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ABSTRACT

The National Geothermal Data System (NGDS) is a U.S. Department of Energy (DOE)-funded program intended to create a nation-wide distributed data system that would provide access to all geothermally relevant information in the U.S. and help stimulate future geothermal exploration and development. To design the data system and its data structures, the DOE contracted with Boise State University and the Arizona Geological Survey (AZGS). In turn, the AZGS has subcontracted with each state survey to compile geothermally relevant resource information for its region. Under Idaho law, geothermal fluids are deemed a sui generis resource—that is, neither water nor mineral—and the permitting and collection of geothermal well information is part of the Idaho Department of Water Resources’ (IDWR) mandate. The Idaho Geological Survey (IGS), as the lead agency responsible for compiling, archiving, and managing geological and mineral resource information in Idaho, recently initiated an informal agreement with IDWR to compile their digital and non-digital geothermal resource information so the data can be served through the NGDS. In addition, the IGS was funded as part of a four-state consortium (with Utah, Nevada and Oregon) to acquire new thermal gradient data in areas of the Basin and Range Province.

Data Compilation

To date, the IGS’s data compilation effort has focused on: a) capturing existing geothermally relevant data in digital form and converting it to NGDS-compliant formats with full metadata. The process of making the data available via the NGDS is now underway, wherein subsets of the data will be uploaded to the NGDS’s servers and tested to ensure full accessibility prior to uploading the full data sets. The information currently being compiled includes:

1. The IGS’s existing Quaternary (active) fault database with map and feature metadata;
2. A comprehensive geothermal bibliography of Idaho-specific reports, prospects, and development data that will eventually be integrated with a geographic database of Idaho’s thermal springs, wells and prospects (Figure 1);
3. A database of the Idaho Department of Lands’ permitted oil and gas exploration wells and IDWR’s permitted geothermal wells, including available drilling, siting, well log and permitting information;

Figure 1. Locations of geothermal features in Idaho (light red circles), silica geothermometry temperatures above 80 °C (yellow; Dansert et al., 1994), and deep oil and gas exploration wells in the eastern Idaho Thrust Belt with temperatures of 146-210 °C (dark red circles). Based on data compiled by Idaho Department of Water Resources (K. Neely, written comm., 2011). Solid red lines indicate high-voltage transmission lines (>345 kV); blue dashed line indicates approximate northern extent of the Utah-Nevada-Oregon-Idaho consortium’s study area.
4. Whole-rock radioactive element data for the Idaho Batholith, Challis and other igneous rocks in Idaho collected under the National Uranium Resource Inventory and other mapping work; and

5. Contact information for regulatory and development assistance with such issues as leasing, permitting, well construction and abandonment regulations, and environmental requirements.

New Geothermal Data Acquisition

Figure 2 indicates the availability and relative quality of heat flow data in Idaho, according to the Southern Methodist University (SMU) Geothermal Laboratory’s heat flow database (SMU, 2010). As part of the four-state drilling consortium, the Idaho Geological Survey’s objective is to obtain representative thermal gradient information in areas where (i) geothermal resource potential is high, (ii) shallow ground water flow obscures the deep conductive heat-flow regime, (iii) more heat-flow data would do the most to spur exploration for power-generation resources, and (iv) power transmission infrastructure already exists.

Figure 3 summarizes proposed locations of potential drilling sites. Two sets of criteria were used to select these sites: availability criteria and site-specific geothermal criteria.

Availability Criteria

(i) Public land is available for geothermal development. The drilling consortium advocated siting wells on BLM land to simplify the permitting process. Sites on protected federal land and land already under lease were excluded from consideration, as were locations on private land so as to avoid granting unfair advantage to individual landowners.

(ii) Areas with inadequate or unreliable heat-flow information. Fewer than 20% of 1024 thermal gradient wells in Idaho have heat flow estimates ranked as good or moderate quality by SMU (2010). Most of these are in the Boise / Bruneau / Mountain Home area of the western Snake River Plain (SRP), the eastern SRP, and in south-central Idaho (Figure 2). In contrast, SE Idaho only has 144 measurements (less than 15% of the statewide total), of which only 85 are rated good to moderate quality.

(iii) Areas that are close to electrical transmission lines. For the state as a whole, this is the most restrictive criterion. In the western half of Idaho’s Basin and Range Province, the distance between potentially favorable geothermal prospects and nearest transmission lines is simply too great (Figure 1). In contrast, a number of high-voltage transmission lines cross the southeast corner of the state, placing many prospects within reach of this infrastructure.

Site-Specific Geothermal Criteria

In much of southeast Idaho, the flow of cold ground water through shallow, highly permeable basalts and unconsolidated sediments typically compromises chemical geothermometry information as well as shallow heat flow estimates. The highest silica geothermometer estimates from shallow thermal wells and springs in SE Idaho are in the range of 80-100 °C, whereas maximum temperatures encountered in deep oil and gas wells in the same area range up to 210 °C. For these and related reasons, three areas were selected based on their geologic and geothermal context and on supporting evidence that indicates they have hidden geothermal resource potential:
1. The Blackfoot - Gem Valley Volcanic Field (Sites 1, 3 and 5)

The Blackfoot - Gem Valley volcanic field (BGVF) is the expression of a long-lived period of Quaternary basaltic and rhyolitic volcanism dating from the middle Pleistocene (Ford and McCurry, 2005; Figure 4). The Blackfoot lava field is a bimodal assemblage comprising basalts younger than 1.2 Ma, with several very young rhyolite domes (58 Ka; Heumann, 2004). China Hat, the largest of these, is one of the most U and Th-rich rhyolites in the western US. Volcanic rifting that is spatially associated with the domes may reflect shallow dike intrusion, and at least some rifting post-dates the domes (Polun et al., 2010).

Although numerous heat flow measurements have been made in the southern Gem Valley where basalts as young as 25 Ka are found, no heat flow data are available for northern Gem Valley, even though basalts there are 100 Ka or younger. The SMU database contains a total of 14 heat flow measurements in and around the Blackfoot lava field (Figure 5). Heat-flow estimates in Paleozoic basement near the margins of the lava field west of the Blackfoot Reservoir range from 109 to 167 mW/m², compared to background values of 56 ±28 mW/m² in Paleozoic bedrock southeast of Soda Springs. The best thermal gradient estimates within the basalt are ranked as moderate quality and reflect background heat flow values (55-75 mW/m²), suggesting that these estimates are affected by the high rate of ground water flow in the basalt (as in the eastern Snake River Plain; Brott et al., 1976; Blackwell et al., 1992).

Despite the large degree of advective overprinting by shallow ground water, a number of wells completed in BGVF basalts display elevated temperatures: fifteen known warm wells range up to 22 °C at depths of 15-67 m, compared to normal ground water temperatures of 8-12 °C in the region. No thermal springs are known in Gem Valley, but numerous warm springs occur around the margins of the Blackfoot lava field, none hotter than about 35 °C. Maximum reservoir geothermometer estimates from these springs are low (100°C or less) and are likely affected by significant mixing and water-rock interactions in the shallow subsurface (Hutspiller and Parry, 1985). Fluid temperatures up to 97 °C were encountered in a narrow zone between 6500 and 7200 ft during drilling of SunHub 25-1, a geothermal exploration well located 2.5 km south of China Hat, but no temperature log was run and the available temperature readings were all derived from mud returns and brief thermistor deployments during drilling (Figure 5). Fifteen kilometers north of Blackfoot Reservoir, the Gentile Valley 9-1 well encountered a bottom hole temperature of 186 °C at 2900 m.

Three drilling sites in the BGVF are proposed (Figure 6):

- In the vicinity of the China Hat rhyolite domes. This group of rhyolite domes and its associated volcanic rift zone is the youngest volcanic feature in the BGVF; together with Big Southern Butte on the eastern Snake River Plain, it represents the only late Quaternary rhyolite in the western U.S. whose associated geothermal reservoir is not generating power. The principal question facing explorers, therefore, is whether this rhyolite heat source has lost much of its latent heat at drillable...
Depth or if local geohydrologic factors are effectively masking its true thermal potential. A temperature gradient well drilled near or between the two domes would penetrate the 800-ft thick basalt section at this location and provide the most reliable heat flow information yet in this very young volcanic field. This location is the highest priority site proposed.

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A site in Gem Valley is intended to help determine whether the valley’s geothermal potential has been grossly underestimated in prior resource assessments. Almost all of the floor of Gem Valley is under private ownership, but a 400-acre BLM parcel is fortuitously located less than 2 km NW of the hottest water well in the northern valley (54 °C, 63 m TD). The priority assigned to this drilling site is 3 of 7 (see Figure 3).

A third potential site is west of Soda Springs at the south end of the Blackfoot lava field where the highest heat flow in the area was reported in AMAX’s SEI-15 borehole (167 mW/m²). This site’s priority is 5 of 7.

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2. Gray’s Lake Area (Sites 2, 4 and 6)

Although the Gray’s Lake area (Figure 4) has no thermal manifestations at the surface, deep oil and gas exploration wells drilled in this area of the eastern Idaho Thrust Belt have encountered high temperatures. The Gentile Valley 9-1 well saw bottom-hole temperatures up to 186 °C at 9500 ft. and the CPC Minerals 17-1 well, 200 °C. The White Mountain prospect, an area of rhyolite, trachyte and basaltic trachyandesite 15 km NNE of the Blackfoot Reservoir is being evaluated for its geothermal potential (C. Austin, written comm., 2009; C. Austin and R. Austin, 2010).

The area is very seismically active. Figure 7 shows epicenters recorded within a 100-mile radius of the Idaho National Laborato-

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The intensity of a seismic swarm beneath Gray’s Lake in 1992 moved the USGS Volcano Crisis Assistance Team to temporary standby status because some events were suggestive of volcanic “spasmodic tremors” (Ryall and Ryall, 1983). Because of this area’s potential, additional heat flow information from one or more deep thermal gradient holes would be useful. The locations of three potential drilling sites, all on BLM parcels,
are shown in Figure 8. These locations were selected in order to sample the area between the nearest oil and gas exploration wells as well as the area in which the most frequent seismic activity has occurred. The priorities assigned to these sites are 2, 4 and 6 of 7.

3. Malad Valley Area (Site 7)

In the past, southeast Idaho prospects like Preston and Maple Grove have had considerable thermal gradient drilling performed (Figure 9), thereby excluding them from consideration. In contrast, the geothermal potential of the northern Malad Valley has been virtually ignored.

Five warm springs and five warm wells in the valley have temperatures in the 20 to 63 °C range. Only two shallow thermal gradient wells are known and neither revealed a significant gradient. However, the Malad Range east of the valley is the northern extension of Utah’s Wasatch Front, where hot spring temperatures range up to 60°C (Murphy and Gwynn, 1979). Very high heat flows (up to 4200 mW/m²) have been reported in the northern Wasatch Front in Paleozoic bedrock, just 25 miles south of the Idaho state line (SMU, 2010).

The only possible drilling sites that are on BLM land in the northern Malad Valley are two 40-acre parcels located within three miles of the hottest well in the valley. The priority assigned to this site is 7 of 7.

Summary

The thermal gradient drilling sites described have been proposed because of their potential contribution to our understanding of southeast Idaho’s hidden geothermal potential. Further refinement of drilling locations and target depths (between 500 and 1,000 feet) will be determined in consultation with SMU, IDWR, USGS and others. Depending on site-specific drilling costs (nominally budgeted at $90 to $150 per foot), the drilling funds that have been made available (ca. $350,000 for Idaho) should be sufficient for three to four thermal gradient holes to be drilled in southeast Idaho by the end of 2012.

References


