AREA NV GTHM Explor

AN OVERVIEW OF GEOTHERMAL EXPLORATION AND DEVELOPMENT OF NEVADA

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ABSTRACT

Nevada has been a focal point of widespread geothermal exploration for at least 25 years. An overview of resource assessment, development, and utilization activities in Nevada is presented here. Both private and government-assisted activities in progress or planned are described. A detailed listing of data being made available to the public domain through a major Department of Energy (DOE) industry-coupled program is provided. A general history of geothermal exploration drilling is included as background information.

INTRODUCTION

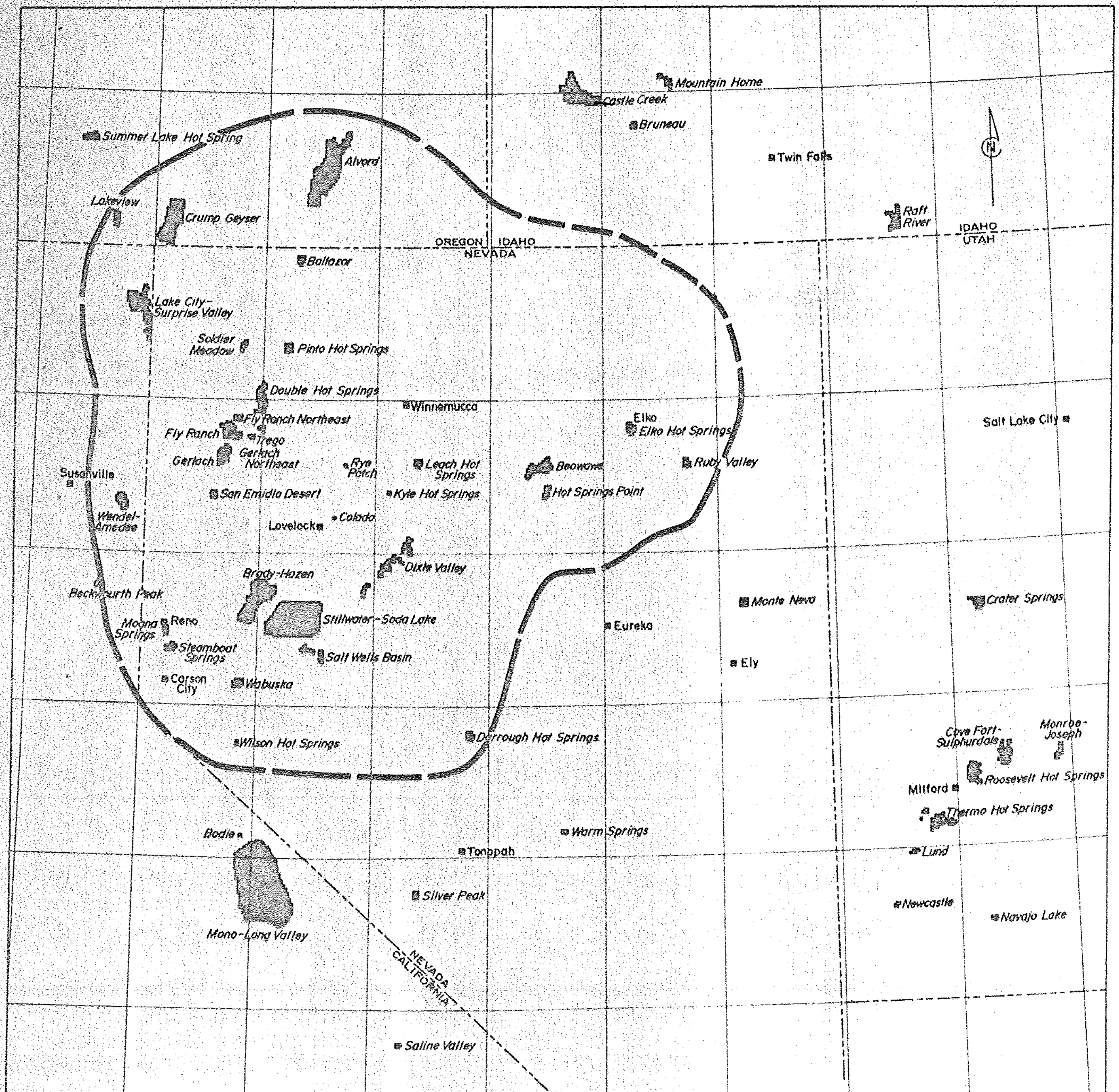
Nevada appears to have a significant geothermal potential for a wide range of applications including electricity generation. High temperature resources appear likely in the northern Nevada region known as the Battle Mountain High. This is a region of anomalously high heat flow and is generally bounded by Darrough and Wilson Hot Springs at the southern limit, Ruby Valley at the approximate eastern limit, Alvord, Oregon at the approximate northern limit, with Lakeview, Oregon, Susanville, California, and Beckworth Peak being the approximate western limits (see Figure 1). The Battle Mountain Heat Flow High is generally characterized by Basin and Range faulting and Quaternary volcanism. Although surface manifestations of geothermal activity such as hot springs are common, it is not prerequisite to the existence of a geothermal reservoir at depth.

Recent exploration and development efforts in northern Nevada have intensified, with the private sector, the DOE, the University of Utah Research Institute Earth Science Labs (UURI), and the University of Nevada - Reno actively involved in various capacities.

GOVERNMENT - FUNDED PROGRAMS

Doe Industry-Coupled Cost-Sharing Reservoir Assessment Program

The DOE (Las Vegas) selected eight private firms in August 1978 to provide reservoir assessment data from 11 areas within The Battle Mountain Heat Flow High (see Figure 2). In addition, existing data from prior investigations will be made available from many of the areas of current work plus San Emidio (Chevron) assessment data. The work,



Data base: GEOTHERMAL ENERGY RESOURCES of the WESTERN UNITED STATES, NGS-TDC NOAA 1977

Figure 1

BATTLE MOUNTAIN HEAT FLOW HIGH
NORTHERN BASIN & RANGE PROVINCE

DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY

▪ CITIES ▪ *KGRA*

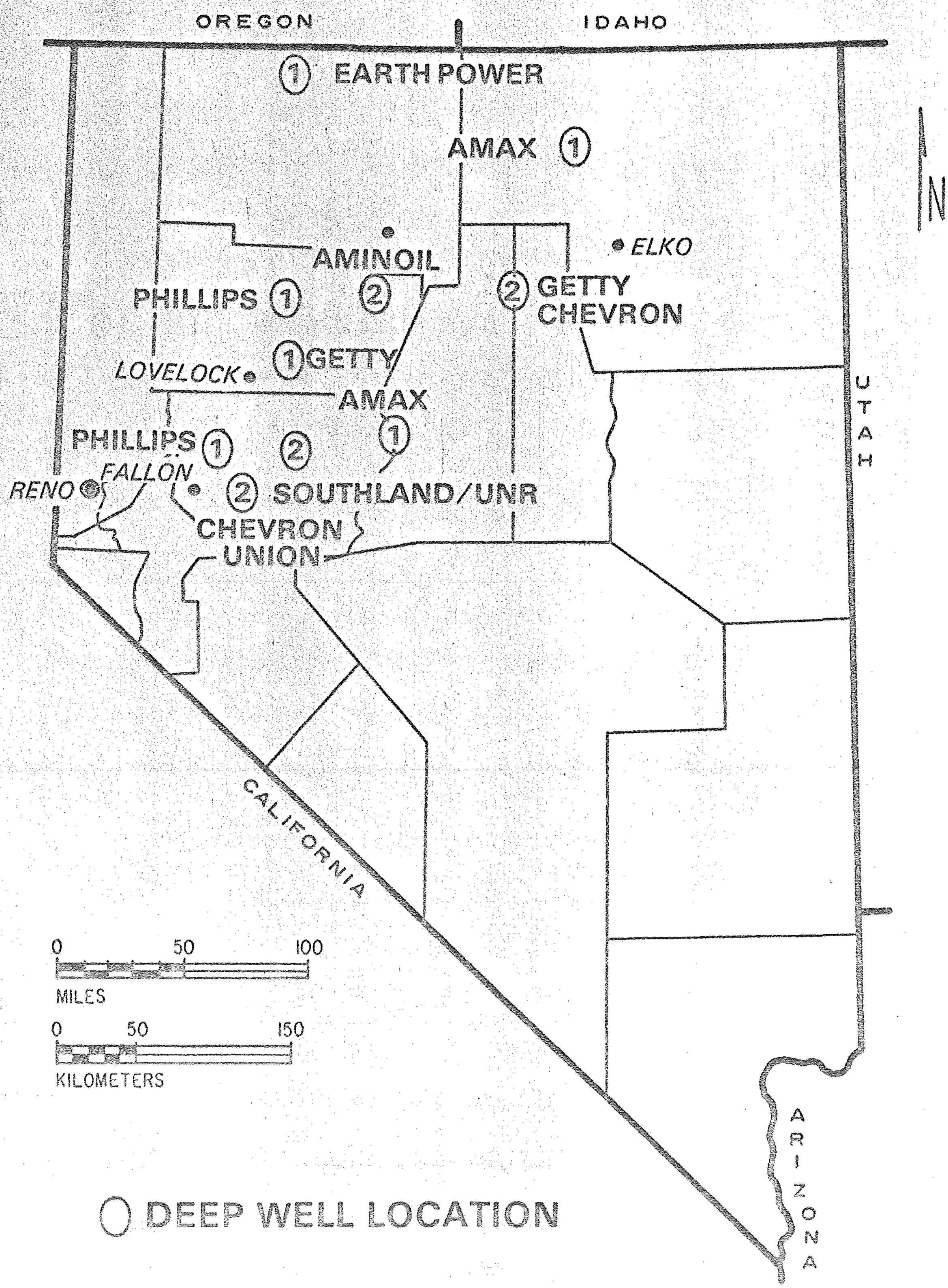
0 50 100 MILES

0 50 100 kilometers

ESL-UURI-001

Figure 2

INDUSTRY COUPLED GEOTHERMAL RESERVOIR ASSESSMENT NORTHERN NEVADA 1978 & 1980



scheduled to take place over the next 2½ years , is detailed in Figure 3.

Geophysical surveys where not already completed will be conducted by the contractors, generally including gravity, aeromagnetic, resistivity, magnetotelluric, passive seismic (ground noise or microearthquakes), reflection seismic and self-potential surveys.

Shallow temperature gradient/lithology holes ranging from 150 to 500 ft (45 to 152m) deep will be drilled to evaluate heat flow contours. Following completion and evaluation of results from the shallow gradient holes, several intermediate depth (1,000-2,000 ft or 305-610m) wells will be completed to determine the lithology, temperature gradients, and pressure in the holes. Other than temperature and pressure logs, geophysical logs from the intermediate holes will be provided as part of the data suite. Some contractors will provide cuttings along with the lithologic data.

The fourteen deep holes will range in depths from approximately 4,000 ft (1,219m) (Chevron) to 10,000 ft (3,148m) deep (Phillips). In all cases, attempts will be made to take at least one core. Short flow tests of 12-24 hours or 24-48 hours will be conducted wherever hole conditions permit testing. Data submitted from deep well projects will be geophysical logs (see Figure 4), physical samples, completion reports and flow test data.

Figure 3. INDUSTRY-COUPLED DOE PROGRAM PARTICIPANTS AND PLANNED ACITIVITIES

Location	Contractor	Existing	New Data	Data Released to DOE
McCoy Area (outside KGRA or prospective KGRA boundary)	AMAX Exploration, Inc.	• Temperature/lithology data from 15 shallow heat flow holes 125 ft (38m) deep.	• Twenty-five 150-350 ft (46-107m) deep temperature/lithology holes by 6/79	9/79
		• Computer representations of heat flow determinations and geophysical surveys.	• Gravity survey over 70 sq miles	9/79
			• Self-potential survey	9/79
			• MT survey - 70 sq miles area	9/79
			• Aeromagnetic survey at 1,000 ft (305m) elevation	9/79
			• Passive seismic survey	9/79
			• Three temperature /lithology holes approx. 2,000 ft (610m) deep by 8/79	11/79
			• Reflection seismic survey	11/79
			• One deep 7,500 ft (2286m) exploration hole, including flow-test by 9/80	12/80
Tuscarora	AMAX Exploration, Inc.	• Computer-generated temperature models based on shallow (130 ft (40m) deep) gradient lithology holes.	• Twenty 150-350 ft (46-107m) deep temperature/lithology holes by 6/79	9/79
			• Gravity survey over 70 sq miles	9/79
			• Self-potential survey	9/79
			• MT survey - 70 sq mile area	9/79
			• Aeromagnetic survey at 1,000 ft (305m) elevation	9/79
			• Passive seismic survey	9/79
			• Three 2,000 ft (610m) temperature/ lithology holes by 10/79	1/80
			• Reflection seismic survey	1/80
			• One deep 7,500 ft (2286m) hole and flow-test by 12/80	3/81
Leach Hot Springs	Aminoil (Tentative)			
San Emidio	Chevron	• Well data for Kosmos 1-8, 1-9 Temperatures, core description lithology log, geophysical logs, drill stem test results, fluid chemistry	• No New Data	
		• Geophysical surveys (gravity, passive seismic, seismic reflection)		
		• Temperature gradient and lithology log data from shallow holes 200-500 ft (61-152m) deep		
		• Photogeology - Lake Range area.		
Beowowe	Chevron	• Data from 2 deep wells 9560 ft (2914M) and 5680 ft (1731m) deep, #1-13 and 21-19: cuttings, core description for 1-13,	• Reflection seismic	9/79
			• One 4,000 ft (1219m) deep hole including short-term flow test.	9/79

Figure 3, continued, page 2

Location	Contractor	Existing Data	New Data	Data Released to DOE
Beowowe, cont.'d	Chevron	• Drill stem test results, lithology log, geophysical logs		
		• Geophysical Data: resistivity, MT survey, self-potential, aeromagnetic, microearthquake, reflectionseismic, ground noise		
Soda Lake	Chevron	• Chevron-Phillips wells 1-29 and 44-5, 4300 and 5070 ft (1,310 and 1,545m) deep respectively incl. cuttings, lithology log, core description, flow test data, fluid chemistry, geophysical logs	• Two 2,000-ft (610m) deep temperature/lithology holes by 1/79.	3/79
		• Data from eleven (11) 500-ft (152m) temperature gradient holes		
		• Geophysical data: resistivity MT survey, reflection seismic		
Baltazor	Earth Power	• Data from 27 shallow temperature gradient holes 230 ft (70m) deep	• Three 1,500 ft (457m) deep temperature gradient holes including lithology logs. (Note: If not favorable will terminate efforts at this time) by 8/79.	12/80
			• One deep exploration hole 9,000 ft (2743m)deep, plus drill stem test if hole conditions permit; completion by 8/80	12/80
Colado	Getty	• Temperature data from two 400 ft (122m) deep mineral core holes	• Eighteen 500 ft (152m) temperature gradient holes	2/79
		• Geophysical: gravity/magnetic survey, resistivity	• One 1,500 ft(457m) temperature gradient hole	6/79
			• One 8,000-ft (2438m) exploration hole	6/80
			• including short-term flow test	8/80
Beawowe	Getty		• Geophysical data gravity/magnetic, resistivity.	5/79
			• Fourteen temperature-gradient holes approx. 500 ft (152m) deep	10/79
			• One 1,500 ft (457m) temperature-gradient hole	3/80
			• One 9,500 ft (2896m) exploration hole	4/81
			• Short-term flow test	9/81
Rye Patch	Phillips	• Surface Geological Map	• One 8,000 ft (2438m) exploration hole	8/79
		• Campbell E-1 lithology log, sub-surface temperature data		
		• Strat test #4, temperature survey, geological cross-section, MT slice map		
Desert Peak	Getty	• Geological map and cross-sections	• One 10,000 ft (3048m) deep exploration hole by 6/79	8/79
		• Strat tests 2 and 5 equil. temperature profiles		
		• Strat test #7 sub-surface temperature survey, fluid analyses, MT slice maps		
		• Lithology logs and temperature survey wells #21-1, 21-2		

Figure 3, continued, page 3

Location	Contractor	Exisiting Data	New Data	Data Released to DOE
Desert Peak, cont.'d	Phillips	• Geophysical Data: ground magnetic gravity		
Dixie Valley	Southland-Royalty	• Geophysical: multilevel aeromagnetic, MT survey	• Two 1,500 ft (457m) deep temperature gradient holes	2/79
		• Temperature gradient hole data from four 1,500-ft (457m) and two 500-ft (152m) deep holes - data included fluid samples, GeothermEx report, economic feasibility reports	• Two 8,500 ft (2,591m) deep exploration holes plus	7/79 and 12/79
			• Short term flow tests	12/79
			• UNR study includes hydro-logic-hydrochemical survey, prepare acquifer flow model, high altitude photographic analysis for structure and surface expression of hot spots, Petrologic alteration study.	12/79
Stillwater	Union Oil Co.	• Geophysical data dipole dipole Resistivity, MT survey, Gravity Map	• One 8,000 ft (2,438m) exploration hole by 4/79	10/79
		• Temperature data from 16 holes with average depth 275 ft (84m)	• Second 8,000 ft (2,438m) exploration hole by 8/79 dependent on results from 4/79 hole including flow tests	1/80
		• Lithology/temperature data plus geophysical logs from 4 deep wells 3,450 ft (1,051m), 5,530 ft (685m), 2,670 ft (814m), and 3,635 ft (1108m) deep.		

NOTE: See Figure 4 for detailed data expected from drill hole activities.

Figure 4. DRILL HOLE DATA EXPECTED FROM EACH CONTRACTOR

A. Shallow holes - temperature and lithologic data.

B. Intermediate holes - geophysical logs including temperature and pressure logs, lithology description from cuttings, plus cuttings in some cases.

B. Deep Holes - Mud logs, cuttings, fluid samples and analyses, core description if coring is successful, and geophysical logs as follows:

Temperature
Pressure
Induction
Densilog
Acoustic
Compensated Neutron
Gamma Ray
Caliper

Log suites will include any combination of the above logs, but are not limited to this list.

In addition, short-term flow tests of 12-24 hours or 24-48 hours are to be conducted if hole conditions permit.

Drilling history and completion reports are required for all deep holes along with any flow test results.

Physical samples such as cuttings and specified portions of the cores recovered will be transmitted to UURI for case study investigations and permanent storage in Salt Lake City custidial facility which is available to the public (Fiore, personal communication).

Samples of fluids will also be sent to UURI, although generally contractors will provide chemical analyses of recovered fluids with the flow test reports.

The overall result of this program will be a fairly comprehensive geothermal evaluation within the Battle Mountain High region with emphasis on the electricity generating potential of the reservoir.

Elko Space Heating Project

A DOE (San Francisco) funded evaluation program for non-electric geothermal utilization will provide for the following project at Elko:

A. Reservoir assessment includes 100-200 surface temperature survey holes approximately 6 ft (2m) deep with temperature readings from thermisters placed downhole. This phase will intensify data density obtained previously. Following contouring of all shallow temperature gradient data, sites for three to five 500 ft (152m) deep temperature/lithology holes are to be drilled. Results from this phase will determine the site for one 2,000 ft (610m) production well.

B. A utilization plant to provide space heat for at least 3 commercial buildings will be designed.

C. Construction of geothermal space heating plant for 3 commercial buildings is the last phase of the program.

The outcome of this demonstration project will determine the extent of future space heating development in Elko. The community is generally receptive to the prospect of geothermally heating schools, businesses and homes, according to Ira Rackley, proponent of geothermal development in Elko.

High temperatures of 185-195°F (85-90°C) are encountered only one-half mile from Elko's central business district in a hot spring called the Elko Hot Hole. Chemical analyses of the fluids from local wells which encounter the prospective production zone gives a silica geothermometer reservoir temperature of 210°F or slightly greater (Rackley, personal communication).

The Hot Hole surface water is potable, having very similar chemical content to that of the local water supply except for a slightly fluoride content. The Hot Hole water level fluctuates with ground water table fluctuations observed during seasonal drawdowns in local wells (Rackley, personal communication).

The immediate valley floor underlying Elko consists of alluvial deposits to approximately 300-400 ft (91-122m) deep. Below 400 ft (122m) the temperatures in wells rise sharply and softer clayey deposits are encountered. Brackish water has been discovered during drilling for potable water.

The north side of the valley is block faulted with a northeast dip and the south side of the valley is highly fractured with surficial hydrothermal alteration. The Elko Hot Hole is located on a fault scarp which dips under the alluvium (Rackley, personal communication).

Geothermal Food Processors, Inc., Brady Hot Springs

Geothermal Food Processors, Inc., the first food dehydration plant utilizing geothermal energy for processing in the United States, was dedicated in November, 1978.

Magma Energy Company did the exploration and assessment work during the late 50's and 60's in an attempt to locate a high temperature resource adequate for electricity generation. When the results were disappointing for economical electric applications, B.C. McCabe affiliated with Mr. Ray Nash, a food dehydration expert. Tests indicated one well would be suitable for vegetable dehydration (GRC Bull.,1978) and the two proceded with development of the plant which is located 50 miles northeast of Reno.

The exploration and reservoir assessment work was privately funded and the plant was built with the assistance of DOE's Geothermal Loan Guarantee Program. The loan was granted by Nevada National Bank for 74 per cent of the total plant cost.

The primary product now being processed in dehydrated onions. The plant has capability of dehydrating celery, carrots, and other similar vegetables, and employs 75 persons.

Fluid temperature is 270°F (132°C) and the well is located only 1,000 ft away from the plant (GRC Bull.,1978).

U.S. Navy

The U.S. Naval Geothermal Utilization Division at the Naval Weapons Center, China Lake, California is actively involved in assessment of geothermal resources located on the Naval Air Station range and associated ranges at Fallon (Stillwater - Soda Lake KGRA). Although a high-temperature resource capable of electricity generation is the first priority, the possibility of space heat utilization is also being considered. The object of the effort is to provide electricity and/or space heating for base facilities (Whelan, personal communication).

University of Nevada - Reno

The University of Nevada - Reno has been engaged in a study to delineate low to moderate geothermal temperature resources throughout the state. A map showing locations, temperatures, and geochemistry wherever possible will be the final outcome. The map is expected to be completed by March, 1979. The study included updating of the U.S. Geological Survey GEOTHERM file (Menlo Park, California) with known well and hot springs data, a process which will continue in the future as new low to moderate resources are defined in Nevada. The project in funded by DOE.

University of Utah Research Institute-Earth Sciences Laboratory

UURI's participation in the industry-coupled reservoir assessment program involves the dissemination of technical data generated from the 2½ year program. Case histories will be prepared for public release including public access to geophysical and drilling data. Physical samples such as core and cuttings will also be publicly available at intervals announced by UURI. UURI is the custodian of all physical samples which are stored at a warehouse facility located in Salt Lake City.

Privately Funded Geothermal Exploration and Development in Nevada

The private sector has been extensively involved in geothermal resource assessment since 1954. Approximately 12 major exploration firms have conducted drilling programs during the 25 year period. GEOTHERM computer print-outs provided the following data (U.S.G.S. 1978).

The earliest drilling conducted in Nevada to tap geothermal energy was in 1954 when Nevada Thermal Power Company started drilling at Steamboat Hot Springs.

Magma Power conducted extensive exploratory drilling programs as early as 1959 at Brady Hot Springs, Beowowe, and Wabuska Hot Springs. They continued throughout the 60's and 70's to explore geothermal resources at Hazen (Brady-Hazen KGRA), Hot Springs Point, Monte Neva Hot Springs, and Darrough Hot Springs.

Two more early geothermal explorers were the Vulcan Geothermal Power Company and U.S. Steel Corporation. In 1962 U.S. Steel drilled at Hind's Hot Springs and Wally's Hot Springs while Vulcan drilled several wells at Beowowe from 1961 through 1963.

A surge of interest came in 1964 with Earth Energy, Inc. drilling at Brady Hot Springs, Sierra Pacific Power drilling at Beowowe, O'Neill Geothermal, Inc. drilling at Stillwater, and Western Geothermal, Inc. drilling several exploratory holes at Pyramid Lake and Fly Ranch KGRA (Ward's Hot Spring).

During 1974, Chevron, Phillips and Union became involved in exploration and assessment of Nevada's resources. Phillips Geothermal drilled at Desert Peak (Brady Hot Springs KGRA) from 1974 through 1977. This assessment effort is continuing with DOE assistance. Chevron and Phillips in a joint effort drilled an exploratory well at Soda Lake. Chevron is still actively evaluating this resource. Chevron also initiated exploratory drilling at Beowowe during 1974. In 1975, they began assessment at the San Emidio Desert KGRA.

Union Oil Company joined with Magma Energy for drilling at Brady Hot Springs in 1974. In 1976 Union drilled at Stillwater KGRA. This is an on-going effort with assistance from DOE.

The Dixie Valley KGRA is presently being evaluated by

Southland Royalty. Earlier exploratory efforts are being expanded to drilling exploratory holes with DOE providing partial funding. Sun Oil Company is also currently drilling in the Dixie Valley KGRA.

The 1978 Phillips drilled an exploratory hole at the Rye Patch KGRA. Another deep hole will be drilled for further reservoir assessment as part of the DOE industry-coupled program.

CONCLUSIONS

The level of reservoir assessment activity currently in progress throughout Northern Nevada implies significant geothermal energy potential will be available for the future. The DOE industry-coupled cost-sharing program alone accounts for total private and DOE expenditures of $20,000,000 over the next 2½ years.

Geothermal potential is not limited to high temperature electricity generating resources. Nevada has abundant and widespread low to moderate temperature resources which are being investigated and developed for non-electric applications.

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