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The Humboldt House–Rye Patch Geothermal District: An Interim View

Al Waibel[1], David Blackwell[2], and Richard Ellis[3]

[1]Columbia Geoscience, 22495 NW Quatama Way, Hillsborough, Oregon
[2]Deptartment of Geological Sciences, Southern Methodist University, Dallas, Texas
[3]PRESCO Energy, 7400 East Orchard Road, Suite 150, Englewood, Colorado

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ABSTRACT

The Humboldt House - Rye Patch Geothermal District extends about 6 miles along the northwestern flank of the Humboldt Range in Pershing County, Nevada and is composed of a number of geothermal cells. The northern Humboldt House portion of the district hosts hot wells and silicic sinter deposits extending from within the Humboldt Range, westward for at least four miles, out into the Humboldt River Valley. The southern Rye Patch portion of the District has scant surface geothermal features, and is identified from well data. Exploration in the District in the mid to late 1970s resulted in numerous temperature gradient wells, ranging in depth from a few hundred feet to 2000 feet, and three production test wells (all between 350° and 401°F maximum temperature). Fluid geochemistry suggests temperatures of 450 to 500 °F (Desormier, 1979) in the system. Subsequent exploration was concentrated in the Rye Patch portion of the District in the early 1990s and in 1999-2001. Currently there are four completed and tested production wells in the Rye Patch area. Surface infrastructure associated with the production wells includes a 12.7 MW power plant (80 to 85% completed) and a partially completed gathering and reinjection piping network.

Introduction

The Humboldt House - Rye Patch Geothermal District is located in Pershing County, Nevada, approximately 120 miles northeast of Reno and about ½ way between Lovelock and Winnemucca. Presco Energy, LLC acquired the assets of the Rye Patch geothermal project in July of 2001, and immediately proceeded to expand its lease position. It now controls a substantial portion of the Humboldt House - Rye Patch Geothermal District (Figure 1).

Geologic Setting

The Humboldt Range and adjacent Humboldt Valley are typical of the Basin and Range province in that they are juxtaposed horst and graben structural blocks separated by an active fault system. The most recent activity was post-Holocene on the Rye

Figure 1. Shaded relief index map to the Humboldt House - Rye Patch District, Pershing County, Nevada, Presco Energy, LLC. Contours of shallow gradients with control wells are shown (°F/100 ft). The Union, Phillips, 44-28, and 72-28 deep wells are identified.

Patch fault in the southern part to the District (Davis, 1983). The Humboldt Range is a portion of a north-trending anticline composed of Mesozoic marine sediments, including thick sections of carbonate. At the core of the range, overlain by the Mesozoic sediments are Early Mesozoic metavolcanic and metavolcaniclastic rocks. Locally within the range Cretaceous dikes and stocks of granite intrude into the older Mesozoic rocks (Silberling and Wallace, 1967; Johnson, 1977).

The Humboldt House - Rye Patch Geothermal District is located along the western margin of the Humboldt Range. To the north the geothermal district ends in the northeast-trending Midas Lineament. To the south the geothermal area ends at the north end of a northwest-trending fault zone that offsets the Humboldt Range from the more southerly West Humboldt Range. The intersection of these structural regimes (and others) causes local dilation along high-angle normal and strike-slip faults. The dilated portions of high-angle faults allow high-temperature geothermal fluid to flow toward the surface from great depth, ultimately dispersing as shallow hot laterally-flowing plumes. Portions of these lateral flow discharge plumes are mapped in the temperature gradient holes and exploration wells.

Temperature data from approximately sixty wells drilled in the Humboldt House - Rye Patch Geothermal District (most less than 500 ft deep) indicate multiple areas of upwelling geothermal fluid. The widely spaced distribution of the wells does not allow the details of the discharge plumes to be clearly defined. The only sustained surface geothermal fluid flow is west of I80 at Humboldt House. As described by Desormier (1979) "At the present time there are no active hot springs in the area. However, there is one mineral exploration hole that is presently flowing hot water. The hole is located in the SE 1/4 of Section 32, T32N-R33E and was drilled by a company called "Estoril". The depth of the hole is not known."

"Sodium chloride water with a temperature of 168°F flows from this hole at a rate of about five gpm. The water .... is chemically similar to water obtained from Campbell E-1 and from other test holes. The silica and the Na-K-Ca geothermometers give predicted reservoir temperatures of 450-490°F..."

Exploration History

Presco Energy, LLC purchased the Project assets in July of 2001 from Mt. Wheeler Power, a rural electric co-op in eastern Nevada. This was the culminating transaction in a series of asset transfers dating from Phillips Petroleum Co.'s initial exploration efforts in the Humboldt House-Rye Patch area some 25 years ago. Confirmation of a commercial resource was established by Phillips production test well Campbell E1 (E1 on the maps). The well flowed 800,000 lbs per hour of 350°F fluid during testing, and thus is generally acknowledged the discovery for the "Rye Patch Geothermal Field". A second production test well, Campbell E2 (E2), failed to match the results of well E1. Union Geothermal Co. also drilled one deep production test well north of Phillip's production test wells (U-C-1 on Figure 1). While recording a down-hole temperature slightly in excess of 400°F, the well did not flow. In addition to the two production test wells, Phillips drilled approximately 40 temperature gradient and stratigraphic test wells, ranging from 300 ft to almost 2000 ft in depth, distributed across the entire Humboldt House-Rye Patch Geothermal District (see Figure 1).

Beginning in 1991, Ormat Energy Services, Inc. (OESI), through its Rye Patch Limited Partnership, drilled a series of gradient holes, leading to the drilling of a successful production well, 44-28, in the southern Rye Patch portion of the district. This well confirmed the potential for commercial power generation and established a target development area. Seven additional wells were drilled in close proximity to 44-28, in concert with construction of the Rye Patch Power Plant. The production results of these wells were mixed (GeothermEx, 1992). The concentrated drilling in the Rye Patch portion of the district has provided a detailed view of shallow and intermediate-depth, lateral, discharge plumes.

Following additional geophysical studies, including a 3-d seismic survey (Feighner et al., 1999) and additional asset transfer events, Mt. Wheeler Power became operator of the Rye Patch portion of the District. They drilled 5 additional 500 ft thermal gradient wells that focused the position of the shallow upflow to the Rye Patch fault. These data resulted in the siting and drilling of successful production well 72-28.

Gold exploration (Hastings et al., 1988) along the western portion of the Humboldt Range has contributed additional data. Condemnation wells drilled in section 10 (Figure 1) have identified lateral discharge flows with unequilibrated temperature measurements near 200°F.

Humboldt House Area

The Humboldt House area is a large region characterized by high temperature gradients, high shallow temperature measurements, and abundant recent silicic hot spring deposits. The northern most and the largest shallow geothermal discharge plume is observed in section 33 and westward into section 32 west of I80 (Figure 1). Temperature gradients ranging from 7°F/100 ft to over 20°F/100 ft are observed there. Four shallow wells there have temperature of 204, 227, 232, and 234°F. This area is identified from temperature measurements in drill holes and from post-Lake Lahontan hot spring and fumarole deposits. A second shallow hot groundwater plume just north of the center of section 10 is identified in condemnation holes drilled by Pegasus Gold as they prepared to expand their waste dump. Hot water is reported in the mining area as well. It is identified by drill holes and by hot water encountered in the mine.

The wells with depths greater than 400 ft generally show temperature reversals. These shallow high temperatures are largely an artifact of shallow laterally-flowing geothermal discharge plumes. The few wells with temperature data in the 500 to 1000 ft range show high temperature gradients below the shallow discharge plumes.

Rye Patch Area

Existing Shallow Wells

Most of the temperature-depth data available for the shallow holes in the Rye Patch area are shown on the location map in Figure 2 and in the temperature-depth plot in Figure 3 as are temperatures in the upper part of three of the deeper production wells for

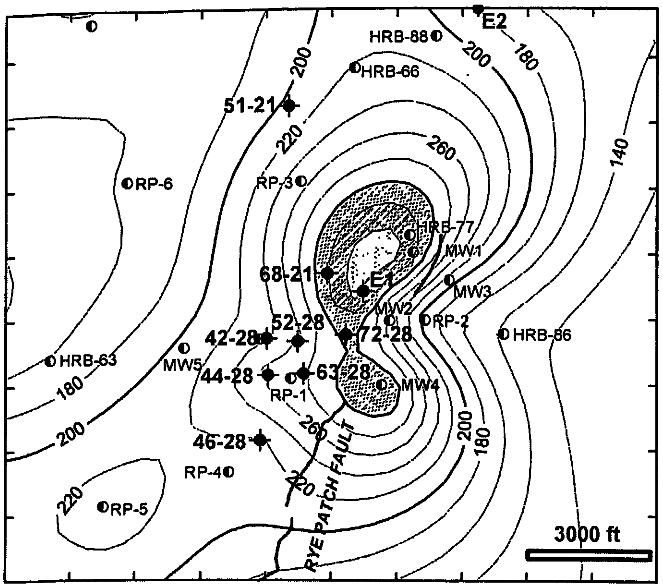

Figure 2. Location map of wells in the Rye Patch geothermal area and contoured temperature at 2,000 ft (in °F). Shallow wells are half filled circles and deep wells (>2,000ft) are solid symbols. The location of the Holocene scarp of the Rye Patch fault from Davis (1983) is shown.

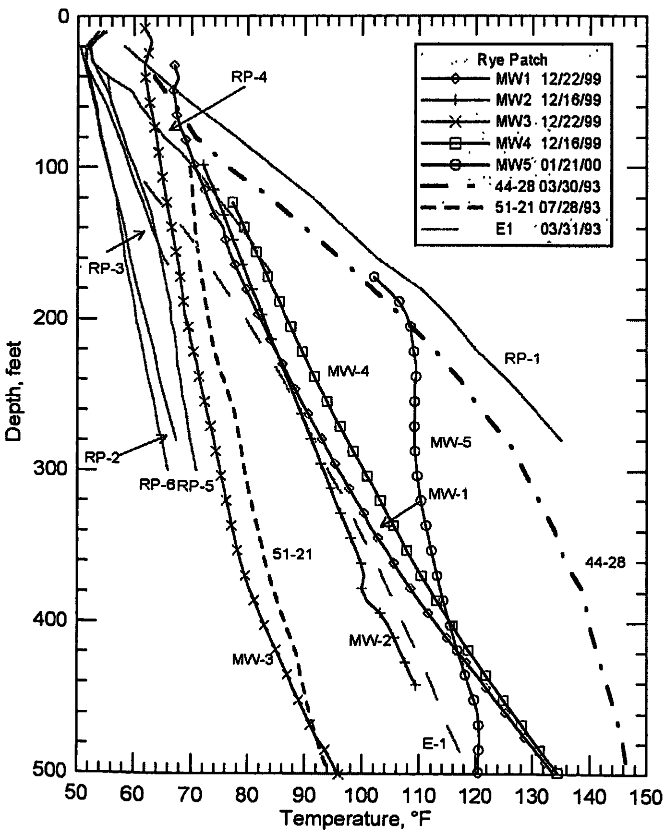

Figure 3. Temperature-depth curves of shallow wells in the Rye Patch geothermal system. The RP series was drilled by OESI and the MW series was drilled by Mt. Wheeler Power. The upper parts of three deep wells are shown for comparison purposes (44-28, Campbell E-1, and 51-21).

comparison. The temperature contours at 2,000 ft (both measured and extrapolated) in the Rye Patch area are shown on Figure 2 and help to illustrate the topology associated with the flow pattern (a contour map of the shallow geothermal gradient is shown in Figure 1). The locations of the thermal gradient wells are shown as are locations and identifications of the deep wells. Extensive temperature measurements from drill holes in the Rye Patch area have identified an area that currently hosts a near-surface hot lateral groundwater plume. From south to north, the first area is near well 63-28. The near-surface plume flows west and north, and can be most clearly identified in thermal gradient well MW-5. Data are too sparse to determine if this shallow plume originates near 63-28 or from further east, near the temperature gradient increase between temperature gradient wells MW-2 and RP-2.

Geothermal Model

A simplified model for the Rye Patch geothermal system is shown in Figure 4 (Blackwell, 2000; Blackwell and Waibel, 2002). This model is a generic Basin and Range model based after the model of the Dixie Valley geothermal system developed by Blackwell et al. (1999). In the Rye Patch area the range bounding fault has multiple strands. The geothermal system as outlined appears to be associated with a valley strand rather than the range bounding strand. The geothermal system has at least three identified regimes of geothermal flow. The main flow system is along the deep-seated normal fault system dividing the Humboldt Range from the adjoining Humboldt River Valley (3). The mapped surface trace of the Holocene scarp along the Rye Patch strand of the fault system (Davis, 1983) is shown. The flow may occur on several strands of the fault system as well as within fractures in the bedrock below the valley. So the flow is certainly more complicated than the pattern shown on Figure 4. Temperatures are at least 400°F at depths on the order of 4,000 ft on the active flow strands in this deep system. The second regime is at the base of the valley fill (2), 2,000 to 2,500 ft in this area, where some of the geothermal fluid spreads out in fractured basement/porous valley fill from the more steeply dipping normal fault system. Temperatures in this system are up to at least 350°F. At even shallower depths the rising geothermal fluid is discharged into

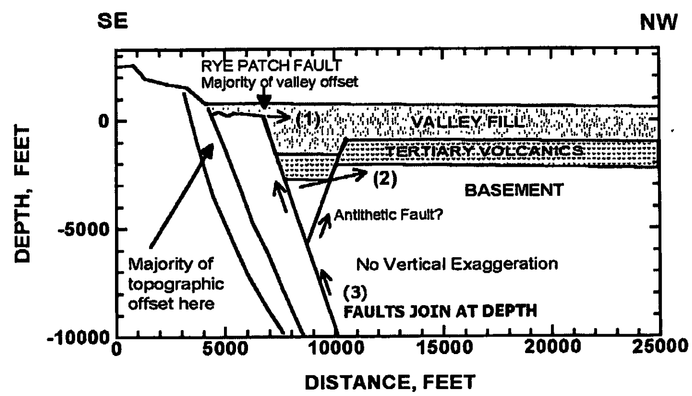

Figure 4. Simplified model of the Rye Patch geothermal system showing the three flow regimes (based on the structural model of the Dixie Valley geothermal field, Blackwell et al., 1999).

the groundwater table, aquifers (1) at a temperature of about 150 °F. The result is the complex thermal picture described above. Based on the possible variations in the design parameters of the power plants, geothermal fluid from either area (3) or area (2) on the diagram (and equivalent areas in the Humboldt House area) may be used for power production.

Heat Loss

One technique to evaluate the potential for electric power production of a geothermal resource is the measurement of the natural heat loss of the system. In the Basin and Range this technique is useful because of the weak surface manifestations due to the low water tables in the arid climate. Direct sampling of the geothermal fluid and measurement of the flow rate of a spring or springs is not possible in many cases so that the conventional evaluation techniques cannot be used. Wisian et al. (2001) showed that using the thermal gradient wells to calculate the natural heat loss of a system allows a reasonable estimate can be placed on the system's electrical potential. The heat loss data from developed geothermal systems show that the upper limit of long term electric power production is about 10 times the natural convective heat flow. A value of 1 is a conservative lower estimate (Wisian et al., 2001).

In the case of the Rye Patch/Humboldt House system the heat loss can be determined from the map of shallow thermal gradients shown in Figure 1. First the thermal conductivity of the valley fill is estimated so that the heat flow for each point can be calculated. Then the data are contoured and the total heat loss is calculated by integration. Subtraction of the background conductive heat loss then gives the natural convective heat flow through the system. The results show that a conservative estimate of the natural heat loss of the combined system is 25 MW. This heat loss value can be compared to the world wide range found by Wisian et al. (2001) and/or the data from producing systems in the western US. The result is a conservative minimum estimate for the electrical potential of the combined system of 25 -MW. This estimate can be considered a minimum because the full extent of the heat flow anomaly associated with the Rye Patch/Humboldt House System is not known, the procedure used will underestimate the heat loss if hot water comes very close to the Earth's surface, and finally because the minimum multiple of electrical to natural heat loss was assumed.

Of course other factors enter into the actual developed power, particularly the temperature of the fluid in the system. For example a large heat loss might be associated with a high flow and a low fluid temperature. However, this area has both a high flow rate and fluid temperatures of at least 400°F are demonstrated (the temperature may be higher) so all of the criteria (high temperature, high natural flow, large area) are met or exceeded. Thus the Rye Patch/Humboldt House geothermal system is a major Basin and Range system and appears capable of substantial electrical power production.

Conclusions

The results to date suggest that the Humboldt – Rye Patch District is a significant Basin and Range geothermal resource. Example deep wells (Figure 1) from north to south are the Union Campbell #1 (6825 ft TD and 401°F maximum temperature), the Phillips Campbell #E-2 (8036 ft TD and 378°F maximum temperature), and the Phillips Campbell #E-1 (1835 ft TD and 350°F maximum temperature). Drilling and fluid geochemistry document a large, hot geothermal system that can be exploited. Additional evaluation activities are ongoing in part with funding from DOE programs.

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