AMERICAN THERMAL RESOURCES, INC.

SURPRISE VALLEY
GEOTHERMAL PROSPECT

Modoc and Lassen Counties

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SURPRISE VALLEY GEOTHERMAL PROSPECT, Modoc and Lassen Counties

INTRODUCTION

Surprise Valley, in the very northeast corner of California, is a long, narrow trough flanked by volcanic mountain ranges. The possibility for geothermal energy is indicated by volcanic eruptive centers and by numerous hot springs on major faults. These thermal fluid seeps are distributed over the length of the Surprise Valley floor which extends approximately 50 miles north-south and 6 to 12 miles east-west. In March 1951, the Lake City Hot Springs, situated on the Surprise Valley fault and in Section 24-T44N-R15E, was the site of a sudden eruption of steam and mud (see enclosed Land Map). This unusual natural event led to the first exploratory geothermal drilling here in 1959.

Surprise Valley was classified as a potentially significant geothermal area by the Geothermal Resources Board of the State of California in 1971. More recently, a maximum downhole temperature of 362^{o}F has been reported from a 4512-foot exploratory well drilled in the Surprise Valley fault zone in Section 23-T44N-R15E. About 2 miles south-east, Gulf Oil Corporation continues a subsurface temperature survey in a 6814 foot stratigraphic test, which is the deepest well yet drilled in Surprise Valley. American Thermal Resources, Inc. (ATR), proceeding with its own technical evaluation on a substantial land position in the southern Surprise Valley, has defined several targets which merit exploratory drilling to depths of 7000 feet. In the northern portion of its land position, ATR has realized with Gulf that a drillable prospect extends under the geothermal leaseholds of both parties. Joint exploratory drilling, with costs and risks equally shared with Gulf, is indicated. In the southern portion of the ATR land position, the drilling target, although

separate and different, can also be tested with a 7000-foot well.

A suitable geothermal steam discovery within Surprise Valley should prompt consideration for use in geothermal electric power systems. Pacific Power & Light Company (PPL) which owns a 69 kv transmission line into Cedarville (on on Land Map) has contemplated a large nuclear or coal-fired electric generating plant in its big, pivotal service area immediately northwest of Surprise Valley. In addition to PPL, Sierra Pacific Power Company and the Eugene Water and Electric Board are interested in the possible rewards that may result from the geothermal drilling explorations continuing in Surprise Valley.

GEOLOGY

The topography and geologic structure of Surprise Valley is of the Basin and Range type; the long, narrow valley being down-faulted between linear mountainous uplifts. The prospect area has been a volcanic province since Miocene times and the Warner Mountains, upthrown on the west side of Surprise Valley, contain young, acidic volcanic features that may point to shallow magmatic intrusions as primary heat sources. Water for thermal energy transport and reservoir capacities at depth appear to be most favorably related to an optimal heat supply along the Surprise Valley fault.

Structure and Heat Source

The most important structural feature, relative to the geothermal potential, is the Surprise Valley fault which separates the Warner Mountain horst from the Surprise Valley graben. The fault is represented by extreme gravity gradients (15 milligals or more per mile) as shown on the Alturas Sheet of the

Bouguer Gravity Map of California. The steep eastern face of the Warner Mountains, rising to crestal elevations of more than 9000 feet, contrasts with the relatively flat valley floor at approximately 4500-foot elevation. The amplitudes of gravity minima under the valley floor are interpreted as sedimentary basins of 3000 to 5000-foot depth. The vertical displacement across the Surprise Valley fault may range between 7000 and 9000 feet. Given this major fault displacement, the west dip of the Warner Mountains horst in its southern part and the presence of younger volcanic eruptive centers both east and west of the Surprise Valley fault, it is reasonable to think of the structural high under the Warner crest as a favored site where young magmatic intrusions may reach shallow positions in the crust. The hot, hidden intrusions could be in or immediately west of the Surprise Valley fault zone as demonstrated by the rhyolite plug immediately west of Menlo Baths in Section 7-T39N-R17E (See enclosed ATR Geologic Sketch and Plate 21 from California Department of Water Resources Bulletin 98).

In addition to the major fault and probable intrusive sites, a third structural element needs careful consideration in geothermal exploration in Surprise Valley. A family of northwest trending faults is present in both the Surprise Valley graben and the Warner Mountain horst. Both the Lake City Hot Springs eruption and the Menlo Bath rhyolite plug are near the intersections of north-west trending faults with the Surprise Valley fault. The proposed exploratory drilling program would test one geophysical anomaly on an indicated northwest trending fault.

Hydrology

Investigations by the California Department of Water Resources have not

demonstrated any subsurface outlet for Surprise Valley ground waters other than by evapotranspiration from the seasonal lakes, wetlands and irrigated crop lands. Annual precipitation of approximately 30" along the crest of the Warner Mountains diminishes to 6" on the east side of the valley floor. Runoff from the steep east face of the mountains enters the long alluvial apron on the west side of the valley floor to recharge shallow ground water reservoirs and probably to drop in cool, dense flows to great depths in the Surprise Valley fault fracture planes. Subsequently heated, such water would rise in convection plumes and appear in the hot to warm springs on both sides of Surprise Valley. The west side thermal fluid belt, north of Lake City Hot Springs has revealed the highest subsurface temperature reported ($362^{o}F$) in drilling to date. This fluid belt tracing north 12 miles along the Surprise Valley fault to Fort Bidwell is identified by surface fluid temperatures of 128 to $190^{o}F$ and total dissolved solids of 1000 ppm. An east side thermal fluid belt extending north 13 miles from Section 6 T42N-R17E, has comparable temperatures and salinities.

Geophysics and Drilling Targets

Electrical resistivity surveying by American Thermal Resources reveals an anomaly in T41N-R16E which aligns with a northwest tranding fault zone mapped in both the Warner Mountains and the Hays Canyon Range immediately east of Surprise Valley. The resistivity anomaly also closely correlates with a distinctive northwestward deflection of the gravity trace of the Surprise Valley fault. Accordingly, the geothermal drilling target to be tested at locations A and/or A2 (see enclosed Land Map) is situated in an intersection of a north west trending fault with the Surprise Valley fault.

The pattern of the gravity contours might fit a left-lateral dislocation of the major fault zone, as if late sinistral movement had occurred on a younger northwest trending fault. No surface thermal fluid manifestations of any kind are known to relate to this geothermal drilling target. The electrical resistivity (ER) sections support the conclusion that the alluvial apron and its internal seasonal ground water regime completely masks the deeper geothermal fluid convection cells. The drilling target is displayed on three ER sections included in the survey report prepared for ATR. Both location A selected by ATR and location A2 selected by Gulf on the basis of their own geophysical work are favorably placed for a conclusive initial test of the geothermal drilling target. Gravity interpretation suggests the proposed exploratory well would penetrate 3500' of clastic sediments above 3500' of volcanics which are expected to be favorably fractured in the fault zone indicated (see Geologic Section A-A').

Location B would test a separate electrical resistivity anomaly at a point of predicted maximum vertical displacement on the Surprise Valley fault. Very steep gravity gradients, leading down from the surface trace of the fault, pass under location B and bottom in the strongest gravity minima in Surprise Valley. This is interpreted to be a 5000 foot structural sink filled with coarse alluvial deposits bounded by the Surprise Valley fault to the west and by fine grained lake bed sediments to the east (see Geologic Section B-B').

ATR LAND POSITION AND EXPLORATORY DRILLING PROGRAM

The Area of Interest shown on the attached Land Map, contains approximately 24,334 acres of ATR geothermal leaseholds and permits and 9367

acres of applications for additional geothermal prospecting permits on State of California water bottoms. Gulf owns geothermal leases on an unspecified amount of acreage, largly north of ATR's land position. ATR and Gulf have designated a 960-acre Exploration Unit for the site of a proposed 7000' exploration well to be jointly drilled with the costs and risks to be equally shared. ATR will be the operator for the single joint well which will be drilled at one of the two proposed locations (A or A2) shown on the map. Gulf may be operator for a second exploration well on the unit, if indicated by a discovery in the first well or by mutual determination between ATR and Gulf. The Agreement between the two companies does not contemplate any joint operations outside of the 960-acre Exploration Unit. In the southern portion of the ATR geothermal leasehold a proposed 7000' exploration well would be drilled by ATR at location B.

The preliminary estimates of 100% costs for the three proposed 7000' exploratory wells are:

	Drilled and Evaluated	Completed to Production
Location A	$170,000	$230,000
Location A2	170,000	230,000
Location B	170,000	230,000
Move in-out	35,000	35,000

Gulf will pay a 50% share of well costs at A and A2 and a proportionate share of move in-out costs.

SELECTED REFERENCES

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AMERICAN THERMAL RESOURCES, INC.

SURPRISE VALLEY GEOTHERMAL PROSPECT, Modoc County, California

Proposed Drilling Program for 7000' Geothermal Exploratory Wells

1. Construct 10-foot square concrete rebar well head pad with 20" center hole open.
2. Move in rotary rig and drill 17½" hole to 92 feet.
3. Run 13 3/8" conductor pipe to 90 feet and cement solid to surface.
4. Install class 3M BOPE (API Class 2M-RSRA or equivalent) on conductor pipe and test to 200 psi.
5. Drill 12½" hole to 1200 feet; commence mud logging upon drilling out shoe of conductor pipe. Continuously record temperature of return mud while drilling this surface casing hole.
6. Run induction electrical log from 1200 to 90 feet.
7. Run 9 5/8" surface casing (36 pound K-55 buttress thread) to 1200 feet and cement solid to surface with Class G cement plus silica flour and calcium chloride. Stand cemented 8 hours.
8. Install wellhead and Class 3M BOPE. Test BOPE and 9 5/8" surface casing to 1000 psig for 15 minutes.
9. Drill out of 9 5/8" casing shoe with 8¾" bits to 7000 foot total depth. Maintain mud as directed by Operator. Lost circulation is expected to be a recurring problem.
10. Open hole drill stem testing is expected to be used as an immediate evaluation procedure.
11. At total depth, cut a 10-foot core, condition hole and run electric logs.
12. Completion plans, using 7" casing, will be determined after well bore evaluation at total depth.

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SURPRISE VALLEY Cost Estimate for 7000' Geothermal Exploratory Well

Drilling and Evaluation

Location, Mat and Road	$ 3,500.00
Water Supply	500.00
Trucking and Rig Move In-Out	separate
Rig and Crew $2500.per day; 20 days	50,000.00
Rig Fuel $5.00 hour; 504 hours	2,520.00
Drilling Fluid	10,000.00
Bits, Reamers, etc.	15,000.00
Conductor	1,630.00
Surface Casing, 1200' type 9 5/8" 36# K-55 buttress	12,100.00
Trucking Stockton to location	1,000.00
Casing Hardware & Services	1,550.00
Cementing Services	4,500.00
Well Head, type 9 5/8" x 7"	1,200.00
Mud Logging, 20 days	5,500.00
Drill Stem Testing, 4 tests	12,000.00
Coring	2,500.00
Electric Logs	9,000.00
Supervision and Overhead	7,000.00
SUB TOTAL	139,500.00
20% Contingency	28,000.00
TOTAL to Drill and Evaluate	167,500.00

Completion

Production Casing, 5000' type 7" 23# K-55 buttress	37,500.00
Trucking, Stockton to location	2,500.00
Casing Hardware & Services	5,000.00
Cementing Services	9,300.00
Master Gate, type ---	3,000.00
Rig, Crew & Fuel, 2 days	5,200.00
TOTAL to Complete	62,500.00
TOTAL Estimated Cost	$230,000.00

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