy evaluations for schools and public buildings.

Projects must be in Oregon. SELP loans pay for capital costs and related costs such as engineering and design, permits, loan fees, and project management. An energy loan can be used to supplement conventional construction project financing.

For SELP case studies, examples of eligible projects, and more information on the program, see http://www.oregon.gov/ENERGY/LOANS/index.shtml. Contact the Energy Loan Program toll-free at 1- 800-221-8035 or 503-378-4040 (Salem).

## Business Energy Tax Credit

Oregon businesses and others that invest in renewable energy projects (for example, energy conservation, recycling, renewable energy resources and less-polluting transportation fuels) can get a state tax credit of 35 percent of eligible project costs. The tax credit recipient must have an Oregon tax liability. Applicants must meet the following three requirements: Be a trade, business, or rental property owner who files taxes for a business site in Oregon or be an Oregon nonprofit organization, tribe, or public entity that partners with an Oregon business or resident who has an Oregon tax liability; own or be the contract buyer of the project; and use the equipment yourself or lease it to another person or business in Oregon. The Oregon Department of Energy must receive your Application for Preliminary Certification for Renewable Energy Projects before the project starts. For case studies and more information on Oregon business energy tax credits, see http://www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml.

*To help diversify the state's energy production, the State of Oregon provides incentives for renewable energy development projects, including geothermal power.*

## Energy Trust of Oregon

The Energy Trust of Oregon utility-scale generation program supports development of large-scale energy projects through cash incentives that buy down the higher costs usually associated with producing renewable energy. Each year, Energy Trust sets aside several million dollars for this purpose and works with PacifiCorp and Portland General Electric to select both new and existing commercial and residential projects that have been proposed as part of those utilities' integrated resource planning. Potential projects include large-scale geothermal resources.

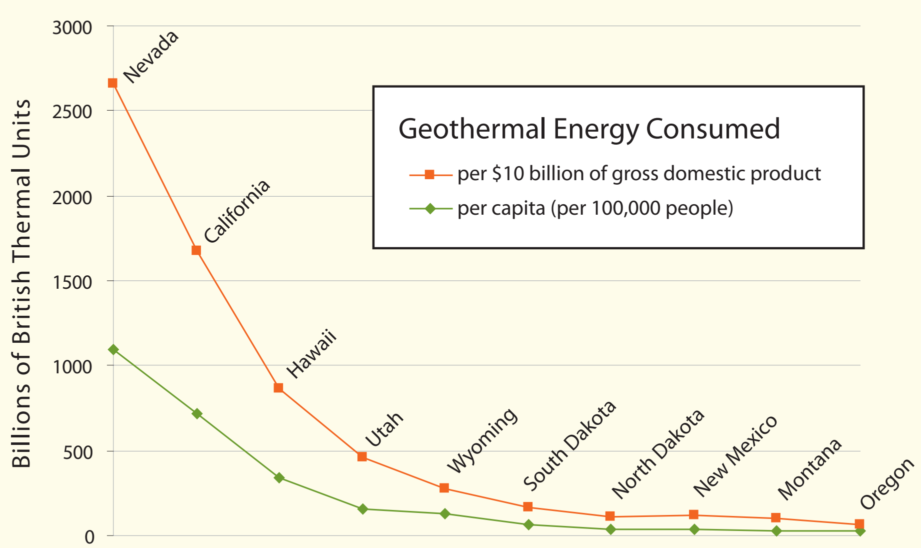
Contact the Energy Trust of Oregon at 1-866-ENTRUST (368-7878) or see http://www.energytrust.org.

## Residential Energy Tax Credit

Homeowners and renters who pay Oregon income taxes are eligible for the Residential Energy Tax Credit if they purchase a closed-loop geothermal heat pump system (which may include water heating). Closed-loop geothermal heat pump systems are eligible for a credit of $0.60 per kWh saved during the first year, up to $1,500.

Local communities may also offer financial incentives. Check with your local electric board.

Details regarding Oregon's renewable energy incentives can also be found at http://www.oregon.gov/ENERGY/RENEW/Geothermal/Incentives.shtml.




**Despite Oregon's enviable access to geothermal resources, the state lags behind in developing and using geothermal energy (source: http://www.statemaster.com, 2001 data). The State of Oregon provides incentives for developing renewable energy resources.**

# Location, location, location: Prime zones for geothermal development

Just as in real estate, the geographic location of a geothermal resource is key. Oregon's fault lines and geologically recent volcanic activity have created prime geothermal development zones.

The U.S. Geological Survey has designated ten areas in Oregon as Known Geothermal Resource Areas (KGRAs). These areas have conditions favorable for discovery of thermal water of sufficient temperature to make electricity. The red areas on the state map to the right show Oregon's KGRAs.

Central Oregon has the highest potential for geothermal power — Newberry Crater has been identified as the hottest geothermal system in Oregon. The next area of high potential is the Cascades mountain range with its robust and active geothermal areas. The Breitenbush Hot Springs KGRA represents the largest thermal spring area in the Oregon Cascades. The KGRAs across the southern part of Oregon — where geothermal exploration began in the 1970s and 1980s and the bulk of the hot springs are found — lie in the upper end of the Great Basin. The Vale area KGRA has also been an area intensely tested for gold mineralization. Gold mineralization there probably correlates with the current geothermal system. It is reasonable to expect that these KGRAs may be extended or that other such areas may be discovered as additional information is obtained from new geothermal exploration.

Approximately 90 percent of the KGRAs in the state are located on federal lands. Two federal agencies share or separately manage geothermal development on those lands: The Bureau of Land Management, an agency of the U.S. Department of the Interior, and the U.S. Forest Service, an agency of the U.S. Department of Agriculture. The State of Oregon owns all geothermal resources located on state and private land.

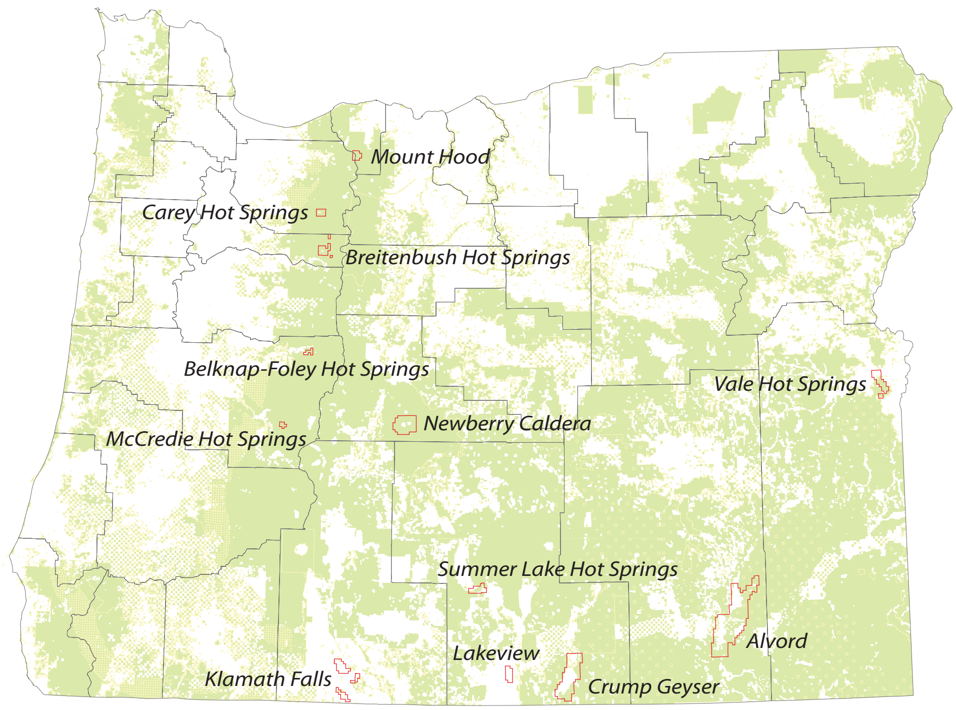



**Figure 1. Oregon's Known Geothermal Resource Areas (KGRAs) are outlined in red. These areas are designated by the U.S. Geological Survey as having the most potential for creating electricity from geothermal energy. White areas are privately owned lands. Green areas are State, Federal, or Tribal lands.**

# DOGAMI's role in geothermal exploration

One of the mandates of the Oregon Department of Geology and Mineral Industries (DOGAMI) is to identify and assess geothermal resources in Oregon and to make the data available to industry, governments (local, Federal, and Tribal), and interested Oregonians. A related objective for the Department is to collaborate with the U.S. Geological Survey to assemble and release data collected as part of this assessment effort through integration of relevant geological, geophysical, geochemical, and hydrological databases that will be the foundation for Oregon in the new geothermal resource assessment.

This year DOGAMI and the Oregon Department of Energy formed a partnership to inventory Oregon's geothermal systems in order to create a Geothermal Information Layer for Oregon (GTILO). GTILO is a database and interactive website that not only will serve as a quick source of Oregon's important geothermal information but also will (1) help facilitate study of potential geothermal resource areas, (2) enhance our ability to test hypotheses using GIS (Geographic Information System) analysis, and (3) support modeling efforts to locate "hidden" geothermal systems. This project is funded by a grant administered by Oregon Department of Energy through GeoPowering the West, a U.S. Department of Energy program (DOE) to promote geothermal usage in the western United States.

DOGAMI began about 40 years ago to evaluate the state's geothermal resources. From the 1966 overview by Gunnar Bodvarsson (*The Ore Bin,* vol. 28, no. 7) and

**(continued on page 10)**

# DOGAMI's role

(continued from page 9)

our first regional study effort in the Klamath Falls area (Peterson and Groh, 1967, *The Ore Bin*, v. 29, no. 11), we've progressed to fifty geothermal-related publications. Nearly the same number of articles on the state's geothermal resources appear in our magazine, *Oregon Geology* (formerly *The Ore Bin*). You can read short annotations and summaries on the major findings of these publications in the Spring 2003 edition of *Oregon Geology*.

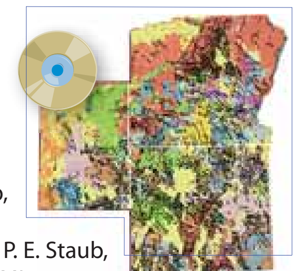
DOGAMI also collects, stores, and makes available the cuttings and core from geothermal wells in Oregon. Many geothermal prospect and exploration wells have lithologic descriptions and geophysical logs. Access to the well information is provided through the Mineral Land Regulation and Reclamation Program (MLRR) of DOGAMI located in Albany, Oregon. As part of GTILO, scanned images of the geophysical logs will be available for download.

MLRR is responsible for the state's regulation of geothermal exploration and production. Their oversight includes supervision of drilling, abandonment, and reclamation of geothermal wells. For more details on MLRR's role, see "Notes from Your State Geologist" on page 2.

# Online resources for geothermal energy

- **Oil, Gas, and Geothermal Reclamation Program at DOGAMI**
  http://www.oregongeology.com/sub/oil/oilhome.htm
- **Geothermal Energy (State of Oregon site)**
  http://www.oregon.gov/ENERGY/RENEW/Geothermal/geo_index.shtml
- **Oregon Geothermal Resources, map, November 2003**
  http://geothermal.id.doe.gov/maps/or.pdf
- **Geo-Heat Center, Oregon Institute of Technology**
  http://geoheat.oit.edu/
- **Virtual Map of Hot Springs, NOAA**
  http://map.ngdc.noaa.gov/website/seg/hot_springs/viewer.htm
- **State of Oregon Energy Plan 2005–2007**
  http://egov.oregon.gov/ENERGY/docs/EnergyPlan05.pdf
- **Geothermal Education Office**
  http://www.geothermal.marin.org/
- **GeoPowering the West**
  http://www1.eere.energy.gov/geothermal/gpw/index.html
- **Geothermal Resource Information Clearinghouse**
  http://rredc.nrel.gov/geothermal/
- **Geothermal Resources Council**
  http://www.geothermal.org/index.html
- **Exploration Permit/Lease for Geothermal Resources**
  http://licenseinfo.oregon.gov/index.cfm?fuseaction=license_seng&link_item_id=14662
- **Geothermal Technologies Program**
  (USDE Energy Efficiency and Renewable Energy Program)
  http://www1.eere.energy.gov/geothermal/
- **Geothermal Energy Association**
  http://www.geo-energy.org
- **International Geothermal Resources Association**
  http://www.geothermal-energy.org
- **USGS/Cascades Volcano Observatory Geothermal and Hydrothermal Activity links**
  http://vulcan.wr.usgs.gov/Glossary/ThermalActivity/framework.html

# Publications available now from Nature of the Northwest

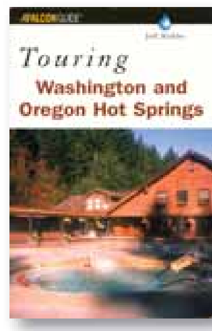


**Oregon Geologic Data Compilation, version 3 (OGDC-3)**, by C. A. Niewendorp, M. D. Jenks, M. L. Ferns, I. P. Madin, P. E. Staub, and L. Ma, DOGAMI, 2006, CD-ROM, $25.

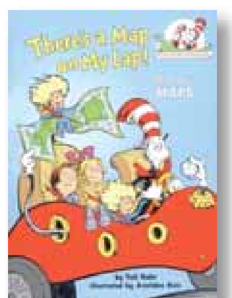
*The third phase of this multi-year project to develop a digital state-wide geologic map and to compile the geologic data in database format for the entire state brings together the best available geologic mapping and data from all relevant published and unpublished sources: state and federal agencies, university thesis work, and other documents. The data on this CD-ROM are designed for use with specialty GIS software and database software. A partial OGDC data set is available as an online interactive map: http://www.oregongeology.com/sub/ogdc/index.htm.*

**A complete list of DOGAMI publications can be found online at: www.OregonGeology.com.**

**Use the order form below or log on to www.NatureNW.org to order.**

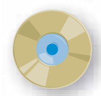



**Touring Washington and Oregon Hot Springs**, by Jeff Birkby, The Globe Pequot Press, Guilford, CT, 2002, 202 pp., $14.95.



**There's a Map on My Lap!: All About Maps** (Cat in the Hat's Learning Library Series), by Tish Rabe, illustrations by Aristides Ruiz, Random House, 48 pp., $12.99.

**Low-temperature geothermal database for Oregon**, by G. L. Black, DOGAMI Open-File Report O-94-08, 178 page report and 5 location maps, 1994, CD-ROM, $25.00.



**Geothermal resources map of Oregon**, geothermal data compiled by DOGAMI, map produced by the National Geophysical Data Center, National Oceanic and Atmospheric Administration, 1 sheet, scale 1:500,000, $4.00.

***More geothermal publications:*** *DOGAMI has published 50 geothermal-related publications to deliver scientific data to industry, governments (local, Federal, Tribal), and interested Oregonians. Nearly the same number of articles on the state's geothermal resources appeared in our magazine,* Oregon Geology *(formerly* The Ore Bin*). You can read short annotations and summaries of the major findings of these publications in the Spring 2003 issue of* Oregon Geology.

## NATURE OF THE NORTHWEST PUBLICATION ORDERS

**Mark desired titles on the list above and fill out this form. A complete list of publications is on the Nature of the Northwest homepage: http://www.NatureNW.org. You can order directly from the website or send this order form to The Nature of the Northwest Information Center, Suite 177, 800 NE Oregon Street, Portland, OR 97232-2162, or FAX (971) 673-1562. If you wish to order by phone, have your credit card ready and call (503) 872-2750. Payment must accompany orders of less than $50. There is a $3 shipping charge per order. Payment in U.S. dollars only. Publications are sent postpaid, except where noted. All sales are final.**

**Total payment enclosed/or to be charged to credit card as indicated below: $ ______________________________**

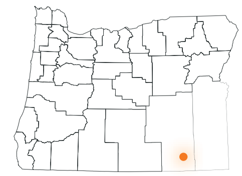
**Name/Address/City/State/ZIP: ______________________________________________________________**

**______________________________________________________________________________**

**Please charge to Visa __ Mastercard __ Account number: ______________________________________**

**Expiration date: ____________ Cardholder's signature: ______________________________________**

# Places to see: Borax Lake & Borax Hot Springs



**Borax Lake and Borax Hot Springs, Alvord Desert, east of Steens Mountain and south of Alvord Lake.**
The 10-acre lake is fed by hot springs that can reach 40°C (105°F). Borax Lake is a biological reserve and home to the endangered Borax Lake chub. In the late 1800s borax was mined here and carted by mule teams to Winnemucca, Nevada. The area is a Nature Conservancy site and is protected from geothermal development through the Steens Mountain Cooperative Management and Protection Act of 2000.

**Photos: Mike Henetz**

**Directions**
*Visit but do not disturb the lake or hot springs—they contain very high levels of arsenic!* From the town of Fields (about 100 miles south of Burns), go north on Highway 201 (Fields Denio Road) toward Andrews. After 1.75 miles (0.25 mile north of the southerly junction with Highway 202), turn right (east) onto a dirt track at the power substation on the right side of the road. Follow the dirt track parallel to the power line due east for 2 miles, then turn left (north) and go 1 mile. A Bureau of Land Management fence crosses the road approximately 0.5 mile southwest of the lake. Park along the road next to the gate and walk to Lower Borax Lake Reservoir. Follow the main track in a northeasterly direction past the lower reservoir to the slightly elevated mound where Borax Lake lies. Several more hot springs lie due east and northeast of the lake.

**Learn more about Oregon's geology by going online at www.OregonGeology.com.**