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OPPORTUNITIES

FOR

DEVELOPMENT OF GEOTHERMAL POWER

AT

ROOSEVELT HOT SPRINGS,

UTAH

for

CITY OF BOUNTIFUL,

UTAH

by

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July 7, 1977

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CONCLUSIONS

1. The McDonald lease is within the proven geothermal field and, although not drilled to date, may be considered very likely to be productive of geothermal hot water of about 500 BTU/lb enthalpy at perhaps 240°C.

2. Because of small size, and based upon well-spacing assumptions of one well per 40 acres, the maximum sustainable yield of the lease is likely to be 7 to 10 mW for an indeterminate period (perhaps over 30 years). This is based upon 1 million pound per hour flows declining by 30 percent over a 10-year well life.

3. Over an assumed 30-year plant life, Bountiful would need to drill and operate three geothermal wells, in succession, plus one disposal well, for an estimated total cost for drilling and testing (1977 dollars) of about $2.25 million.

4. No long-term flow tests have been held at Roosevelt; the longest is approximately 3 days. Tests of up to 6 months are planned by Phillips, including re-injection of residual fluids into another well. These tests are vital; Bountiful should attempt to participate in them if an active role is planned in geothermal development.

5. Federal regulations have delayed geothermal operations at Roosevelt by many months, and have the potential to cause still-greater delays. This would affect the McDonald lease, but might not cause equal problems in adjoining Section 16, a State of Utah property leased by Natomas Company and O'Brien Gold Mines. A successful well, Utah State 72-16, exists there.

6. Unresolved risks to Bountiful would include: (a) cost overruns due to increased time delays; (b) lack of assurance that the 10-year federal lease will be extended in 1984; (c) uncertainty over authorization to appropriate water, which must be approved by the Utah State Engineer; (d) lack of long-term production data for extrapolation on the McDonald lease.

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7. An opportunity may exist for obtaining ERDA financing (in part) for testing of geothermal wells, or construction of a 50 mW demonstration power plant. The latter would require co-venturing with Natomas-O'Brien in order to obtain a sufficiently large leasehold to support 50 mW. To date ERDA has made no commitments at Roosevelt.

8. Downside protection to Bountiful lies in the likelihood of finding other operators (perhaps Phillips, Natomas, Getty, AMAX, Union, or O'Brien) to take over the McDonald lease at no net loss to Bountiful.

9. Terms asked by McDonald are undoubtedly high, but probably are not unrealistic or extortionate. Probably they could be passed on to future would-be purchasers.

10. There appears to be no compelling reason to join Phillips' geothermal unit at this time. Phillips appears willing to consider applicants at later dates; this possibility should be kept in mind for later.

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DESCRIPTION OF THE ROOSEVELT HOT SPRINGS GEOTHERMAL FIELD

The Roosevelt geothermal field, as presently defined, is located on the west flank of the Mineral Range in Beaver and Millard Counties of west-central Utah (Figure 1). The area is about 200 miles south-southwest of Salt Lake City and about 10 miles northeast of Milford, the most important town in the vicinity.

Geology and Geophysics

Regional Geology

This is the transition zone between two geologic provinces, each with a distinct character and history. The basic tectonic framework of the region was established in Precambrian time. West of the area, Precambrian rocks of the Utah-Nevada province form a thick sequence of slightly metamorphosed quartzite, carbonate rocks, and argillite ranging in age from 1.0 to 0.6 billion years. To the east, beneath the Colorado Plateau, Precambrian basement of the Churchill province consists of crystalline schist, gneiss, and other high-grade metamorphic rocks; ages in this suite range from 1.8 to 1.6 billion years. Rocks of probable Precambrian age in the Mineral Mountains appear to belong to the Colorado Plateau province on the basis of lithology, and may represent the western edge of that province.

From Cambrian to Triassic time, there was a miogeosyncline in eastern Nevada and western Utah and a crational area to the east, under the Colorado Plateau. Stratigraphic sections indicate that the Mineral Range lies within the transition zone between these two provinces. Depositional history during this long time-span comprises episodes of marine transgression, during which sedimentation extended eastward over the craton; and of regression, when deposition was confined to the axial regions of the geosyncline.

Throughout this long Paleozoic-Early Mesozoic interval, the main rock types deposited were limestone, dolomite, and quartz arenites. Shales were laid down only during brief intervals.

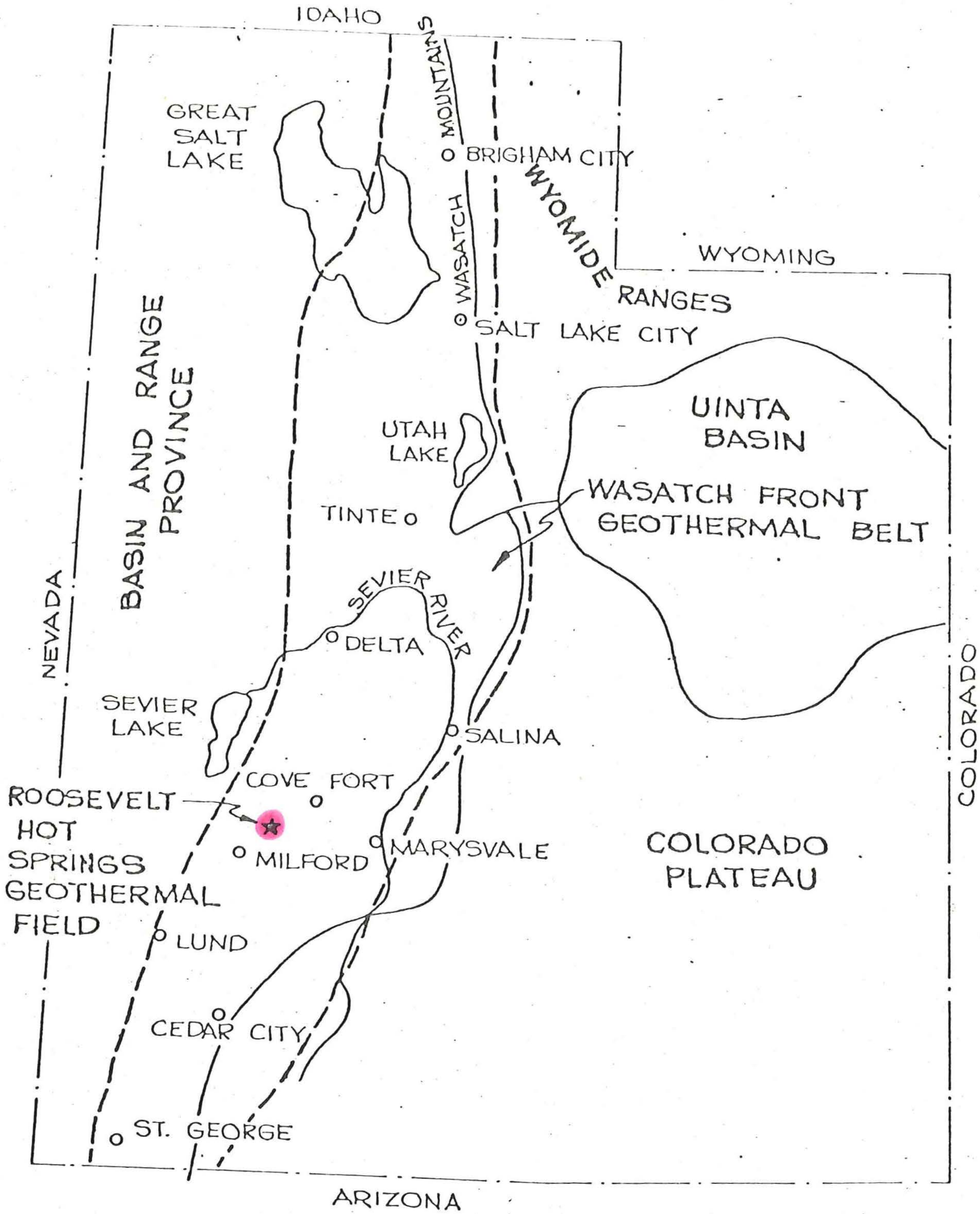

Figure 1. Location of the Wasatch Front Geothermal Belt of Utah.

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Based on very limited deep drilling for oil and gas in the region, it appears that most of these Paleozoic sedimentary rocks lack primary porosity. Any significant porosity now existing is likely the result of fracturing or solution-channel development (in carbonate rocks). Furthermore, the limited amounts of shale in the section would seem to be insufficient to form cap rocks or to break hydraulic continuity within the carbonate sequence. Thus, it is likely that fluid storage capacity exists throughout the entire Paleozoic section, and there is no reason to anticipate that one part of this sequence has more attractive reservoir potential than another. Rather, reservoir may be best developed where there is most active tectonism. Fracture permeability may be developed equally well in Precambrian rocks.

By Middle Triassic time, sedimentation throughout the area had become continental in type. There was a short-lived period of marine deposition in Jurassic time.

During Cretaceous time, the province west of the Roosevelt area underwent deformation that included extensive low-angle thrust faults with horizontal displacements of tens of miles; while the Colorado Plateau province to the east underwent less intense deformation, including folding and minor thrusting. In Early Cenozoic time, the region was the site of deposition of extensive fluvial and lacustrine sediments. This was followed, in Upper Eocene through Miocene time, by the eruption of thick ash-flow tuffs of regional extent. The later Cenozoic igneous history of the Mineral Mountains is dominated by intrusion of the granitic stock which makes up the bulk of the range.

Late in Cenozoic time, there was a major episode of normal faulting in the region, resulting in the development of the present fault-block ranges and graben valleys of the Basin and Range province. The Mineral Mountains are the easternmost of the typical basin-and-range mountain blocks at this latitude. Faulting along the west side of the range has continued at least into the Pleistocene epoch (Figures 2 and 4).

Local Geology

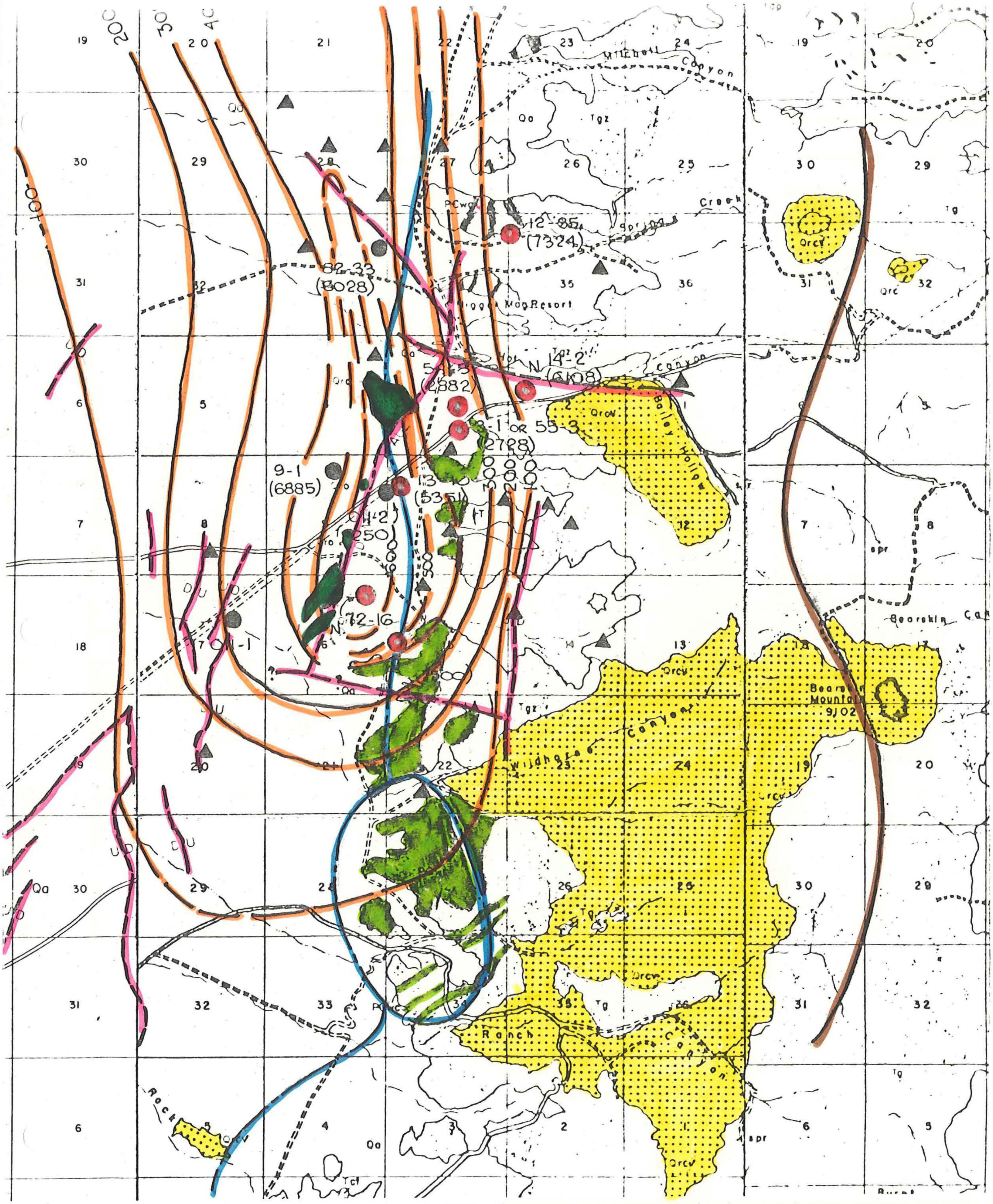
The west-central part of the Mineral Range, where exploratory drilling in the Roosevelt geothermal system has been done by

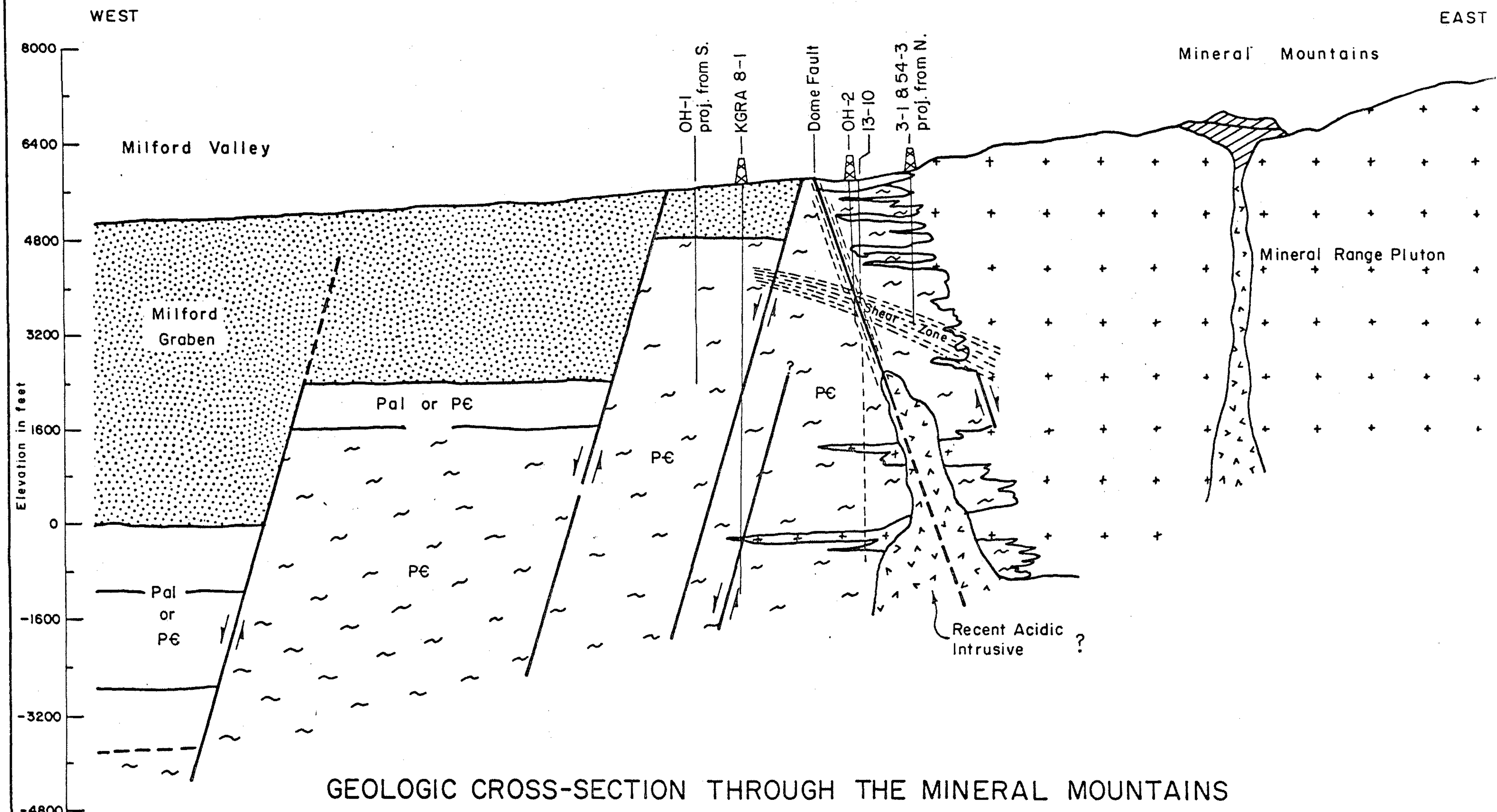
Figure 2. Geology, Temperature Gradients, Gravity Anomalies and Geothermal Wells, Roosevelt Hot Springs, Utah.

LEGEND

Geologic Units

Qro	Quaternary opalite and siliceous sinter
Qa	Quaternary alluvium and related sediment
Qb	Quaternary basalt flows and cinder cones
Qrvc	Quaternary rhyolite domes and flows (Ranch Canyon Volcanics)
Tdp	Pliocene (?) dellenite porphyry dike
Tl	Pliocene (?) lamprophyre dike
Tg	Miocene-Pliocene (?) granite (Mineral Range pluton)
Tgz	Zone of pre-Miocene inclusions in Mineral Range pluton
p€wc	Precambrian gneiss and schist (Wildhorse Canyon series)
	contact
?	fault, dashed where inferred, queried where uncertain
72-16	geothermal well, designator number
(6885)	geothermal well belived capable of producing steam depth (feet)
	drilling site proposed by Phillips Petroleum Co.
L	axis and center of complete Bouguer low
	approximate axis of rhyolite domes
200	temperature gradients, °C/km; dashed where data are sparse


Mitchell Canyon
Creek
Spring
Canyon
Bailey Hollow
Bearskin Ca
Bearskin Mountain 9102
Wildhorse Canyon
Ranch Canyon
12-85
(7324)
82-33
(8028)
9-1
(6885)
N 14-2
(6108)
72-16
Qa
Tgz
Qrcv
Tg



GEOLOGIC CROSS-SECTION THROUGH THE MINERAL MOUNTAINS AND ROOSEVELT HOT SPRINGS GEOTHERMAL FIELD

1 0 1 miles

Vertical Exaggeration 2X

Redrawn from Phillips Petroleum Co., Sept., 1976, Field Guide to Roosevelt Hot Springs.

FIGURE 3

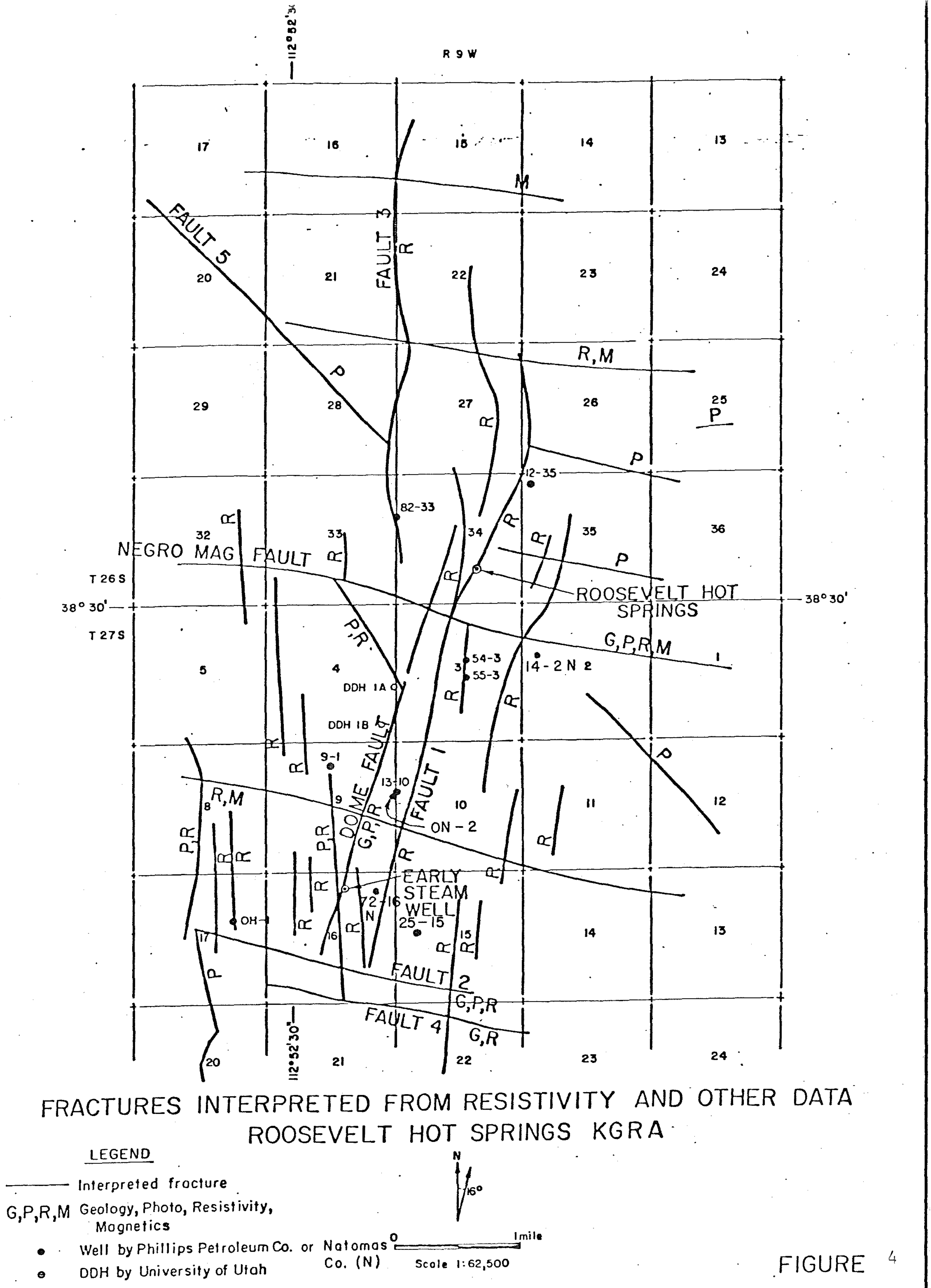

R 9 W
112°52'30"
FAULT 5
FAULT 3
NEGRO MAG FAULT
ROOSEVELT HOT SPRINGS
DOME FAULT
FAULT 1
FAULT 2
FAULT 4
EARLY STEAM WELL
T 26 S
T 27 S
38° 30'
12-35
82-33
54-3
55-3
14-2 N 2
DDH 1A
DDH 1B
9-1
13-10
ON-2
72-16 N
25-15
OH-1
G,P,R,M
G,P,R
G,R
R,M
P,R
FRACTURES INTERPRETED FROM RESISTIVITY AND OTHER DATA
ROOSEVELT HOT SPRINGS KGRA
LEGEND
Interpreted fracture
G,P,R,M Geology, Photo, Resistivity, Magnetics
Well by Phillips Petroleum Co. or Natomas Co. (N)
DDH by University of Utah
N
16°
0
1 mile
Scale 1:62,500

FIGURE 4

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Phillips and Natomas, consists essentially of three types of rocks (Figure 2 and 3). They are: (1) Precambrian metamorphic rocks, including schists and gneisses; (2) the Mineral Range stock, a large granitic intrusion; and (3) very young volcanic rocks of rhyolitic composition. To the west on the sloping floor of Milford Valley is an accumulation of unconsolidated sediment of varying thickness. This probably covers Precambrian (and possibly Lower Paleozoic) rocks at a depth of several hundred to a few thousand feet (Figure 3).

Precambrian(?) Metamorphic Rocks. These rocks, which were called the Wildhorse Canyon Series by Condie (1960), consist mainly of biotite gneiss with minor associated schist and phyllite. The Precambrian age assignment of these rocks is based on their metamorphic style and grade, and on their lack of compositional similarity to any of the Paleozoic or younger rock of the region. As discussed above, these rocks may belong to the Churchill province of Precambrian rocks in the Colorado Plateau and be about 1.8 billion years old.

Mineral Range Stock. The central Mineral Mountains are made up largely of a major Tertiary granite body (Condie, 1969).

This is the largest of the exposed Tertiary stocks in Utah. The age of this pluton is variously reported to be 9.2 m.y. (Armstrong, 1970) and 15.5 ± 1.5 m.y. (Park, 1968). However, these ages may be too young as a result of subsequent reheating during Late Tertiary or Quaternary volcanic phases; if so, the intrusion may belong to one of the intrusive episodes represented in adjacent areas by stocks which were emplaced in the 27-28 m.y. and 20-22 m.y. time intervals. All of the proposed ages of the pluton are too old to permit the exposed parts of the body to act as a heat source for a local geothermal system. Quaternary intrusions at depth have been postulated by geologists (Phillips Petroleum Company and researchers at the University of Utah, oral communications, 1976).

Quaternary Rhyolite Rocks. These rocks, which were called the Ranch Canyon volcanics by Condie (1960), consist of rhyolite plugs, flows, and associated minor tuffs resting upon

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an erosional surface developed on the Mineral Mountains granite. The main eruptive centers were at North and South Twin Flat Mountain and Bearskin Mountain. Flows extend down the west side of the range from these eruptive centers. The basal part of the section includes local deposits of tuff and pumice up to 1,000 feet thick. These are overlain by rhyolite and rhyolite porphyry flows, then by obsidian and vitrophyre flows, and finally by more rhyolite tuffs. The total thickness of the section may locally reach a maximum of 2,000 feet (Condie, 1960). The linear distribution of some of the eruptive centers suggests that they occur along one or more fault zones. On the basis of composition, it has been suggested that the source of the rhyolite could be granite remelted at depth (Evans and Nash, 1975). Nash (1976) reported that the ages of these volcanics range from 0.78 to 0.49 m.y., which makes them amongst the youngest rhyolite eruptives in Utah.

Faulting. The principal structures in the central Mineral Range are high-angle normal faults of Late Cenozoic age (Figures 2 and 3). The youngest and most important of these faults occur in north-trending zones along the east and west sides of the Mineral Range horst. Gravity data indicate that these zones are made up of several sub-parallel faults along which step-like displacements have taken place. Total displacement along the western zone is estimated to be about 4,500 feet and, along the eastern side, about 6,200 feet (Thangsuphanich, 1976). The horst between the two fault zones appears to be tilted westward.

The range-bounding faults are located valleyward from the major bedrock escarpments and are covered by alluvium. However, detailed photogeologic mapping along the west side of the range shows that Holocene fault scarps are present in the alluvium (Petersen, 1975). The zone in which these scarps occur is as much as 6 miles wide in the Roosevelt Hot Springs area. Trends of these small faults are mainly northerly but some are northeasterly or northwesterly. The largest of them is the Dome fault, which has a length of about 3 miles. This fault has been the locus of past hydrothermal activity, indicated by the development of a siliceous sinter mound and silica-cemented gravels along it. Deposits of this type have been fault-offset by as much as 20 feet (Petersen, 1975, and Mower and Cordova, 1974).

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A prominent and unusual group of east-trending normal faults is present in the Mineral Range. In the Roosevelt geothermal area, probable faults in Negro Mag Wash and in Sec. 15 and 22, T. 27 S., R. 9 W., trend easterly. Long, straight, east-west topographic lineations in the range suggest that joints or faults with this trend may be more common than indicated by available reconnaissance mapping (Figure 4). The significance of this fault trend to geothermal prospecting is uncertain. The faults in Sec. 15 and 22 may somehow limit the thermal anomaly along the southern Dome fault, and the fault in Negro Mag Wash appears to correlate with a perturbation in temperature-gradient contours.

Geophysical Data

Geophysical data are available from gravity, telluric, aeromagnetic, resistivity, microearthquake, and temperature-gradient surveys. Taken together they show a major, apparently active normal-fault zone along the west side of the Mineral Mountains, containing a strong temperature-gradient anomaly. Pronounced vertical zones of high and low resistivity parallel faults in this zone, but have no simple relationship to the geothermal reservoir as presently known.

Gravity. Gravity measurements (Figure 2) show that the Mineral Range is a horst (expressed as a gravity high) flanked by normal faults of major displacement. Escalante Valley, to the west, is a deep graben (expressed as a gravity low), with pre-Tertiary bedrock as much as 7,000 feet deep near its center (Figure 3). Basement is significantly shallower along the valley margins. Beaver Valley, on the east, also is a deep graben, and bedrock there has a maximum depth of about 6,000 feet. On both sides of the horst, steep gravity gradients indicate that a series of step faults is present. The data are not detailed enough to show individual faults.

Within the Mineral Range, the Bouguer anomaly varies considerably from north to south along the range axis. At its north and south ends there are closed gravity highs. Near the middle there is a discrete gravity low and a gravity "saddle," each with Bouguer values as much as 20 milligals (mgal) lower

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than elsewhere in the Range. The cause of this large variation is unknown and cannot be explained readily in terms of surface geology. However, the minimum does coincide approximately with the presumed eruptive center of the Ranch Canyon volcanics in the vicinity of North and South Twin Flat Mountains (Figure 2). The coincidence suggests the possibility that a large, relatively low-density intrusion is associated with these young volcanics. The elongate Bouguer gravity low in Sec. 17-19, T. 27 S., R. 8 W., may represent a molten or near-molten body (S. H. Ward, oral communication, 1976), perhaps as an apophysis rising from the postulated larger and deeper magma. Figure 2 shows the relationship of gravity axes and minima to geology and the geothermal well field.

The regional 20 mgal deficit can be modeled by a variety of hypothetical low-density mass-distributions at depth; for example (D. D. Blackwell, oral communication, 1976), as a horizontal cylinder with a diameter of 5 km and a length of 7 km, with its top about 1-1/2 km below the ground surface and a density still lower, its volume would be correspondingly smaller. In any case, data suggest that the anomalous body may have a volume of dozens of cubic kilometers and may approach a density corresponding to the melting point for rhyolite.

Geoelectrical surveys. Dipole-dipole resistivity surveys covering a long narrow strip along the west flank of the Mineral Range, including the Roosevelt geothermal area, were performed by the Department of Geology and Geophysics of the University of Utah.

Several fracture sets were recognized (Figure 4) in the vicinity of three steam-producing wells; hydrothermal alteration and brines in these fractures produce pronounced resistivity lows at shallow depth (less than 500 m). These fracture sets appear to carry fresh water into, and brine away from, the center of a convective hydrothermal system.

However, the resistivity data have revealed very little of the deep geothermal system, because maximum depth of dipole-dipole exploration was just over one km. To this depth, the data do not reveal a heat source for the hydrothermal system. More importantly perhaps, the data do not define that system at depths

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greater than 500 m. Furthermore, Ward and Sill (1976) reported that large-scale bipole-dipole surveys done by Phillips were no more successful in defining hydrothermal system at depth.

Temperature Gradients. Temperature-gradient holes have been drilled in the Roosevelt area by Phillips Petroleum Company, Thermal Power Company of Utah, AMAX Exploration, Inc., and other parties. Gradients range from less than 2.0°F per 100 feet (equivalent to background) to 26.8°F per 100 feet (35°C/km to 485°C/km). The gradient contours outline the elongate north-trending anomaly, the most intense part of which is almost coincident with the Dome fault in Sec. 4, 9, and 16, T. 27 S., R. 9 W. (Figure 2), and the western Bouguer low or saddle discussed above. The anomaly is at least 8.5 miles long (north-south) and 2.5 miles wide (east-west), as contoured on the 100°C/km isograd.

Based on both publishable and proprietary data, gradients drop off approximately equidimensionally and rapidly east and west of the Dome fault. Termination at the north and especially the south ends of the main anomaly is even more rapid. However, a lobe of higher-than-normal gradient extends northwestward into Milford Valley. This high corresponds to the direction of subsurface thermal outflow from the deep geothermal reservoir and probably represents a thermal plume from the vicinity of the Dome fault.

To the east, the rapid decrease in gradient in the mountains is surprising, as the principal mass of Pleistocene rhyolite is exposed to the east. However, the number of available gradient holes in the mountains probably is inadequate. Also, it is likely that terrain factors and the higher amount of precipitation in the mountains serve to depress gradients in holes of 50 meters or less. Further and deeper drilling may reveal a heated cell to the east beneath the cold-water recharge cap. As evidence to support this, a very high temperature well was drilled by Natomas Company on the east edge of the temperature anomaly (Figure 2) near a shallow hole having a calculated gradient of only 69°C/km (Sec. 2, T. 27 S., R. 9 W.).

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Exploration History and Results

Exploration began with the drilling of a 270-foot-deep hole into the opalite mound along the Dome Fault, in 1968. That event yielded an eruption of 270°F water, and began a leasing rush that is still in progress; this in turn led to the discovery of the Roosevelt geothermal field.

Figures 2 and 4 show the location of deep holes (greater than 400 meters) in the Roosevelt area, and Table 1 gives their characteristics. These holes were drilled either by Phillips Petroleum Company or by Thermal Power Company (a subsidiary of the Natomas Company). In addition to this deep drilling, which has reached approximately 7,500 feet in maximum depth, there have been dozens of gradient holes drilled in the 60-mile-long area from north of Cove Fort to south of Thermo. This has been accompanied by tens of line-miles of resistivity and magnetotelluric soundings, several months of microseismic recording, and correspondingly great efforts in hydrogeochemistry, seismic profiling, passive noise recording, gravimetry, aeromagnetometry, photogeology and field geologic mapping, and other exploration techniques.

This work has been accomplished by private companies, members of the U. S. Geological Survey and Utah Geological and Mineralogical Survey, faculty and student researchers at the University of Utah, and private contractors. Relatively little data are in the public domain, although proprietary information does circulate informally by trade of privileged release. These efforts in the Roosevelt Hot Springs area rival those accomplished at The Geysers or in Imperial Valley, California. Phillips Petroleum Company alone acknowledges spending $6 million on leasing, exploration, and drilling since beginning work in 1973; they estimate a total outlay of $30,000,000 by 1982 to develop 110 mW of electric power generation (Gary Crosby, oral presentation, September 1976).

Drilling results (Table 1) reveal a hot-water reservoir with temperatures as great as 260°C (500°F) at depths as shallow as 1,200 feet. Production comes from highly sheared and fractured Precambrian(?) gneiss and schist and possibly from fractured Tertiary granite.

Table 1. Geothermal Wells Drilled at Roosevelt Hot Springs, Utah

Well Number	Location	Date Drilled	Depth, ft.	Casing	Results and Status
Phillips Petroleum Company					
OH-2	SW/4 NW/4, 10-27S-9W	2/2/75-2/15/75	2,250	N.D.	Deep temperature-gradient hole; reportedly high gradient
OH-1 (also 17-1)	SE/4 NE/4, 17-27S-9W	3/3/75-3/12/75	2,321	N.D.	Deep temperature-gradient hole; "high" temperature; low permeability
9-1	NE/4 NW/4, 9-27S-9W	3/13/75-4/8/75	6,885	N.D.	"High" temperature; poor permeability
3-1 (also 55-3)	NW/4 SE/4, 3-27S-9W	4/20/75-5/24/75	2,728	N.D.	Tested at 1.2 million #/hr of hot water
54-3	SW/4 NE/4, 3-27S-9W	7/5/75-8/28/75	2,882	N.D.	∿1 million #/hr of hot water at >500°F and >500 BTU/#; rated as "best" well
12-35	NW/4 NW/4, 35-26S-9W	8/6/75-10/1/75	7,324	7" liner to 4,500'	Suspect shallow-zone cool-water contamination; ∿440°F thermal aquifer now lined off; cannot test satisfactorily
13-10	SW/4 NW/4, 10-27S-9W	10/2/75-11/4/74	5,351	N.D.	Tested above 1 million #/hr of hot water at 75-125 psig
82-33	NE/4 NE/4, 33-26S-9W	11/5/75-12/23/75	6,028	13-3/8" to 575'	>300°F, <350°F; possible future injection well
25-15	NW/4 SW/4, 15-27S-9W	8/26/76-11/12/76	∿ 7513	9-5/8" at ∿2,500'	Shallow-zone cool-water contamination; less satisfactory than wells to north, but producible
(Note: All Phillips' wells are on Federal lease blocks)					
Thermal Power Company (Natomas Company)					
Utah State 14-2 (ML27536)	SW/4 NW/4, 2-27S-9W	9/11/76-10/21/76	6,108	9-5/8" at 1,805'	Reported >400°F hot water at ∿4,000'
Utah State 72-16 (ML25128)	NW/4 NE/4, 16-27S-9W	10/22/76-1/5/77	1,254	N.D.	Reported 1 million #/hr of hot water at 432°F and 355 psig

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Figure 3 is a conceptualization by geologists at Phillips Petroleum Company that pervasively fractured rock, rather than individual fault planes, forms the reservoir. Those holes not cutting the "shear zone" of Figure 3 reportedly exhibit lower permeability. However, all youthful faults may serve to carry hot fluids toward the surface, thus generating high temperature gradients in shallow holes.

The fault trending east-west across Negro Mag Wash apparently does not terminate the field: high temperature (∿440°F) was reported from hole 12-35, nearly 1.5 miles north of this south-dipping feature (Gary Crosby, oral presentation, September 1976). Similarly, the southern boundary of the field is unknown.

Wells drilled very close to the range front commonly exhibit low gradients in the upper positions, reflecting cold-water recharge through fractured rocks of the mountains. Those drilled west of Dome fault exhibit high gradients in their upper portions because of outflow of thermal fluid up Dome fault or other faults. However, deeper gradients may be disappointing, and permeability often is limited west of Dome fault.

Field Size and Capacity

Water to 195°F discharged from Roosevelt Hot Springs (Sec. 34, T. 26 S., R. 9 W.) until about 1963, when either blocking of the spring system by mineral deposition or lowering of the water table caused a cessation of flow. Thereupon, wisps of hot water vapor issued from warm ground. A tepid chloride-water seep about one-quarter mile north of the former hot spring area probably represents upward leakage from the reservoir along the Dome fault. Soil temperatures reach 204°F at about 4 feet in depth near the former main orifice for Roosevelt Hot Springs. A nearby group of springs in Negro Mag Wash (NW/4 Sec. 3, T. 27 S., R. 9 W.) may also have been active to about the same period. Extensive siliceous sinter deposits and elevated temperatures (to about 195°F) are also reported in shallow trenches at Negro Mag Wash.

Deposits in sinter, opal, and hematite-stained silicified gravel occur over a distance of about 2-1/2 miles south of Negro

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Mag Wash along the Dome fault. These deposits indicate formerly extensive leakage of thermal water from along the fault. The large deposit in Sec. 16, T. 27 S., R. 9 W., is offset by the fault with vertical displacement of about 20 feet.

Heat Source

The area is characterized by high heat flow and Quaternary silicic volcanism. Meteoric water entering fractured granitic and volcanic rocks of the surface may be heated to temperatures of 200°C (400°F) or more by (1) deep circulation in fault zones under regional gradient conditions and (2) less deep circulation within fractured zones in the vicinity of buried hot plutons.

Evans and Nash (1975) determined intrusion temperatures of about 700°C for the Quaternary silicic rocks with a source region at 13 to 16 km depth below sea level. D. D. Blackwell (unpublished data, 1974) has estimated emplacement of such a silicic pluton at about 4 km beneath ground surface. A cross-sectional area may be inferred by considering the surface distribution of Quaternary rhyolite, or the size of the thermal gradient anomaly (over 20 mi^2 within the 100°C/km isograd).

Not all of this mass need be at near-molten temperatures; the average deep gradient across this zone might be 50° to 70°C/km. This would make portions of the area underlain by Quaternary plutons non-commercial for geothermal development. Its center is presumed to be in T. 27 S., R. 9 W.

A slightly differing view, held by Dr. S. H. Ward and associates of the University of Utah, is that the intrusive center is represented by an elongate Bouguer low centered on Sec. 17-19, T. 27 S., R. 8 W., and covering some 3.5 square miles. This might represent a molten or near-molten body according to Ward (oral presentation, Golden, Colorado, September 1976). This is significantly east of the present-day well field.

Reservoir

Production in the developing Roosevelt geothermal field is obtained from fracture systems in Precambrian(?) gneiss and possibly in Tertiary granite. Prospectively valuable lands have

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been sought along the contact zone between the Mineral Mountains granite and Precambrian(?) gneiss, and within deeply fractured zones in the granite. It is possible that highly cemented and fractured sections of Tertiary sediment may serve locally as reservoir in the deeper portions of Milford Valley, but this is not very likely. It appears that reservoir potential in all of these rock types is of fracture type. Obviously, the best environment for fracture development is within or near fault zones (Figures 2, 3 and 4). This appears to be borne out by the location of the geothermal field as presently known.

In carbonate rocks, permeability may be enhanced locally by through-going solution activity. However, exposures of carbonate rocks are limited to a zone just south of Ranch Canyon.

In the Roosevelt geothermal system, various factors can be significant in limiting and localizing the reservoir. Deposition of silica, clay or other minerals may occur around the periphery of the reservoir, thus sealing the fracture systems. In addition, clay-mylonite in fault zones or a zone of so-called cataclastic metamorphism (Condie, 1960) might act as a seal. Finally, fine-grained lacustrine facies of the valley-fill probably are very poorly permeable to the geothermal fluid.

Quaternary and possibly active tectonism may serve to reopen sealed fractures and to create additional fracture channels. Therefore, areas along the Dome fault or cut by other presumed Quaternary faults offer better prospecting possiblities.

It is apparent that the location of the Roosevelt thermal-gradient anomaly is controlled significantly by the north-trending zone of faulting and fracturing along the west side of the Mineral Mountains. However, it is not apparent whether other individual faults and fractures in this zone have special significance. As stated earlier, east-west faults may terminate or deflect the strike of the Roosevelt anomaly (Figures 2 and 4).

Reservoir fluid is water-dominated and chloride-rich ($\sim$3,000 mg/ℓ) with TDS of 6,000 to 9,000 mg/ℓ, average enthalpy of 500 BTU/pound, and temperature at one kilometer of 160°C (320°F) to 260°C (500°F). Mass flow in productive wells averages about one million pounds of hot water at pressures slightly

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above hydrostatic. Individual well tests up to 1.5 million pounds per hour have been reported, but stabilized flow may be expected to be less than this. An average steam flash of 18 to 20 percent is anticipated, although pressure, mass flow, and therefore percentage of steam flash and steam enthalpy vary somewhat from hole to hole.

Some holes have encountered poorer conditions either because of restricted permeability in the reservoir rock or because of unsatisfactory well completion practices.

Using "average" conditions, a productive well may be expected to yield 200,000 pounds of steam per hour after flash separation. This should serve to generate 10,000 kW per hour (10 mW). This is quite high and therefore attractive commercially. Ultimately, stabilized flow may be somewhat lower.

It is possible that more than one thermal zone is present, one being a shallow system of fractures fed by leakage up faults, and a second being a deeper system of pervasively fractured rock. Differences may be expected in pressure, temperature, enthalpy, and possibly mass flow and well life in these two systems. Depth of the deeper system is believed to be 2 km or greater.

The species and concentration of chemical ions dissolved in the geothermal fluid are different from the concentration/composition of the shallow ground water that is used for irrigation in Milford Valley; this seems to indicate there is little or no connection between the two hydrologic systems. Water from the deep wells averages 8,000 mg/ℓ of total dissolved solids, mostly sodium chloride. This means that the water cannot be disposed of on the ground surface, and injection wells will be required for waste disposal. Some of the unsuccessful exploration holes may be convertible to disposal wells.

Phillips has applied to drill 21 additional wells to define field boundaries and parameters. Still additional wells will be required for development purposes.

Yield and Life

Ultimate field capacity and field life are unknown. Lacking long-term production data at Roosevelt, it is necessary

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to examine results from other geothermal fields for insights into field behavior and life. From this it may be possible to extrapolate long-term conditions at Roosevelt.

The only geothermal field presently developed in the United States is at The Geysers, California, some 80 miles north of San Francisco. The field produces essentially pure steam ("vapor-dominated system") from a reservoir at approximately 240°C and over 450 psig, from fractured metagreywacke at depths that average about 7,000 feet. Heat source is believed to be a large molten or semimolten body underlying a Quaternary rhyolite-dacite-andesite volcanic complex at depths of perhaps 3 to 7 miles. Reservoir is pervasively fractured rock of Jurassic-Cretaceous age (Franciscan Formation). All steam condensate is either evaporated to the atmosphere or re-injected into the formation. Some 20 percent of the steam is thus re-injected.

Field extent, after nearly 20 years of development, still is not known but is believed to be equivalent to a super-giant oil field (>1 billion barrels) in energy content. Wells define an area of at least 20 square miles. Within the field, average well yield is about 150,000 pounds per hour of steam. As an approximation, some 20 pounds of steam generate 1 kw-hr of electricity. Therefore, an average well may yield 7,500 kW (or 7.5 mW) over its life.

Well life is known to be shorter than field life. Ten years is the best approximation of well life, on the basis of limited statistics. Field life is expected to last several decades. Thirty years is a common approximation of field life, but this is not clearly supported by available data. Rather, it appears to represent the period of amortization that utilities feel most comfortable with when planning generation facilities.

Well spacing has been determined experimentally to be 1 per 40 acres. That is, at much closer intervals (say, 1 per 10 acres), wells interfere with each other during production. Interfering wells have the potential to damage the producing field and represent unnecessary expenditures. Optimum well spacing is determined by testing adjoining wells and recording declines in pressure or static level in shut-in wells (interference) and the rates of recovery after testing is stopped.

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With no interference at a 40-acre spacing, there is the possibility to drill replacement or make-up wells at 20-acre centers later in the field history. This appears to be sound and conservative strategy in a freely-communicating geothermal field such as The Geysers. This is shown diagrammatically in Figure 5.

Declines in mass flow and pressure with time occur commonly in oil and gas wells and in certain geothermal fields (for example, Wairakei, New Zealand). Such depletion means that sustained flow will be different from initial production tests. Shallow and gas-rich (CO_2, H_2S) wells are particularly susceptible to severe decline at The Geysers. Budd (1973) showed that declines in mass flow of 19 percent in 6 years could be expected in wells spaced 1 per 45 acres, whereas for wells at 1 per 20 acre spacing the decline in 6 years would average 28 percent. At 5-acre spacing, declines of 53 percent would be expected after 6 years. However, these decline rates were leveling off rapidly in the sixth year, and might assymptotically approach stability thereafter. An average 10-year decline of about 33 percent is assumed as generally valid.

From the above it can be seen that 1 square mile (a section of 640 acres) at The Geysers may be able to support some 120 mW of electric generating capacity (7.5 x 16) at 40-acre spacing. Net production per section, however, probably will be confined to 100 mW at any given time, with producible wells held in reserve as standby against emergencies. Therefore, the continuously utilizable net capacity of the 20 square miles mentioned earlier may be 2,000 mW. This would supply electricity needs of approximately 2 million persons (1 kW installed capacity per person).

Ultimate depletion is likely because natural recharge appears to be on the order of a few percent of consumption, and recharge via injection of spent steam is only 20 percent of the mass produced.

Only one other field in North America has a production history; however, data from Cerro Prieto, Mexico, a hot-water field, are of shorter duration.

The two sets of data are not clearly compatible. For example, whereas experience has led to development of a well

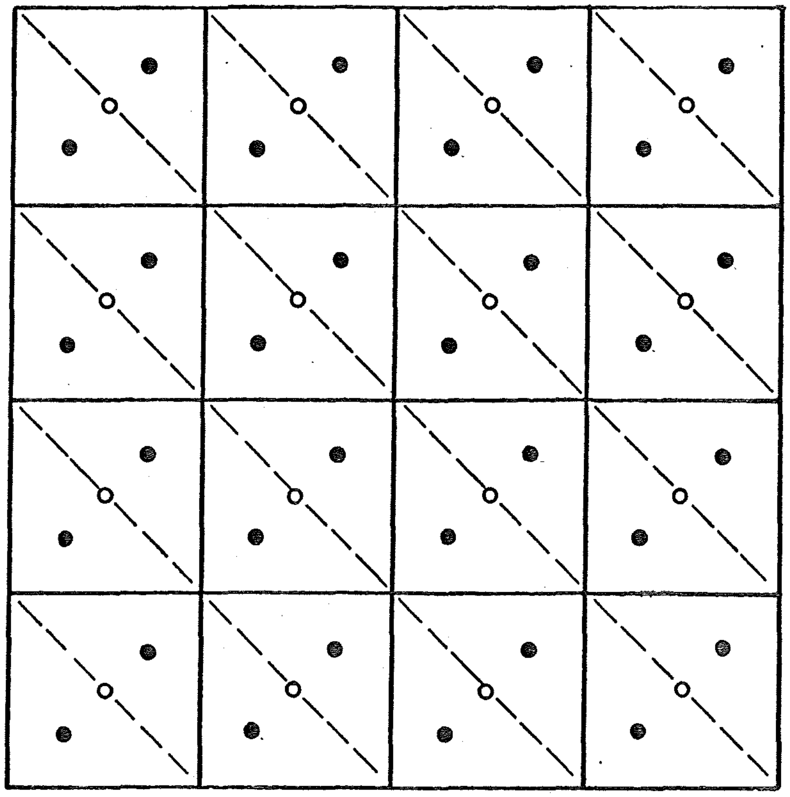

Figure 5. Diagram of Well Spacing at 40-acre intervals.

0 mile (640 acres) 1

Boundary of 40-acre blocks

Wells located on 40-acre centers (16 per square mile)

Make-up wells on 20-acre centers (32 per square mile)

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spacing of 1 per 40 acres at The Geysers, at Cerro Prieto 1 per 10 acres has been used recently. At Cerro Prieto, very little has been reported on interference except that spacings of 1 per 5 acres, used initially, have been found unsatisfactory. Interestingly, a study of reservoir characteristics in Imperial Valley (exclusive of Cerro Prieto) suggested that well spacing would have to increase with increased depth of wells there (perhaps to 1 per 80 acres) because of decreased permeability with increased depth. So far there is no indication that this would be true at Cerro Prieto, The Geysers, or Roosevelt.

LAND POSITIONS

A Known Geothermal Resources Area (KGRA) was established at Roosevelt Hot Springs prior to the beginning of leasing in the public domain in January 1974. Therefore, no applications for noncompetitive leases were accepted for a zone of 23,000 acres centered on the former hot spring and the opalite mount. Figure 6 shows the location of the KGRA, and Table 2 lists the successful bids entered in the competitive lease sales.

The principal bidders at the 30 July 1974 sale were Phillips Petroleum Company, Getty Oil Company, Union Oil Company (all of whom were successful in varying degrees), Gulf Oil Company, Al-Aquitaine Oil Company, and American Geothermal Energy Co. (all of whom were unsuccessful). Phillips was the major winner, purchasing nearly 19,000 acres for a bonus of \$800,000 or \$43 per acre averaged. Actual bids by Phillips ranged up to \$128.06 per acre for lease units 6 and 4. This revealed their preference for the western side of the Dome fault; this, of course, was prior to their first deep drill holes.

One parcel of 40 acres (lease unit 12, in Sec. 9, T. 27 S., R. 9 W.) was claimed under the "grandfather" clause of the Federal Geothermal Steam Leasing Act of 1970 by A. L. and W. L. MacDonald of Milford, for the equivalent of \$58.38 per acre, thereby matching Phillips's bid.

On 12 June 1975 1,200 acres in the KGRA were reoffered and were bid on (and won by) a private party, Gary Seltzer.

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Table 2. Summary of KGRA lease sales in Utah

ROOSEVELT HOT SPRINGS, JULY 30, 1974

Unit	Acreage	Bids Received: Amount	$/Acre	Bidder
1	2,560	$ 51,994	20.31	Union Oil*
		23,372		Gulf Oil
		13,082		Phillips Petroleum
2	1,640	87,543	53.38	Phillips Petroleum*
		62,090		Union Oil
		14,973		Gulf Oil
3	1,920	9,812	5.11	Phillips Petroleum*
4	2,454	314,199	128.04	Phillips Petroleum*
		93,234		Union Oil
		22,400		Gulf Oil
5	1,644	8,401	5.11	Phillips Petroleum*
		5,877		Aquitaine
6	1,940	248,392	128.04	Phillips Petroleum*
		53,350		Getty Oil
		42,672		Union Oil
		17,709		Gulf Oil
		6,139		Aquitaine
7	1,961	41,856	21.34	Phillips Petroleum*
8	2,273	62,903	27.67	Phillips Petroleum*
		28,412		Getty Oil
		20,747		Gulf Oil
9	1,920	24,000	12.50	Getty Oil*
		17,529		Gulf Oil
		9,811		Phillips Petroleum
		4,992		American Oil Shale Corp.
10	2,560	13,082	5.11	Phillips Petroleum*
11	2,480	12,673	5.11	Phillips Petroleum*
12	40	2,335	58.38	A.L. & W.L. McDonald* (grandfather applicant)
		2,335		Phillips Petroleum

JUNE 12, 1975

Unit	Acreage	Amount	$/Acre	Bidder
1	1,200	2,586	2.16	Gary Seltzer

*indicates bid accepted by Dept. Interior

LEGEND

100 % by O'Brien

66 % by O'Brien
33 % by Natomas

Phillips

Getty

Union

Thermal Exploration Co.

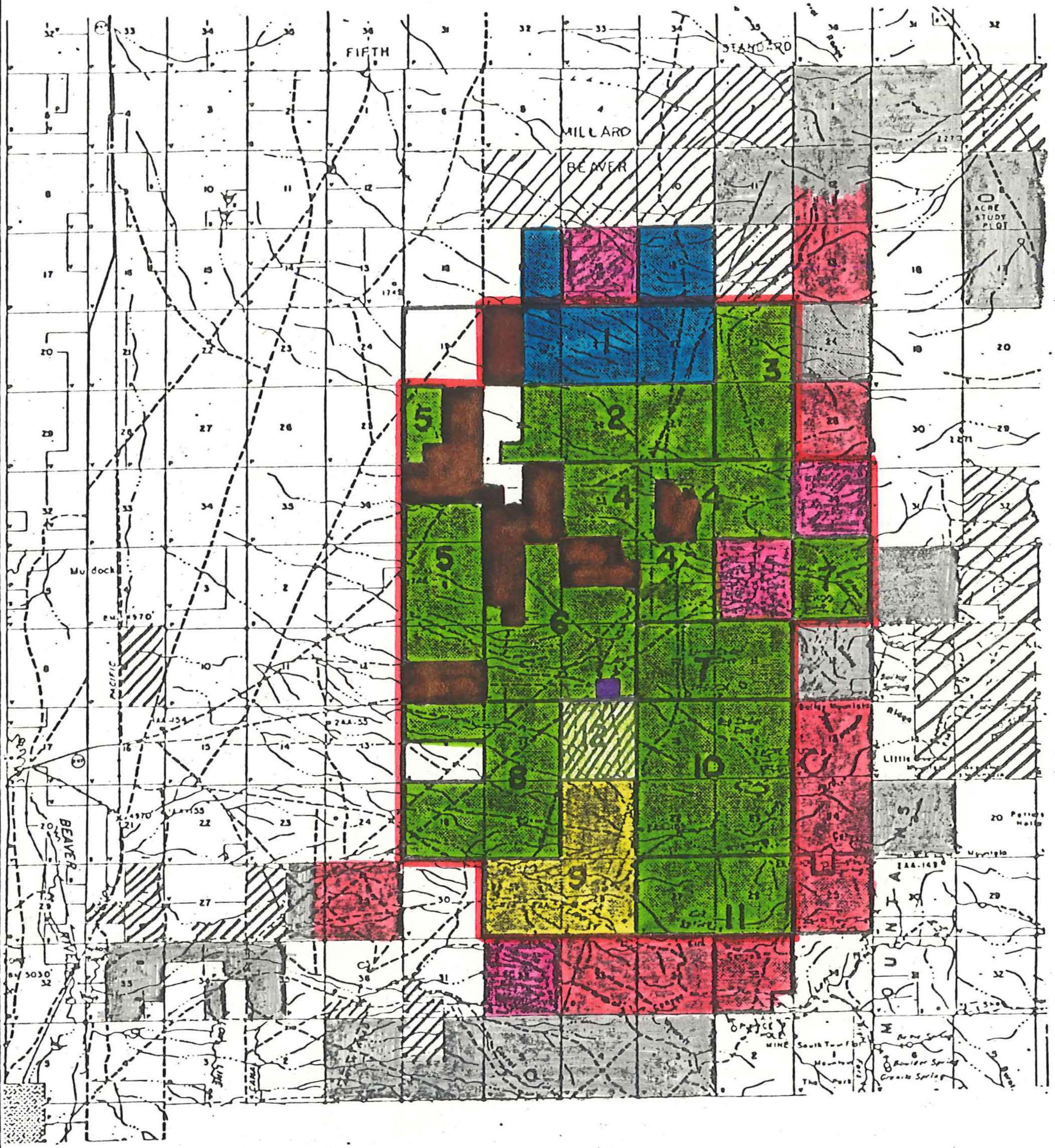
Geothermal Power Corp.

Geothermal Exploration Co.

AMAX options on O'Brien

American Geothermal Energy

A.L. & W.L. McDonald



Geothermal leasing patterns in the Roosevelt Hot Springs Region, Utah

LEGEND

4 KGRA lease units

Geothermal operating area

N 16°

1 0 1 2 miles

Scale 1:125,000

FIGURE 6

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The largest block of fee leases in the area was assembled by Thermal Exploration Company. Acreage in these leases had been optioned or subleased to O'Brien, Natomas Company, AMAX Exploration, Inc., and others. In addition to fee leases, several companies and private parties have applied for noncompetitive leases to public domain. These include Phillips, Union, Getty, AMAX, American Geothermal Energy, Geothermal Power Corp., and Geothermal Exploration Company among many others. In addition to Seltzer, private applicants include Milton Fisher (associated with American Geothermal Energy), Malcolm Justice, Christopher Marks and Trevor Windsor, to name a few.

Several sections of state land also have been applied for and awarded for lease, principally to Thermal Exploration Company, and thence conveyed to O'Brien and others.

Taken togehter, these leases and applications cover at least 85 percent of a continuous zone 17 miles long (north-south) and 9 miles wide (east-west).

Leasing continues in discontinuous fashion westward across the floor of Milford Valley, southerly and southwesterly toward and beyond Thermo Hot Springs, and northeastward into the Cove Fort region. The scope and intensity of this leasing operation rivals leasing at The Geysers geothermal field in California and clearly exceeds activities elsewhere in Utah or in adjacent Nevada, Arizona, Idaho, or Wyoming.

Many companies that have not established satisfactory leasehold positions at Roosevelt have gone farther afield or have attempted to purchase positions. Therefore, although not listed as active at Roosevelt, the interest of Chevron Oil Company, Hunt Oil Company, Earth Power Corp., Sun Oil Company, and Atlantic Richfield Co. should be noted.

It can be said fairly that at this time a market exists for the farm-out, sale, or joint venture of all leases and applications within the 150-square-mile zone described above, even though much less than one-twentieth of that area can be classified as proven geothermal field.

Because of the very intense competition for attractive acreage, no significant new position can be acquired within

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T. 26 and 27 S., R. 9 W., without either bonus payments in cash, or a commitment to expend money on exploration and deep exploratory drilling, or both.

Undoubtedly there will be unsuccessful holes drilled in the Roosevelt area as exploration proceeds. At that time the value of certain lease blocks will decline, depending upon position relative to these dry holes. Conversely, further drilling probably will expand the perimeter of production, possibly eastward, thus raising the value of certain acreage.

Unitization

Phillips has obtained government permission to operate a geothermal production unit at Roosevelt in accordance with federal geothermal regulations. The unit covers some 40 sections (see Figure 6 and Table 3) in T. 26 and 27 S., R. 9 W. It has one stated objective (to prevent damage to the field through improper reservoir management) and two unstated advantages to Phillips. These are:

1. Lands within the geothermal unit are not charged against a company's statewide authorization to lease 23,040 acres of public domain (federal lands) in any single state.

2. The agreement of other parties to participate largely eliminates the possibility of a lawsuit between them and Phillips over the latter's possible draining of their acreage.

To date, two companies have entered the unit agreement with Phillips: Superior Oil (as a 25 percent owner of mineral interests in Sec. 5, T. 27 S., R. 9 W., acreage otherwise held by American Geothermal Energy Corp.) and Union Oil Company. Amongst others, O'Brien, Getty, A. L. McDonald, American Geothermal Energy, and Thermal Power (Natomas) have not entered the unit agreement. O'Brien and Natomas hold the only producible wells other than those of Phillips.

O'Brien has stated that if Phillips came into commercial production earlier than they, O'Brien would join the unitization agreement. Phillips representatives express no reluctance to

- ✓ Lease Record Checked
- ✓ Acreage agrees with Exhibit "A"
- ✓ Executed Unit Agreement
- Considered for segregation

Checked By E.U.K.

TABLE 3. OWNERSHIP AND STATUS OF GEOTHERMAL RIGHTS WITHIN THE ROOSEVELT HOT SPRINGS GEOTHERMAL UNIT

EXHIBIT "B"

SCHEDULE SHOWING THE PERCENTAGE AND KIND
OF OWNERSHIP OF GEOTHERMAL RESOURCES
ROOSEVELT HOT SPRINGS UNIT AREA
BEAVER COUNTY, UTAH

TRACT NO.	DESCRIPTION OF LAND	NUMBER OF ACRES	SERIAL NUMBER AND EXPIRATION DATE OF LEASE	BASIC ROYALTY AND OWNERSHIP PERCENTAGE	LESSEE OF RECORD AND PERCENTAGE	OVERRIDING ROYALTY AND PERCENTAGE	WORKING INTEREST AND PERCENTAGE
FEDERAL LANDS							
1. NC	T27S-R9W, SLM Sec. 9: SW¼SE¼	40.00	U-14990 10-31-84	USA - All	A. L. McDonald 100%	None	A. L. McDonald 100%
2. FC	T26S-R9W, SLM Sec. 20: E½ Sec. 21: All Sec. 22: All	1,600.00	U-27383 10-31-84	USA - All	Union Oil Company of California 100%	None	Union Oil Company of California 100%
3. FC	T26S-R9W, SLM Sec. 27: All Sec. 28: All Sec. 29: E½, SE¼SW¼	1,640.00	U-27384 9-30-84	USA - All	Phillips Petroleum Company 100%	None	Phillips Petroleum Company 100%
4. FC	T26S-R9W, SLM Sec. 23: All Sec. 26: All	1920 1,280.00	U-27385 9-30-84	USA - All	Phillips Petroleum Company 100%	None	Phillips Petroleum Company 100%
5. FC	T27S-R9W, SLM Sec. 3: Lots 1,2,3,4, S½, S½NE¼, Mineral Survey 4976B, S½, NW¼ Sec. 4: Lot 1	2,463.37	U-27386 9-30-84	USA - All	Phillips Petroleum Company 100%	None	Phillips Petroleum Company 100%

(continued)

10. NC	T27S-R9W, SLM Sec. 21: All Sec. 28: All Sec. 29: All	1,920.00	U-27391 10-31-84	USA - All	Getty Oil Company 100%	None	Getty Oil Company 100%
11. FC	T27S-R9W, SLM Sec. 14: All Sec. 15: All Sec. 22: All Sec. 23: All	2,560.00	U-27392 9-30-84	USA - All	Phillips Petroleum Company 100%	None	Phillips Petroleum Company 100%
*12. FC	T27S-R9W, SLM Sec. 26: All Sec. 27: All	1,280.00	U-27393 9-30-84	USA - All	Phillips Petroleum Company 100%	None	Phillips Petroleum Company 100%

12 FEDERAL TRACTS TOTALING 20,600.97 ACRES OR 79.40% OF UNIT AREA

STATE LANDS

13. NC	T27S-R9W, SLM Sec. 16: All	640.00	ML-25128 2-20-78	State of Utah All	Eugene N. Davie 33 1/3% O'Brien Resource Corp. 66 2/3%	Thermal Power Co. of Utah ½ of 1% of 1/3 Louis Cooper-1/3 of difference between 10% royalty interest due State of Utah and 15% royalty interest Austin B. Smith-1/3 of difference between 10% royalty interest due State of Utah and 15% royalty interest	Eugene N. Davie 33 1/3% O'Brien Resource Corp. 66 2/3

22. NC	(continued)		Unleased	Roy Yardley 12.5000%	Unleased	None	Unleased
			Unleased	North Divide Grazing Company 12.5000%	Unleased	None	Unleased
			Unleased	Ira Yardley, Deceased 12.5000%	Unleased	None	Unleased
			Unleased	Alice H. Slick 1.1111%	Unleased	None	Unleased
			Unleased	Gertrude H. Wright 1.1111%	Unleased	None	Unleased
			Unleased	Lucy H. Bulloch 1.1111%	Unleased	None	Unleased
			Unleased	Ralph A. Hamilton 2.6666%	Unleased	None	Unleased
			Unleased	Phillips Petroleum Company 11.3335%	Unleased	None	Unleased
			6-23-85	Fred Hamilton 2.6666%	Phillips Petroleum Company 100%	None	Phillips Petroleum Company 2.6666%
				MINERAL INTEREST OWNERS			
			5-6-81	Phyllis L. Goates, Louise L. Campbell & Dorothy L. Sheilds (Sole and equal devisees of Estates of F. R. & Lena Levi) 100%	American Geothermal Energy Co. 100%	None	American Geothermal Energy Co. 100%
23. NC	T27S-R9W, SLM Sec. 18: Lots 3,4, E½SW¼, SE¼	330.50	Unleased	SURFACE OWNER			
				Kenneth F. Schade 100%	Unleased	None	Unleased
				MINERAL INTEREST OWNER			
				Kenneth F. Schade 100%	Unleased	None	Unleased

7 PATENTED TRACTS TOTALING 2,863.53 ACRES OR 11.04% OF UNIT AREA

TOTAL 23 TRACTS, 25,946.38 ACRES IN ENTIRE UNIT AREA

14. NC	T27S-R9W, SLM Sec. 2: Lots 1,2,3,4, $S\frac{1}{2}$, $S\frac{1}{2}N\frac{1}{2}$	681.88	ML-27536 5-24-81	State of Utah All	Thermal Power Co. of Utah 100%	None	Thermal Power Co. of Utah 100%
15. NC	T26S-R9W, SLM Sec. 32: $S\frac{1}{2}$, $NE\frac{1}{4}$, $SW\frac{1}{4}NW\frac{1}{4}$	520.00	ML-27796 8-31-83	State of Utah All	American Geothermal Energy Co. 100%	Glenna M. Sorensen $\frac{1}{2}$ of 1%	American Geothermal Energy Co. 100%
16. NC	T26S-R9W, SLM Sec. 36: All	640.00	ML-27889 8-31-83	State of Utah All	Thermal Power Co. of Utah 100%	None	Thermal Power Co. of Utah 100%

4 STATE OF UTAH TRACTS TOTALING 2,481.88 ACRES OR 9.56% OF UNIT AREA

PATENTED LANDS

17. NC 25%	T26S-R9W, SLM Sec. 20: $W\frac{1}{2}$ Sec. 29: $NW\frac{1}{4}$, $N\frac{1}{2}SW\frac{1}{4}$, $SW\frac{1}{4}SW\frac{1}{4}$ Sec. 30: $E\frac{1}{2}$, $SE\frac{1}{4}SW\frac{1}{4}$ Sec. 31: Lots 1,2, $NE\frac{1}{4}$, $E\frac{1}{2}NW\frac{1}{4}$	1,895.89	9-30-81	SURFACE OWNER G. Arron Hanson Sheep Co. 100%	American Geothermal Energy Co. 100%	None	American Geothermal Energy Co. 100%
	T27S-R9W, SLM Sec. 4: Lots 2,3,4, $S\frac{1}{2}N\frac{1}{2}$ Sec. 5: Lots 3,4, $S\frac{1}{2}NW\frac{1}{4}$, $N\frac{1}{2}SW\frac{1}{4}$, $SE\frac{1}{4}SW\frac{1}{4}$		9-30-81	MINERAL INTEREST OWNERS G. Arron Hanson Sheep Co. 75%	American Geothermal Energy Co. 100%	None	American Geothermal Energy Co. 75%
			Unleased	The Superior Oil Co. 25%	Unleased	None	Unleased 25%
18. NC	T27S-R9W, SLM Sec. 7: Lots 3,4, $E\frac{1}{2}SW\frac{1}{4}$, $SE\frac{1}{4}$	329.11	4-3-81	SURFACE OWNER John Armstrong & Sons, Inc. 100%	American Geothermal Energy Co. 100%	None	American Geothermal Energy Co. 100%
				MINERAL INTEREST OWNER John Armstrong & Sons, Inc. 100%	American Geothermal Energy Co. 100%	None	American Geothermal Energy Co. 100%

19. PC	T26S-R9W, SLM Sec. 32: NW¼NW¼	40.00	2-3-83	SURFACE OWNERS M. W. & Julia M. Goff 100%	Union Oil Company of California 100%	None	Union Oil Company of California 100%
			2-3-83	MINERAL INTEREST OWNERS M. W. & Julia M. Goff 100%	Union Oil Company of California 100%	None	Union Oil Company of California 100%
20. FC	T26S-R9W, SLM Sec. 32: SE¼NW¼	40.00	2-7-83	SURFACE OWNERS Donald E. & Marjorie K. Rule 100%	Union Oil Company of California 100%	None	Union Oil Company of California 100%
			2-7-83	MINERAL INTEREST OWNERS Donald E. & Marjorie K. Rule 100%	Union Oil Company of California 100%	None	Union Oil Company of California 100%
21. PC	T26S-R9W, SLM Sec. 32: NE¼NW¼	40.00	2-18-83	SURFACE OWNERS Clifton H. & Estelle G. Goff 100%	Union Oil Company of California 100%	None	Union Oil Company of California 100%
			2-18-83	MINERAL INTEREST OWNERS Clifton H. & Estelle G. Goff 100%	Union Oil Company of California 100%	None	Union Oil Company of California 100%
22. NC	T26S-R9W, SLM Sec. 34: Lots 2,3,8,9, Patented Mining Claims - Paradox & Paradox No. 1	188.03	Unleased	SURFACE OWNERS Alvin Darnell Yardley 4.2500%	Unleased	None	Unleased
			Unleased	Ray Yardley 4.2500%	Unleased	None	Unleased
			Unleased	Waldo Yardley 8.5000%	Unleased	None	Unleased
			Unleased	John R. Yardley 8.5000%	Unleased	None	Unleased
			Unleased	William R. Yardley 8.5000%	Unleased	None	Unleased
			Unleased	Ellis Yardley 8.5000%	Unleased	None	Unleased

(continued)

"Notice of Interest" filed of record stating Resources Management Co. has an interest in all mineral and mineral rights in and under Lots 2, 3, 8 & 9, Sec. 34, Township 26 South, Range 9 West, SLM, pursuant to Agreement dated March 30, 1972, with North Divide Grazing Co.

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admit O'Brien to the already-formed unit if O'Brien achieves production first. However, Phillips may be reluctant to admit latecommers after Phillips is in production. Therefore, seeds of disagreement may have been planted which might conceivably lead to a suit over drainage at some unspecified future date.

Of the 26,000 acres in the geothermal unit, 79 percent is federal acreage, and 28 percent (including some 1,960 acres of federal land) is not committed. Seventy-five percent of the federal acreage is the minimum participation needed to establish the federal geothermal unit; Phillips obtained 90 percent (almost all its own acreage). The State of Utah apparently takes no legal recognition of the unit in its water appropriations and leasing activities.

As noted, most participants are taking a wait-and-see attitude regarding joining the geothermal unit. Reasons for this are complex:

1. Majority vote, weighted by acreage, sets policy for operating the unit. With over 80 percent participation, Phillips will dominate the unit, probably to its own end.

2. Natomas-O'Brien have a State of Utah section under lease. This will present fewer regulatory delays to development than federal acreage (time for permitting, etc.). This means that they may be able to get into production faster than Phillips on federal leases, utilizing well Utah State 72-16. If, however, the Utah State Engineer delays authorizing water appropriations, this time advantage may be lost by Natomas-O'Brien.

3. Some smaller companies may plan on selling their interests, and would prefer the leases to be unencumbered by commitment to unitization.

4. Some entities are puzzled over implications of unitization, and prefer to wait for clarification.

It remains unclear what decisions Phillips will take regarding testing, drilling or producing from within the unit.

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Therefore, it appears soundest to wait for the near future, without making any commitment to join the geothermal unit.

INSTITUTIONAL FACTORS

Several factors complicate geothermal operations in the Roosevelt Hot Springs area. Certain of these tend to delay operations; others may serve as a spur to development.

Environmental Protection

Concern over environmental protection invariably leads to delays in geothermal development. Each operation (leasing, drilling, testing, construction of facilities) on Federal land is predicated upon obtaining approval of agencies of the Department of the Interior. To obtain approval, applicants have had to submit proposed work plans for review by the U. S. Geological Survey and other agencies; environmental impact statements have had to be prepared; permits have been required for every well and well-testing operation; public hearings have been held.

Although the purpose of these activities has been benign, the effect has been to delay development of the geothermal resource. For example, Phillips was delayed for several months in drilling deep exploratory tests because of the time required for a comprehensive review of its proposed work plans. Similarly, Phillips has spent some four months in pursuit of permits to conduct extended flow tests on wells 54-3 and 82-33 (26 week tests). An additional effect is increased costs for all operations.

The Department of the Interior filed an environmental impact statement prior to holding the KGRA sale in 1974. Perhaps no additional environmental statements would be required for drilling, testing or construction of facilities on the KGRA. However, any facilities extending onto other parts of the public domain or into National Forest land (such as power transmission lines, access roads, waste disposal facilities) may require new environmental studies.

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ERDA's Involvement

Three of ERDA's programs may have a bearing on future geothermal operations at Roosevelt Hot Springs. The major ERDA program is the Geothermal Loan Guaranty Program (GLGP), under which development loans are made by a private financial institution to a developer, and are backed by ERDA, to a total of 75 percent of expenditure.

As of July 7, no applications for the loan guarantee program had been approved for any projects in the Roosevelt Hot Springs area, although according to a May 27 ERDA news release, the following Utah applications were being processed:

Project	Location	Lender	Application $M
CU-I Venture (GKI/McCulloch)	Beryl & Lund, UT	Bank of Montreal	6.326
Southern Calif. Public Energy Corporation (City of Burbank)	Roosevent Hot Springs, UT, and other sites	Dean Witter & Co.	25.000

A number of other entities also have been in contact with ERDA about the program, amongst them O'Brien Mines, who have expressed interest in installing a 10 mW plant on the well Natomas Utah State 72-16, one-quarter mile south of the McDonald lease.

Interest in the ERDA program has come from other groups that do not presently have a land position in the area. These groups apparently have options on land or are considering joint ventures with leaseholders.

ERDA signed the first agreement under the GLGP in May, 1977, for a program in California, and in doing so, made the following findings and determinations:

1. Application complies with GLGP Regulations (10 CFR 790);

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2. Project will not have a significant affect on the quality of the human environment;

3. The risks are acceptable;

4. Project is consistent with the goals and objectives of P.L. 93-410;

5. Overall probability of success is 63% or higher; and

6. There is a reasonable assurance that the loan will be paid off.

ERDA recently has expressed interest (Appendix A) in reviving the program for a 50 μw demonstration power plant, to be jointly funded by industry and government. According to a notice in the Federal Register (May 4, 1977), the project will be located at a site where reservoir development is already underway.

According to the notice, the plant is intended to demonstrate commercial generation of electric power with a high-temperature, low-to-moderate salinity resource, using either a binary fluid or a flashed-steam or a fossil-geothermal hybrid conversion cycle. Target date for power-on-line from this plant is 1982 or earlier.

It should be noted that a proposal for a demonstration power plant must prove that the same goal cannot be accomplished through the guaranteed loan program.

ERDA previously had discussed funding such a program for a demonstration power plant. In 1973, a study to find a suitable site for such a plant was carried out, and Heber, California, was selected, because (1) apparently there is an attractive resource and (2) Chevron Oil Company, Magma Power Company and San Diego Gas and Electric Co., who jointly had carried out exploration and drilling in the area, were interested in cooperating in the program.

Because of requirements that ERDA pursue more than one alternative site, Heber has not to date been selected as the site for the demonstration power plant. Indeed, ERDA has responded by calling for submittal of notices of interest by all parties anywhere in the U.S. However, Heber remains a favorite for selection.

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Another ERDA program that has a bearing on development of the Roosevelt Hot Springs geothermal field is the so-called "bottom-hole money" program, whereby ERDA will pay cash for geo-science information from wells, geophysical surveys, and the like and will then publish the data. A number of proposals under this program have been received for Roosevelt Hot Springs and the Cove Fort area. A final decision will be made July 7 on which proposals will be accepted. Until the current proposals have been dealt with, it is impossible to tell if any money would be left for new proposals.

Therefore, ERDA is pursuing involvement at Roosevelt actively, but has made no final commitment to any course of action or any party. Bountiful may elect to proceed with ERDA at any time that it sees its interests to be served.

Term of Federal Leases

The 10-year primary term of the federal leases poses an uncertainty for development. In effect, the Department of the Interior may refuse to extend the lease at its discretion. It probably would consider the following factors before deciding to refuse renewal:

a. diligence of exploration on that lease;

b. co-operativeness of the lease-holder (environmental regulations, permit hearings, etc.) on that lease and elsewhere;

c. public response (complaints, etc.);

d. political pressure pro or con.

The Solicitor of Department of the Interior has agreed to study the question of renewals, but has not issued the Department's opinion to date. Requests for such opinions have come in connection with U. S. Geothermal Lease 1 and 2 at The Geysers, reportedly from Shell Oil Company (the lease holder) and Pacific Gas and Electric Co. and Northern California Power Administration (possible purchasers of steam). At this date, automatic renewal for 10 additional years cannot be taken for granted.

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If automatic renewal were to be granted for developed sites, such as The Geysers, or for sites undergoing development or testing (Roosevelt), there still might be a problem: Interior might attempt to re-negotiate lease terms, to gain more revenue for the government. This could adversely affect the price structure of energy.

The principal defense against this will be intensive public education and political lobbying. Several members of Congress are reported to be sympathetic to granting leases in perpetuity to producing leaseholds, subject to termination only in event of national emergency or upon cessation of production.

If Interior did refuse to renew a lease at Roosevelt, it probably would be for non-performance of required diligent exploration. The lease might then be re-offered in a special KGRA sale.

However, the uncertainty creates insecurity.

Public Utilities Commission

Geothermal power plants and their transmission lines would be subject to the same regulatory and time constraints as other power plants in Utah. However, it is noted that a 48-kVe power transmission line crossing the Roosevelt geothermal field has capacity to carry an additional 10 kVe. If this capacity can be utilized with a small generating unit, the lengthy process of hearings, condemnation of right-of-way and line construction can be eliminated. Otherwise, some two years may be needed for this step.

Appropriation of Water Rights

The Utah State Engineer's Office is charged with responsibility for allocating rights to underground water. This agency regulates consumption of geothermal fluids within the State also.

After lengthy hearings in Beaver, Utah, the State Engineer found that Phillips Petroleum's geothermal operations did not interfere with the lawful use of underground water by any other

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party. However, the State Engineer has not to date authorized appropriation of water by Phillips or any other party for geothermal resources.

Bountiful would have to receive a similar favorable finding from the State Engineer, again probably after lengthy hearings. The delays in authorizing appropriation by Phillips tends to support suggestions that the State Engineer wishes to orchestrate water use across the entire geothermal field (including federal, state and fee lands), perhaps as part of a major water appropriations unit.

Implications of this are severe. For example, if the State Engineer proposes to delay authorizing water appropriations for Natomas-O'Brien, they will be unable to utilize their advantage of occupying a State of Utah section (fewer delays for permitting, etc.). Also, a potential conflict is set between federal and state regulators over land use and water rights.

OPPORTUNITIES AND RISKS

Lease Terms

A. L. McDonald holds a renewable 10-year federal lease dated November 1, 1974 on 40 acres within the proven geothermal field. McDonald is obligated to:

a. pay annual rental to the U. S. Department of the Interior of $1 per acre for the first five years, increasing by $1/acre/year through the tenth year;

b. pay royalty of 10 percent on geothermal steam produced or sold;

c. perform diligent exploration on the property;

d. abide by various stipulations, operations orders and regulations as specified in the lease or in federal regulations and orders.

In addition, McDonald made a one-time payment of $2,335 to match the bonus bid offered by Phillips Petroleum Company for the lease.

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In offering this lease for sale, McDonald requires:

a. adherence to all primary terms;

b. a bonus payment of $125,000, equal to $3,125 per acre;

c. an additional overriding royalty of 5 percent on geothermal steam produced or sold;

d. drilling of a geothermal well within five years;

e. compliance with various land-use and access stipulations.

It is difficult to compare these terms with those on any other geothermal lease. No production has been achieved, but the property is bounded to north, south and east by productive wells (figure 2). The property is very small, but probably is productive in its entirety. Bonus and royalty terms are high; but risk is less than for many other properties elsewhere.

At The Geysers in January 1974, Shell Oil Company bid $1,367.52 and $847.46 per acre for parcels of 2,340 and 1,534 acres. The next highest bids were $648.15 (Signal Oil & Gas Company and Natomas Company jointly) and $758.77 (Union Oil Company). The acreage adjoined productive land and was on trend with a favorable axis, but was unproved. (It since has been drilled successfully.) Bids for two smaller parcels ($508.18 by Union on 626 acres; $1,021 by Occidental Petroleum Corporation) were rejected by Interior. These parcels, also unproven, were within the proven field. When re-offered in May 1974, winning bids were $3,287.84 (Natomas) and $1,377.14 (Union) per acre respectively. Aminoil U.S.A. exercised grandfather rights to buy the first parcel, again at $3,287.84. Both parcels now are productive.

At Roosevelt, prior to discovery of geothermal energy, Phillips paid a maximum of $128.06 per acre on two tracts. After Phillips' discovery, Union paid $361.83 per acre on two tracts at Cove Fort, 20 miles to the northeast.

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From this it can be seen that proven acreage is expensive, and that a nearby discovery raises the value of adjacent unproven acreage.

McDonald's bonus price still is at the high end of the bid range, especially when one considers that The Geysers produces dry steam and not hot water.

At The Geysers, royalty to the federal government is 12.5 percent, or 2.5 percent higher than at Roosevelt. Many private leases, and at least one federal lease have been sold at higher royalty burdens. The maximum for a single lease known to me is 14 percent paid by Union for a fee lease within the productive field. However, where leases have exchanged hands more than once, total royalty burdens may reach 20 percent or even more.

Performance obligations are common in all leases. Only unsophisticated land owners fail to insist upon these; and even lease speculators commonly agree to these, believing that they can transfer the obligation to a further party to whom interest would be transfered. Performance within five years is not onerous. For Bountiful to commit to payment of a bonus implies that Bountiful is eager to proceed with drilling. Otherwise there would not be any reason to purchase this lease.

All leases required adherence to laws, operating regulations, pre-existing lease terms and stipulations. Most have terms governing access by the land owner or original lease holder, as well as minimal environmental safeguards.

McDonald does not request a back-in clause, wherein he could regain partial interest by payment of some amount after development has occurred. He also does not expect to retain any voice in operation of the lease or in subsequent development. Such clauses are not unheard of.

In summation, McDonald's terms are stiff, but probably not excessive or unparalleled. I would have estimated a cash value of perhaps $1,500 to $2,000 per acre as a bonus, with overriding royalty on steam of 2 or 3 percent, as more equitable to Bountiful. However, if the property becomes productive, the bonus becomes insignificant with time. The royalty payment will become burdensome after production is achieved, as it varies directly with increases in steam value.

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Lease Productivity

As mentioned earlier, the lease is unproven by drilling of deep wells, but is bounded on three sides by produceable wells, and is within one-half mile of the original 270-foot-deep hole that yielded 270°F fluid. Therefore, there is every indication that a successful well can be drilled on the McDonald lease.

However, there is no certainty that any given well will be successful, even within the field. Witness the difficulty with, and high cost of, Natomas Utah State 72-16, which is less than one-half mile to the south. Cost exceeded $1 million for a 1,200 foot hole, and the hole (although a powerful producer) barely was saved. Further, at The Geysers, one in five holes within the productive field is unsuccessful, for various geological or engineering reasons. Therefore, more than one hole may be necessary to achieve production.

In addition, a disposal well undoubtedly will be mandatory. This commonly is an unsuccessful steam well. Therefore, a failure on the McDonald property might be useful for re-injection. However, if the first well is a success, Bountiful has to either:

a. drill a special re-injection well;

b. arrange to obtain use of an unsuccessful hole from Phillips for re-injection; or

c. arrange to share cost of a disposal well with the Natomas-O'Brien group, who also need such a hole.

A single injection well may serve 2 or 3 producing wells, depending upon permeability, lateral distance, quantity of fluid to be injected, etc. Its costs may be estimated at 80 percent that of a producing well. Pumping will be required, except in those uncommon cases where gravity flow is possible.

If arrangements are made with Phillips, costs would be reduced, but rental payments can be expected. No cost figure can be estimated at this point, except that rental over a 5-year period should be less than the cost of drilling a disposal well. If cost-sharing with Natomas-O'Brien is possible, costs may equal only 40% of a producing well.

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As described in an earlier section, depletion is likely over a period of years. This can be expressed two ways:

a. within a few(?) decades, the 40-acre parcel may not be capable of sustaining production;

b. within 10(?) years, the discovery well may be incapable of further production.

These tentative postulates are based upon operating experience at The Geysers (dry steam) and Cerro Prieto (hot water). To date the longest flow tests at Roosevelt have been approximately 3 days; no useful projections of well life can be derived from such tests.

In the absence of other data, Bountiful must plan on drilling make-up or replacement wells every 10 years. Therefore, over an assumed 30-year field life, 3 producing wells plus 1 injection well will be needed. If Phillips conducts prolonged tests, Bountiful should try to participate, in order to obtain these valuable data. Lacking such data, the above assumptions are open to severe challenge.

Similarly, data from The Geysers (see section on Field Size and Capacity) and basic conservation suggest that the 40-acre McDonald lease will support only one producing well. If additional wells are produced at the same time, there may be harmful interference. That is, production from one will cause decreases in flow rate and pressure from the other. This results in added costs (for the additional well or wells) with no sustainable increase in total flow, and possibly may damage the field.

Therefore, it is likely that this lease parcel will be able to sustain one well, and its re-drilled successor, but only one well at a time.

The Natomas well Utah State 72-16 was tested at 1.2 million pounds per hour, on a 24-hour flow test. Of this flow, some 20 percent flashed to steam, for an approximate steam yield at about 100 psig of 240,000 pounds per hour. Enthalpy is reported at about 500 BTU/lb. This would be capable of producing from 12 to 14 mW, depending upon conversion efficiency, turbine pressures, etc. This well is closest to the McDonald lease of any drilled to date.

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Other wells in the vicinity (for example, Phillips 13-10) reportedly have tested at above 1 million pounds per hour of total flow. This might be equivalent to 10 mW of electric generation.

As discussed in an early section, sustainable yield might be significantly lower than initial tests indicate. For purposes of approximation, and lacking prolonged flow-test data at Roosevelt, it is assumed that sustainable yield will be 70 percent of initial yield for wells on 40-acre centers. For wells spaced at 20 acres (see Figure 5), sustainable yield may be 60 percent or less. Thus, sustainable yields of about 7 to 10 mW per well may be projected. Each well will behave differently. Each will have a different life history. Yield will decline with time in each well, until it is replaced by a new well with capacity close to that of the original well.

Obviously, additional long-term tests are vital at Roosevelt.

Costs

In addition to bonus payment of $125,000, Bountiful would be faced with three major sets of costs:

a. drilling and testing of wells;

b. capital construction;

c. royalties and taxes.

A fourth, less intensive cost is:

d. maintenance and operation.

Drilling would have to take place within 5 years. Using 1977 costs, this should require about $90 per foot. It is assumed that wells at the McDonald lease will first encounter steam at shallow depth (perhaps 1,500 to 2,500 feet), and that special measures will be necessary to control this shallow zone. This will raise the per foot cost somewhat. If there is no problem comparable to that of Natomas Utah State 72-16, costs may reach $300,000 for a 3,000-foot well, and approximately double that for a 6,000-foot well.

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Testing will average $150,000 per well for separator, flow lines, ponds and service. Re-injection holes may average 80 percent the cost of production wells; except that it may be difficult to locate a re-injection site on this small acreage.

Assuming that three production wells and one disposal well are drilled over the life of the field, and that depths will be variable, total drilling and testing cost will be about $2.25 million in 1977 dollars. To be safe, 35 percent should be added to this sum for planning and budgeting purposes, for a total of $3 million. The first production well and the disposal well will be necessary almost simultaneously.

If 7 to 10 mW are available from the McDonald lease, capital costs for turbine, generator and auxilliary equipment, exclusive of transmission and disposal costs, may be $600 per kW, or $4.2 to $6 million. This, of course, must be invested before there is any cash flow to Bountiful.

Value to be set on steam, and thus royalty, may be determined by Bountiful by calculation of amortization of field and capital costs over 30 years. If it displaces fossil-fuel generation, a value could be established in comparison with the fuel displaced. However, if Bountiful's calculations are significantly lower than prices paid to other steam producers at Roosevelt or elsewhere, McDonald and/or Department of the Interior may file protests.

In any event, a sum equal to 15 percent of the value of steam produced or consumed will go out in royalty payments.

Operation and maintenance may be minor. Further, it may be possible for Bountiful to contract these costs and duties to a field operator, perhaps one of the other companies active at Roosevelt. Principal responsibilities will be environmental protection against spills or leaks, monitoring of quality of steam, and perhaps periodic clean-out of producing wells. Additionally, re-injection will have to be supervised, and roads and physical plant maintained.

Numerous studies suggest that such operational costs are equal to 0.5 to 1.5 mills per kW-hr.

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Transmission

It is assumed that Bountiful will be able to arrange for transmission of power to its system via the Utah Power and Light Company line that passes across the field. Otherwise, it appears to be impractical to construct a 10 mW plant at so great a distance from load center.

Downside Risk

Several areas of risk are noted:

a. non-productivity of the lease;

b. early depletion of the field (essentially a variant of (a), above);

c. unanticipated costs of drilling, production, plant construction or maintenance;

d. unavailability of transmission-line capability;

e. failure of Department of the Interior to renew lease after 10th year;

f. legal actions arising from (1) claims of drainage made by other lease holders; (2) dissatisfaction over valuation of steam for purposes of calculating royalty.

g. refusal of the State Engineer to authorize appropriation of water, except to members of a geothermal unit dominated by Phillips.

Risks (a) and (b) cannot be resolved at this time. Risk (a) appears unlikely, however. Risk (b) may be quantifiable after Phillips has conducted its planned long-term flow tests. Bountiful may be able to obtain such data otherwise by participating in tests of the Natomas Utah State 72-16.

Risk (c) can be evaluated in part by establishing maximum and minimum estimates of costs for each item, summing the cost ranges, converting these to approximate costs per kW-hr, and

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comparing these approximate costs to Bountiful's cost data for other generation modes. However, true imponderables (lengthy shut-downs, future environmental restrictions, legal actions, lease revocations) cannot be quantified.

Risk (d) can be evaluated only after negotiations with Utah Power and Light Co.

Risk (e), as discussed earlier, is amenable to intensive public education and political lobbying, and cannot easily be quantified.

Risk (f-1) may be resolved by adherence to unitization prior to production. This will involve negotiation with Phillips over terms for membership. Risk (f-2) also will be resolvable through negotiation at a future date.

Risk (g) cannot be evaluated until the State Engineer publically states his position. To date he has done nothing other than hold hearings.

Downside Protection

Protection to Bountiful's investment comes from the possibility of re-sale of the McDonald lease to other operators. Amongst these would be: Natomas and/or O'Brien; AMAX (who holds an option on much O'Brien acreage); Phillips; Getty Oil Company; Union Oil Company. Each of these is active in exploration of the region. As mentioned earlier, Getty plans a drilling program at Roosevelt in the near future. Other possible purchasers would include Hunt Oil Company and Chevron Oil Company.

As long as an economically attractive market exists for geothermal steam at Roosevelt, there should be willing purchasers of productive leaseholds.

Alternative to sale would be merging of interests with Natomas-O'Brien into a joint venture on the McDonald acreage and Section 16. The advantage to Bountiful would be access to a State of Utah section, with its lessened requirements for permitting, etc. The advantage to Natomas-O'Brien would be to have Bountiful as a potential consumer. The principal drawback would

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be that a 10 mW plant would not do justice to the 680 acres available jointly; 50 mW would be attainable, preferable and economically sounder. This would require a new transmission corridor, with perhaps 2 years additional needed for it.

However, the advantage of a potential 50 mW plant, located on and largely supplied from a State of Utah lease, would outweigh the time constraints of constructing new transmission lines.

Still another alternative to sale or joint venture would be to offer ERDA the opportunity to fund research, testing, perhaps demonstration facilities and possibly production facilities on the McDonald lease within the proven field. This could offer Bountiful a payback on its investment, plus the ultimate possibility of development of commercial generating facilities.

In conclusion, decision to approve the McDonald lease sets in train a series of events likely to cost Bountiful a minimum of $8 million (1977 dollars) over a several year period. The prospects of finding commercial reserves of geothermal energy are very high. The chances of development of about 10 mW of electric power are favorable. The operation is not risk-free. Possibilities of time delays, cost overruns, legal involvements are real. Unresolved questions of lease renewal and water appropriations remain. Opportunities exist to co-venture with other entities (principally Natomas-O'Brien), to obtain ERDA financing for many steps of the way, or to sell out at no loss to other would-be operators. The latter remains Bountiful's downside protection.

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APPENDIX A

ERDA's Request for Expression of Interest for a Geothermal Demonstration Power Plant upon payment of all charges required by law.

HARRY L. PEEBLES,
Deputy Advisory Committee Management Officer.

[FR Doc.77-12747 Filed 5-3-77;8:45 am]

GEOTHERMAL ENERGY

Request for Expression of Interest for a Geothermal Demonstration Power Plant

INTRODUCTION AND PURPOSE

The Energy Research and Development Administration (ERDA) is requesting an expression of interest (REI) from organizations desiring to participate in a demonstration project for the utilization of geothermal energy for electric power generation. The demonstration will be a commercial-size plant constructed and operated under realistic industrial conditions. The intent is to demonstrate to industry that electric energy can be generated economically from liquid-dominated geothermal resources in an environmentally and socially acceptable manner. Successful demonstration will reduce the uncertainties that attend the utilization of geothermal resources for power production and will thereby advance the realization of geothermal energy as an option for meeting national energy needs. The expression of interest is intended to obtain information about who is interested in geothermal exploitation and their capabilities for conducting a demonstration project.

INTENDED DEMONSTRATION PROJECT

ERDA plans to initiate a commercial-scale (50 megawatts electrical or greater) demonstration project in Fiscal Year 1978. Joint industry and government funding of construction and operation of the project is anticipated. The project will be located at a site where reservoir development work is already underway in order to accelerate geothermal development in the near term.

The plant is intended to demonstrate commercial generation of electric power using a high-temperature, low-to-moderate salinity resource with a binary fluid, flashed-steam or a fossil-geothermal hybrid conversion cycle. Target date for power-on-line is 1982 or earlier.

FUTURE DEMONSTRATION PROJECTS

The ultimate objective of the demonstration program is to accelerate the pace of commercial application of geothermal energy. In order to accomplish this objective, it is likely that future demonstration projects, in addition to the one mentioned above, will be considered for other resource types (e.g., geopressured) in other regions of the nation with large promise for geothermal development. The magnitude of the demonstration program that would be needed will be determined in large part by the results of several current Federal policy and planning studies. The information ERDA gathers from this request for an expression of interest is expected to exert substantial influence on these studies. Therefore, respondents are encouraged to submit any additional information that will assist ERDA in formulating Federal plans for future demonstration projects. For example, if respondents are unable to fulfill the criteria provided for the first planned demonstration plant, ERDA would like to know what additional activities are planned by the respondent which would meet the criteria by a later date.

INSTRUCTIONS

Responses to this REI are requested on or before June 20, 1977. This request for an expression of interest is not a request for proposal and does not commit the Government to contract with any party or to pay any costs incurred in connection with preparing and submitting any response.

A suggested format for an expression of interest is presented as an Appendix to this publication. Respondents that are unable to address all of the information of interest in the Appendix are nevertheless encouraged to provide that information which is readily available. Nor is it necessary to reformat information which currently exists in corporate format. Information which is not readily available is not expected to be created for this expression of interest.

Respondents may mark trade secrets and commercial or financial information "Company Confidential." Information so marked will be accorded the treatment provided in ERDA PR 9-3.150 for proprietary data and priviledged business information contained in proposals, except that information will be reviewed for planning purposes instead of evaluation purposes. Accordingly, data marked "Company Confidential" will be disclosed only to designated Government personnel and a limited number of non-Government personnel under the circumstances specified in ERDA PR 9-150-5. Submissions will be returned after review if requested.

Expressions of interest should reference this request and be submitted to:

Dr. James C. Bresee, Director, Division of Geothermal Energy, U.S. Energy Research and Development Administration, Washington, D.C. 20545.

Inquiries relative to this request for expressions of interest should be directed to A. G. Follett, Mission Team Leader, Saline Hydrothermal, telephone 202-376-1690.

GENERAL CRITERIA FOR SUCCESSFUL DEMONSTRATION

Analysis of Government involvement in past demonstrations of all kinds indicates that three general criteria must be observed to ensure success.

1. A clear rationale for Federal involvement must be presented. It must be evident that exploitation by private enterprise alone is not likely, or that it will be slow in coming. In any case, Federal involvement must materially add to the likelihood of success of the demonstration and the rate of exploitation of geothermal resources. It should be noted that ERDA cannot participate in a project which would be eligible for loan guaranty under Pub. L. 93-410.

2. A demonstration is warranted only if lesser or partial measures, such as pilot plants or test beds, will be inadequate to produce the desired results. It should be evident that other Federal activities, such as reduction of institutional roadblocks, will not in themselves adequately accelerate geothermal energy development unless accompanied by a commercial-scale demonstration.

3. The third criterion includes a number of factors that directly influence the commercialization of the project; for example.

The technology for the demonstration should already be established. It is unwise to mix R&D with a commercial demonstration.

Participants in the eventual commercial process—field developers, utilities, and the financial community—should be involved in the planning and execution of the project.

Clear arrangements must be made at the outset for commercial acquisition and Federal withdrawal at the project's conclusion.

The development schedule should be realistic in the light of construction and drilling time and technical complexity.

SPECIFIC CRITERIA FOR GEOTHERMAL DEMONSTRATION PROJECT

Beyond the general criteria discussed above, several specific criteria are essential to the success of a geothermal demonstration:

The demonstration project must offer timely acceleration of the exploitation of a specific geothermal resource type with significant national development potential.

The demonstration must be conducted under realistic conditions.

The project must exploit a reservoir of demonstrated commercial production potential beyond that represented by the demonstration plant by at least an additional 150 MW.

The project planning should include a schedule for commercial expansion.

The objectives of the demonstration must be clearly defined.

The project planning should include appropriate environmental safeguards and water resource evaluation.

State and local attitudes should be favorable to the demonstration.

Inasmuch as the intent of the demonstration program is to accelerate the pace of geothermal exploitation by U.S. industry, consideration of responses for eventual Government costsharing will be limited to U.S. participants.

The planned schedule for a Demonstration Plant would require a proven reservoir and technology that is well in hand.

DONALD A. BEATTIE,
Acting Assistant Administrator for Solar, Geothermal, and Advanced Energy System.

APPENDIX

RESPONSE FORMAT

The type of information desired, if available is outlined below. Any proprietary information submitted should be specifically identified.

SECTION I. General information concerning the following: Participating organizations; Organization and management; Experience and competence in electric power generation; Experience and competence in reservoir development and fluid production

SECTION II. Project information relating to: Location; Geology; Reservoir type and characteristics; Reservoir reserves; Seismological stability; Accessibility; Cooling water availability and requirements; Zoning and land use restrictions; Project scale; Energy conversion process, description; Means for disposal of spent geothermal fluid; Environmental control technology.

SECTION III. Planned schedule for the following: Reservoir definition and capacity; Design; Permitting; Construction; Operation; Expansion.

SECTION IV. Business arrangements considered appropriate concerning: Cost and risk sharing, including patent arrangements; Federal Government and private sector participation.

SECTION V. Information on other factors such as: 1. Local, state, and public acceptance and participation; 2 Environmental considerations; 3. Plans for collecting, processing, and transferring to the public sector design, construction, and operation data and experience; 4. Restriction on technology transfer due to proprietary information; 5. Actual or anticipated impediments.

[FR Doc.77-12810 Filed 5-3-77;8:45 am]

FEDERAL COMMUNICATIONS COMMISSION

CANADIAN FM BROADCAST STATIONS

Table of Channel Assignments and Allocations

APRIL 27, 1977.

Amendment of Table A of The Canada-U.S.A. FM Broadcasting Agreement of 1947, Supplement No. 1; (to the Table of Canadian FM broadcasting channel assignments and allocations within 250 miles of the Canada-U.S.A. border, dated April 22, 1977, as revised April 12, 1977).

Pursuant to exchange of correspondence between the Department of Communications of Canada and the Federal Communications Commission, Table A of the Canada-U.S.A. FM Broadcasting Agreement has been amended as set forth in the attached list. It is to be noted that those representing assignments will indicate call signs plus parameters.

The allocations below have been deleted from Table A.

Location	*Channel No.*
Amherst, Nova Scotia	244C
New Castle, New Brunswick	257C
Antigonish, Nova Scotia	256C
Dalhousie, New Brunswick	289C

Further additions, changes, and deletions will be issued as reported to the Commission by the Canadian Department of Communications.

Copies of the basic Table of Allocations may be obtained from Downtown Copy Center, 1730 K Street, NW., Washington, D.C. 20036, telephone (202) 452-1422.

FEDERAL COMMUNICATIONS COMMISSION,
VINCENT J. MULLINS,
Secretary.

FM engineering data base listing, Federal Communications Commission, Broadcast Bureau

[Unofficial secondary source. Use primary sources for official information]

Canmore, Alberta	250 A 97.9	51-05-00.0 115-21-00.0	United States of America	770421
Exshaw, Alberta	251 A 100.7	51-03-00.0 115-09-00.0	do	770421
Lethbridge, Alberta	282 B 104.3	49-42-00.0 112-50-00.0	do	770421
Pincher Creek, Alberta	248 A 97.5	49-29-00.0 113-57-00.0	do	770421
Dalhousie, New Brunswick	278 B 103.5	48-03-51.0 66-22-37.0	do	770421
New Castle, New Brunswick	289 B 105.7	47-00-04.0 65-34-01.0	do	770421
Amherst, Nova Scotia	257 B 99.3	45-49-44.0 64-12-25.0	do	770421
Antigonish, Nova Scotia	295 C 106.9	45-37-26.0 61-59-35.0	do	770421
Church Point, Nova Scotia	240 A 95.9	44-20-10.0 66-07-00.0	do	770421
Dryden, Ontario	265 C 100.9	49-45-49.0 92-40-52.0	do	770421
Do	274 B 102.7	49-45-49.0 92-40-52.0	do	770421
Osnaburgh, Ontario	283 A 104.5	51-14-35.0 90-13-41.0	do	770421
Pickle Lake, Ontario	286 A 105.1	51-28-11.0 90-11-00.0	do	770421
Savant Lake, Ontario	285 A 104.9	50-15-30.0 90-42-00.0	do	770421
Sioux Narrows, Ontario	239 A 95.7	49-25-43.0 94-03-44.0	do	770421
Charlottetown, Prince Edward Island	245 C 96.9	46-14-17.0 63-07-37.0	do	770421

[FR Doc.77-12544 Filed 5-3-77;8:45 am]

CANADIAN FM BROADCAST STATIONS

Table of Channel Allocations

APRIL 18, 1977.

Amendment of Table A of the 1963 working arrangement for allocations of FM broadcast stations under the Canada-U.S.A. FM Agreement of 1947, Supplement No. 3; (to the Table of Canadian FM broadcasting channel allocations within 250 miles of the Canada-U.S.A. border, dated May 16, 1973, as revised to April 1, 1973).

Pursuant to exchange of correspondence between the Department of Communications of Canada and the Federal Communications Commission, Table A of the FM Working Arrangement has been amended as follows:

Location	Channel No.	
	Delete	Add
Canmore, Alberta		250A
Exshaw, Alberta		251A
Lethbridge, Alberta		282B
Pincher Creek, Alberta		248A
Albert Bay, British Columbia		286A
Burns Lake, British Columbia		276B
Camp Weiss, British Columbia		225B
Fort Fraser, British Columbia		275B
Hope, British Columbia	230A	269A
Lytton, British Columbia		273B
Oliver, British Columbia	260B	264B
Dalhousie, New Brunswick	289C	278B
New Castle, New Brunswick	257C	289B
Amherst, Nova Scotia	244C	257B
Antigonish, Nova Scotia	256C	295C
Church Point, Nova Scotia		240A
Dryden, Ontario		265C, 274B
Orillia, Ontario	246A	
Osnaburgh, Ontario		283A
Penetanguishene, Ontario		243B
Pickle Lake, Ontario		286A
Savant Lake, Ontario		285A
Sioux Narrows, Ontario		239A
Charlottetown, Prince Edward Island		245C
Montreal, Quebec	257A [1]	
Sept-Iles, Quebec		245C
Ste. Adele, Quebec		258B
St. Agathe des Monts, Quebec	258A	

[1] Special negotiated short-spaced allocation.

Further amendments to Table A will be issued as public notices in the form of numbered supplements or recapitulated lists.

Copies of the basic Table of Allocations may be obtained from Downtown Copy Center, 1730 K Street, NW., Washington, D.C. 20006, telephone (202) 452-1422.

WALLACE E. JOHNSON,
Chief, Broadcast Bureau,
Federal Communications Commission.

[FR Doc.77-12545 Filed 5-3-77;8:45 am]

CANADIAN TELEVISION BROADCAST STATIONS

Table of Channel Allocations

APRIL 18, 1977.

Amendment of Table A of The Canada-U.S.A. TV Agreement of 1952 (TIAS-2594), Supplement No. 4 (to the Table of Canadian television channel allocations within 250 miles of the Canada-U.S.A. border, dated December 6, 1974, as revised to September 12, 1974).

Pursuant to exchange of correspondence between the Department of Communications of Canada and the Federal Communications Commission, Table A of the Canada-U.S.A. Television Agreement has been amended as follows:

Location	Channel No.	
	Delete	Add
Etzikom, Alberta: 49°33'59" N., 111°07'52" W.		12+ L(1)
Burns Lake, British Columbia: 54°13'25" N., 125°40'36" W.		4+
Houston, British Columbia: 54°26'36" N., 126°39'30" W.		2+ L(1)
Smithers, British Columbia: 54°47'28" N., 127°[illegible]" W.		5+
Dryden, Ontario: 49°47'40" N., 92°[illegible]" W.	7	7L
Hearst, Ontario		