RECENT DEVELOPMENTS AT THE ROOSEVELT HOT SPRINGS KGRA

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PHILLIPS PETROLEUM COMPANY, GEOTHERMAL OPERATIONS

DEL MAR, CALIFORNIA 92014

ABSTRACT

The Roosevelt geothermal field, located in southwestern Utah, has been the focus of a high level of activity by both private industry and the academic community. Phillips Petroleum Company has drilled seven and Thermal Power Company two, of nine exploration wells to depths ranging between 370 and 2300 meters into a late Tertiary granitic igneous complex which intruded Precambrian (?) metamorphic rocks. The reservoir is confined to fractures within the granitic and metamorphic rocks. The nature of the reservoir is such that all wells drilled are wildcats.

The geothermal field lies along the west side of the central Mineral Range. Young rhyolite domes, with associated flows, pierce the late Tertiary granitic complex a few kilometers to the east and south of the producing wells. The heat at Roosevelt is probably supplied by the parent magma for the rhyolite domes.

Phillips' integrated exploration program combining geology, geochemistry and geophysics culminated in the drilling of the discovery well in April of 1975. The resource is a water dominated geothermal system with a maximum temperature in excess of 265°C. The water is a sodium chloride water with salinity less than 8000 mg/l. Recent activities include the formation of the Roosevelt Hot Springs Unit, applications to appropriate water from the state, the establishment of a groundwater monitoring system in the valley, and preparation for additional reservoir testing.

INTRODUCTION

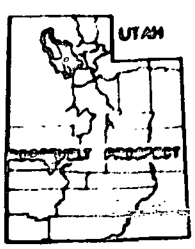

Fig. 1
Utah Index Map

The Roosevelt geothermal field is situated in the western foothills of the Mineral Range in eastern Beaver County, Utah, near the eastern edge of the Basin and Range physiographic province (Fig. 1). The field named for a now dry-hot springs is about 12 miles northeast of the city of Milford and about 18 miles northwest of Beaver, the county seat. Among previous investigations are water studies by Lee (1908), Mundorff (1970) and Mower and Cordova (1974). Earll (1957) geologically mapped portions of the Mineral Range. Condie (1960) investigated the petrogenesis of the Mineral Range Pluton. Recently, Petersen (1974) focused attention on the geology and geothermal potential of the Roosevelt Hot Springs area. In 1975 the University of Utah researchers launched an in-depth program and have published many reports, too numerous to be mentioned here.

Phillips Petroleum Company's exploration activities in Utah began in late 1972 and a chronological listing of the activities at Roosevelt are given in Table 1. As shown, many exploration surveys were completed in the 1-1/2 years preceding the Roosevelt KGRA lease sale. An evaluation of these surveys led to the conclusion that the Roosevelt area showed exceptional promise. The lease sale in July 1974, was the first KGRA put up for bid in the state. The original eight sections in the KGRA had grown to 36.5 sections as a result of the competitive interest shown in the January 1974 noncompetitive acreage filing period. Of twelve tracts offered in the July sale, Phillips acquired nine tracts totaling 18,67[illegible] acres at a cost of $79[illegible],669. The location of the tracts, the successful bidder, cost of each tract, and cost per acre are shown in Fig. 2. After the leases issued in October 1974, exploration activity shifted to drilling the acquired acreage. During 1975 six exploratory wells and two stratigraphic tests were drilled. The discovery well (3-1), the second well drilled, came in at the end of April. During 1976, efforts focused toward furthering the knowledge of the geothermal system t[illegible] reservoir tests and a variety of geophysical and geochemical surveys.

TABLE 1

CHRONOLOGY OF PHILLIPS ACTIVITIES AT THE ROOSEVELT PROSPECT

LATE	1972	LITERATURE SURVEY & FIELD RECONNAISSANCE
FEB	1973	RECONNAISSANCE GEOCHEMICAL SURVEY
MAR	1973	GRAVITY SURVEY
MAY	1973	GEOCHEMICAL SURVEY (CONTINUED)
MAY	1973	EARLY LEASING ACTIVITIES (CONTINUED)
JUNE	1973	DIPOLE - DIPOLE SURVEY
JUNE	1973	GROUND NOISE SURVEY
JULY	1973	TEMPERATURE GRADIENT SURVEY (CONTINUING)
OCT	1973	MAGNETOTELLURIC SURVEY
JULY	1974	COMPETITIVE LEASE SALE (~10,000 ACRES)
OCT	1974	LEASES ISSUE
DEC	1974	REFLECTION SEISMIC SURVEY
FEB	1975	SPUDDED OBSERVATION HOLE #2
MAR	1975	SPUDDED OBSERVATION HOLE #1
MAR	1975	SPUDDED ROOSEVELT KGRA #3-1
APR	1975	SPUDDED ROOSEVELT KGRA #3-1 - DISCOVERY WELL
APR	1975	GROUND LEVEL MAGNETIC SURVEY
MAY	1975	MAGNETOTELLURIC SURVEY
JUNE	1975	PETROLOGIC STUDIES
JULY	1975	SPUDDED ROOSEVELT KGRA #54-3
AUG	1975	SPUDDED ROOSEVELT KGRA #12-35
OCT	1975	SPUDDED ROOSEVELT KGRA #13-10
NOV	1975	SPUDDED ROOSEVELT KGRA #82-33
JAN	1976	WATER OBSERVATION SYSTEM
FEB	1976	MAGNETOTELLURIC SURVEY
FEB	1976	MOST SIGNIFICANT FLOW TEST (#54-3)
MAR	1976	ISOTOPIC STUDIES
APR	1976	WATER APPROPRIATION HEARING
APR	1976	UNIT APPROVED
MAY	1976	HELIUM SURVEY
AUG	1976	SPUDDED ROOSEVELT HOT SPRINGS UNIT #9-15
OCT	1976	MICROEARTHQUAKE AND GROUND NOISE STUDIES
OCT	1976	SPONTANEOUS POTENTIAL SURVEY
NOV	1976	HIGH RESOLUTION SEISMIC SURVEY
DEC	1976	LANDSAT IMAGERY STUDY

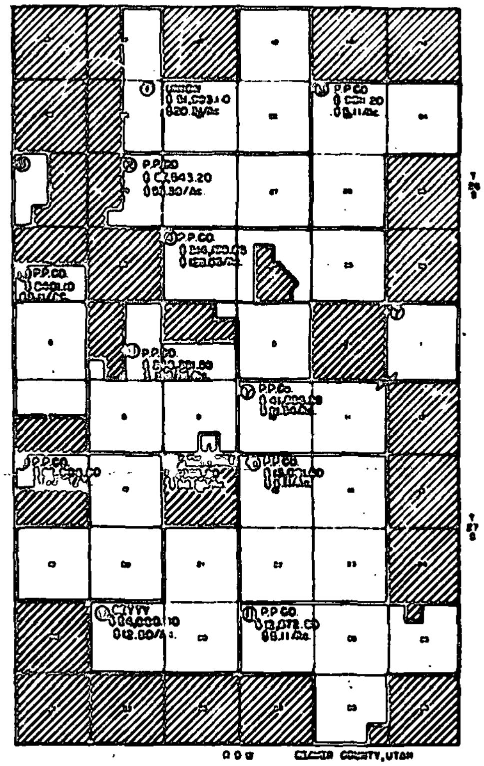

Fig. 2. The Roosevelt Hot Springs KGRA showing the location of 12 tracts offered at the July 1974 lease sale.

GEOLOGY

The Roosevelt geothermal field is located at the junction between Escalante Valley, a north-south trending graben, and the Mineral Range, a horst block paralleling the east side of the valley (Fig. 3). The valley is flanked on the west by a horst forming a number of smaller mountain ranges. The graben is filled with upwards of 5,000 feet of poorly consolidated sediments, volcanics and alluvium resting on more dense consolidated rocks. The valley fill is thickest immediately northeast of Milford.

The Mineral Range is about thirty miles long and six to ten miles wide. Topography is rugged, with steep slopes and high relief. The southern third of the range is composed of folded and faulted Paleozoic and Mesozoic sediments and Tertiary volcanic rocks which have been intruded by small acidic igneous stocks. The central Mineral Range has a granitic central core which is recognized as Utah's largest pluton. The granite has intruded and metamorphosed Paleozoic sedimentary rocks now cropping out along the southeast edge of the Range. To the west, granite intruded Precambrian schists and gneisses (Fig. 4). The granite-metamorphic rock contact is gradational with a zone about one-mile wide consisting of metamorphic inclusions within the granite forming the granite-metamorphic rock contact (Earll, 1957). North of Roosevelt Springs, granite is in gradational contact with a granodiorite intrusive which in turn intruded a sequence of upper Precambrian and lower Paleozoic sedimentary rocks at the north end of the range (Liese, 1957). Late Cenozoic acidic ash flow tuffs and lava flows partly fill older erosional valleys cut in the granite and partly cap portions of the granite in the central Mineral Range. These volcanics appear to be younger than the basin-range faulting which exhumed and permitted dissection of the granite pluton. Age dates of 400,000 years to 0.8 m.y. are reported by W. P. Nash (1976) for the volcanics. Bearskin Mountain has been identified as one of perhaps several volcanoes supplying the tuffs and lavas (Earll, 1957). Other possible sources are North and South Twin Flat Mountain and a small siliceous stock in Section 31, T26S, R8W.

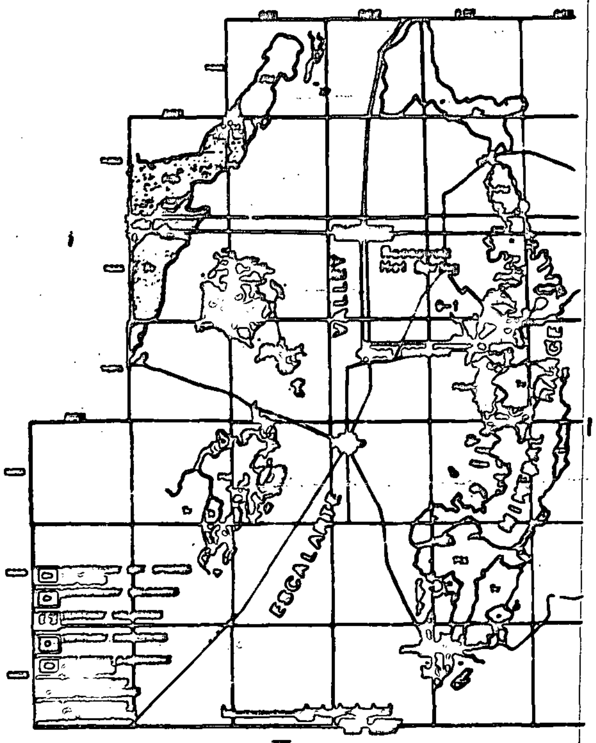

Fig. 3. Geologic Map of Northern Escalante Valley. Modified after Petersen, 1974; Liese, 1957; Earll, 1957; Mintzer, 1963.

Faulting is ubiquitous throughout the area. Several faults within the Roosevelt KGRA apparently have a significant influence on the hydrology. These are the Dome Fault, striking NNE through the center of the KGRA, and the east-west striking Negro Mag Wash fault.

The Phillips exploration program has been discussed elsewhere by Berge et. al. (1976) and Lenzer et. al. (1976) and only the results of temperature gradient surveys will be reported here. In addition, the University of Utah investigating team led by Dr. Ward have published many reports on the Roosevelt area, which will not be discussed. The temperature gradient map (Fig. 5) is based on a total of thirty-nine holes and combines Phillips' results with data from Petersen (1975) and Whelan (University of Utah, personal communication). Depths of gradient holes vary from 60 to 610 m (200 to 2,000 ft). Gradients in five holes in the center of the thermal anomaly exceed 40°C/100m. The anomaly is elongate north-south with a change in trend to the northwest in the northern third of the anomaly. The north-south trace of the Dome Fault centers on the anomaly, and the east-west Negro Mag Wash fault is coincident with the zone of the change in trend. All exploration wells presently drilled fall in areas having gradients exceeding 30°C/100 m. Drilling activity to date totals nine geothermal wells and four stratigraphic test holes (Table 2 and Fig. 7). Seven of the nine wells encountered geothermal resources. Two wells (54-3 & 72-16) are reported to be capable of producing 1 x 10^6 pounds per hour or more total mass flow. One of the seven, (3-1), cannot be produced due to safety considerations.

The rocks encountered in drilling beneath the thin veneer of alluvium, are either igneous intrusive rocks of the Tertiary Mineral Range granitic complex or metamorphic rocks of the Precambrian Wildhorse Canyon series (Fig. 6). These rocks have almost no intergranular porosity or permeability. The geothermal reservoir is associated with interconnected fracture zones and faults lending local high effective permeability to the crystalline rocks. The reservoir is confined beneath a cap varying from 300 to several thousand feet in thickness—the cap apparently formed by precipitated silica sealing the fractures. All the wells drilled to date are considered wildcats since the targets sought are fracture systems whose attitudes are poorly known and are not related to any particular lithology or formation. Using the classification of White and Williams (1975), the geothermal resource is identified as a high temperature, low salinity, liquid dominated type. Geothermal reservoir water is classified as sodium chloride water containing 6000 to 8000 mg/1 T.D.S. (Table 3). These waters contain anomalously high amounts of Si, Na, K, Cl, F, B, Li, NH_3 and salinity relative to other basin waters. The Na-K-Ca empirical geothermometer of Fournier and Truesdell (1973) has been applied to the reservoir water from geothermal wells 54-3 and 3-1, Roosevelt Hot Springs water, and present surface water discharging near the old hot springs (Table 3). There is close agreement (within 10%) between the calculated reservoir temperatures and the reservoir temperatures measured in the wells.

ROOSEVELT HOT SPRINGS UNIT AGREEMENT

Efforts to utilize the Roosevelt Hot Springs reservoir have been successful. The

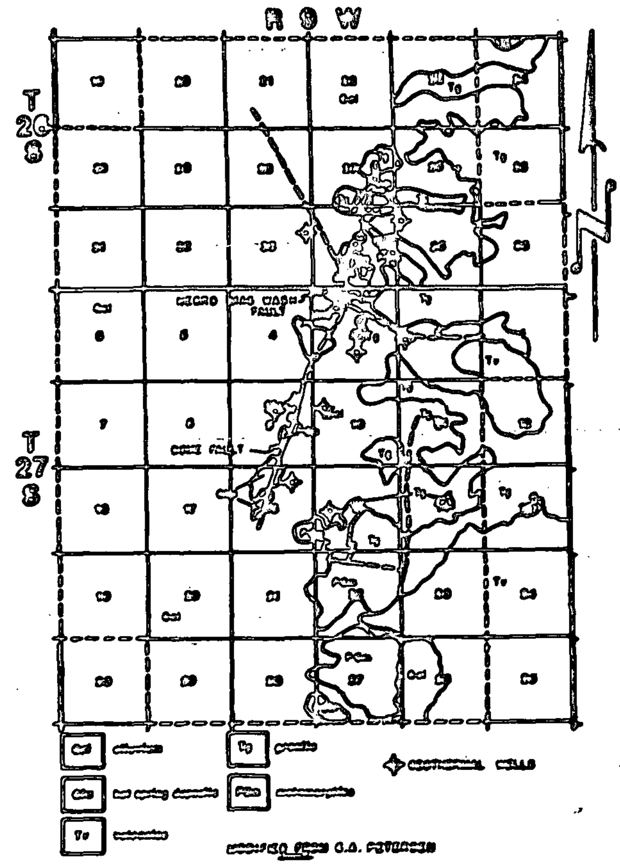

Fig. 4. Geologic Map of the Roosevelt Hot Springs area. Modified after Petersen, 1974.

purpose of forming a geothermal unit is for the same purposes as unitization in oil and gas exploration, and that is the efficient and economic development of the resource. A unit accomplishes this by eliminating lease lines, allowing the field to be developed in the most prudent manner; offset situations are thereby avoided.

The Roosevelt Hot Springs Unit is the first approved Federal geothermal unit in the United States. The unit area is shown in Fig. 7. The formation of any unit can be an extremely involved process, and the Roosevelt Unit, being the first of its kind, took well over a year to write and to receive final approval. The Federal geothermal unit agreement, which states the regulations regarding unit operation, was derived from the basic Federal oil and gas unit agreement. If more than one party holds land in the area to be unitized, as is the case at Roosevelt, a Unit Operating Agreement setting forth the operating conditions must be agreed upon by the different parties.

The fact that the geothermal reservoir at Roosevelt is contained in fractures and the distribution of fractures can be highly erratic led to the adoption of a divided type unit on a tract basis. Under this system, costs and production are apportioned to each party based on the amount of their acreage included within a participating area, and entrance into a participating area is gained by drilling a production well. Each well drilled is credited with a certain amount of acreage which, if the well is a producer, is then included within the participating area. Dry holes do not count and acreage credited to them is not included in a participating area.

WATER APPROPRIATION PROCEDURE

Everyone desiring to develop geothermal resources in Utah is faced with the same problem and that is the appropriation of water necessary to run the power plant. This holds true even if the resource to be developed is on Federal lands, for in the state of Utah, all waters within the state are public property. The basis for granting a water right in Utah is that the water shall be put to beneficial use. Phillips has taken steps to appropriate the necessary water by submitting applications to the State Engineer. The notices of application were published, protests were filed, and a public hearing before the State Engineer was held in Beaver, Utah, in April 1976 to consider the applications. For the State Engineer to approve any application, the following requirements must be met: (1) There is unappropriated water in the proposed source. (2) The proposed use will not impare existing rights, or interfere with more beneficial use of the water. (3) The proposed plan is physically and economically feasible and will not prove detrimental to the public welfare. (4) The applicant has the financial ability to complete the proposed works and the application has been filed in good faith and not for purposes of speculation or monopoly. At the hearing specific testimony was present to meet each of these specific requirements.

As a result of the geothermal discovery and the concern of existing water users in the Valley, Phillips has initiated a monitoring system in Escalante Valley in consul-

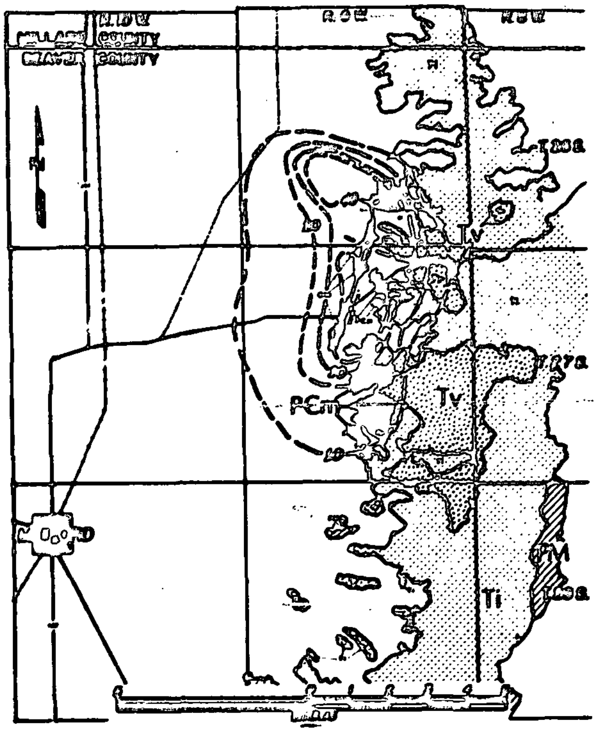

Fig. 5. Temperature gradients in the Roosevelt Hot Springs area. Contour Interval is 10°C/100m (Includes data from Petersen, 1975 and Whelan, 1976, personal communication).

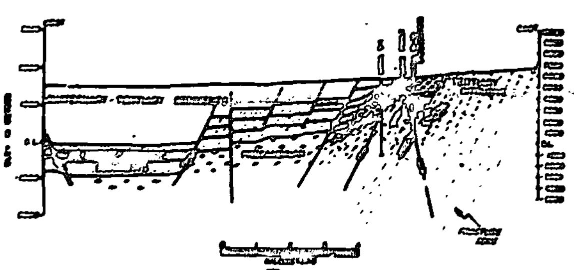

Fig. 6. Generalized Structure section through Well No. 9-1.

tation with the USGS Water Resources Division. At present, the system includes six stock wells, the Roosevelt seep, four water observation wells specifically drilled by Phillips for monitoring purposes, and one stratigraphic test hole modified to act as a water observation well (Fig. 8). The Phillips' wells are located between the geothermal wells and the existing water users points of diversion and penetrate the same reservoir utilized by the ranchers and farmers in the valley. The well sites were located far from existing irrigation wells to minimize or eliminate the effect that present pumping in the irrigation district might have on the water table at the monitoring sites.

The system is an early warning system designed to detect any effect that testing or production would have on existing water users source of supply. Additional monitoring points will be added to the system as necessary.

EXPLORATION ACTIVITY

Most recently, exploration activity at Roosevelt has consisted of drilling several 2000 foot observation holes or deep temperature gradient holes. These have been drilled to test certain ideas concerning the Roosevelt geothermal system. This intermediate depth drilling step has proven extremely valuable in evaluating other prospects.

The chief benefit of drilling a 2000 foot observation hole is the large quantity of information obtained for a relatively low cost. Our average drilling cost is less than $50,000, which is 1/10 that of drilling an exploration well to 6000 feet. Information generated by drilling these holes includes the following: temperature gradients, stratigraphy, hydrology, alteration, drilling problems and structure. These holes are particularly useful in minimizing the risk in picking the proper spot to drill an exploration well. Such a hole might be drilled if it were suspected that the thermal anomaly might be caused by lateral movement of warm waters below depths reached by shallow temperature gradient holes.

ENGINEERING

The engineering program at Roosevelt is a multipurpose program designed (1) to gain experience, (2) to determine the production capabilities of each well drilled, and (3) to characterize the reservoir. Testing has been limited to short term flow tests of about two days duration on the production wells. The longest test was a 3.5 day flow of Well 54-3. With tests of such short duration, we have not reached all our objectives. We have gained invaluable experience and confidence in operating equipment and in interpreting the results and we have been successful in determining each well's capabilities. Two systems have been used for testing. The initial testing at Well 54-3 used

Table 2. Exploratory Geothermal Wells & Stratigraphic

Test Holes, Roosevelt KGRA Utah.

Location	Operator	Well	Status	Depth
SW NW Sec. 10, T.27S., R.9W.	Phillips Petroleum Co.	O.H. 2	Abandoned 1975	2250'
SE NE Sec. 17, T.27S., R.9W.	Phillips Petroleum Co.	O.H. 1	Idle-Strat Test	—
NE NW Sec. 9, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 9-1	Idle Dry Hole	6885'
SW NE Sec. 3, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 3-1	Idle	2724'
SW NE Sec. 3, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 54-3	Idle	2882'
NW NW Sec. 35, T.26S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 12-35	Idle	—
SW NW Sec. 10, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 13-10	Idle	—
NE NE Sec. 33, T.26S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 82-33	Idle Disposal	—
SW NW Sec. 2, T.27S., R.9W.	Thermal Power-Natomas	Utah State 14-2	Idle	6108'
NW SW Sec. 15, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt HSU 25-15	Idle	—
NE NE Sec. 16, T.27S., R.9W.	Thermal Power-Natomas-O'Brien	Utah State 72-16	Testing	1254'
NE NW Sec. 33, T.26S., R.9W.	Phillips Petroleum Co.	O.H. 4	Idle-Strat Test	—
SE NE Sec. 28, T.26S., R.9W.	Phillips Petroleum Co.	O.H. 5	Drilling Strat-Test	—

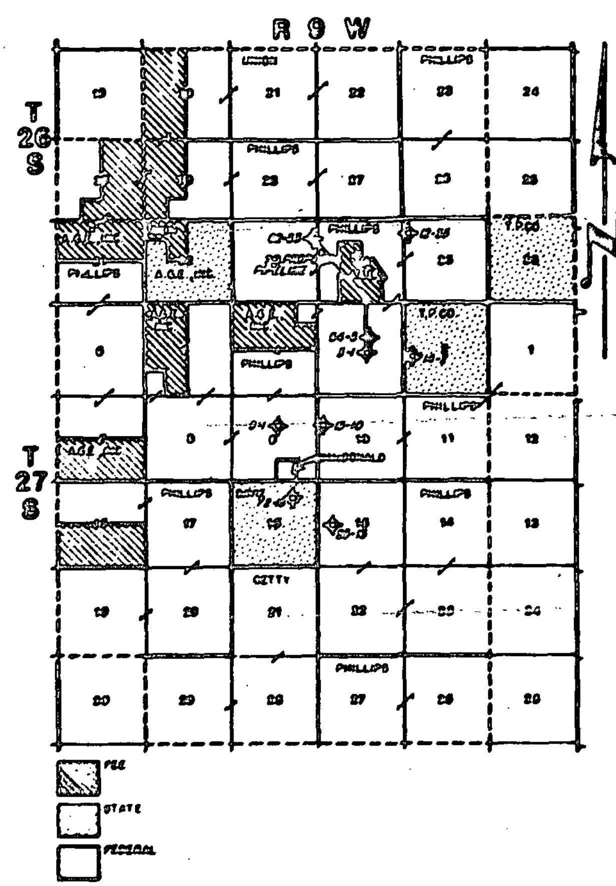

Fig. 7. Roosevelt Hot Springs Unit Area.

for testing. The initial testing at Well 54-3 used a separator to separate liquid and vapor phases so they could each be measured separately. The separator has a capacity of 1 million pounds per hour of total mass flow and it proved to be inadequate to handle the maximum well flow. At the other production wells, flow has been measured using Russell James (1966) method of steam-water measurement employing an orifice plate and a lip critical pressure measuring device.

The limiting factor on the duration of the flow tests is the disposal of the produced liquids. At present the reserve pits adjacent to the wells are used to contain the test fluids. During the 3.5 day flow test of Well 54-3, the liquids produced were discharged into the natural drainage system. It was an experiment designed to measure the effect that reservoir fluids would have on the native vegetation, and was allowed to proceed because the shallow groundwater in the area is similar in quality to the reservoir fluids. The discharge pipe was buried beneath riprap in the center of a large wash. After the test gullying was noted below the outlet pipe for several 100 feet downstream. A second result was the death of trees immediately adjacent to the channel, but not all

TABLE 3.

SELECTED WATER ANALYSES OF ROOSEVELT KGRA

	[illegible] Hot Springs[1]	[illegible] Hot Springs[1]	[illegible]	[illegible]	54-3	3-1
Date	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature (°C)	[illegible]	[illegible]	47	[illegible]	> [illegible]	> [illegible]
Silica (ppm)	[illegible]	[illegible]	73	107	[illegible] +	[illegible] ?
Calcium (ppm)	13	22	113	107	101	0.0
Magnesium (ppm)	3.3	0	17	[illegible]	0.04	0.64
Sodium (ppm)	[illegible]	[illegible]	[illegible]	[illegible]	2000	2307
Potassium (ppm)	472	[illegible]	[illegible]	[illegible]	[illegible]	443
Bicarbonate (ppm)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sulfate (ppm)	[illegible]	73	[illegible]	70	64	[illegible]
Chloride (ppm)	[illegible]	4040	[illegible]	[illegible]	3400	4000
Fluoride (ppm)	7.1	7.5	[illegible]	[illegible]	6.0	[illegible]
Nitrate (ppm)	1.0	11	TR	TR	TR	0.1
Boron (ppm)	-	[illegible]	37	[illegible]	[illegible]	[illegible]
Lithium (ppm)	-	0.27	-	17	13.0	20.0
TDS (ppm)	7040	7000	[illegible]	[illegible]	6442	7037
pH	-	7.9	[illegible]	6.45	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	247	[illegible]	294	278
[illegible]	307	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1 [illegible] 2 [illegible]

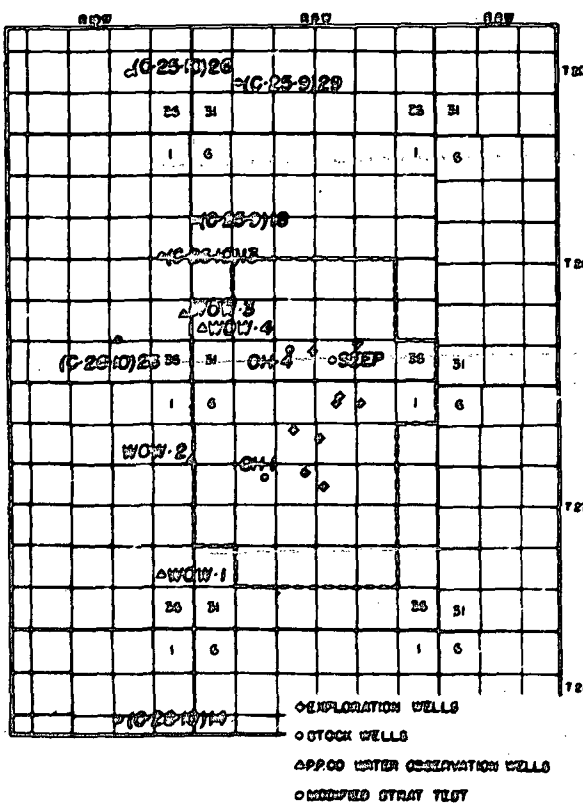

Fig. 8. Water Observation Well System in the area of the Roosevelt Hot Springs Unit.

trees were effected. A recent field check indicates that dead trees are juniper trees, but healthy pine trees are found next to dead junipers. A detailed study of the effect which this test has had on the environment has not yet been made, and until it is, it is unlikely that any further surface disposal will be permitted.

In order to acquire needed reservoir data, there is in preparation a plan for a long term flow test. The proposal calls for flow-testing Well 54-3 for a sustained period of up to six months to determine reservoir size and production characteristics.

The fluids produced at Well 54-3 will be piped through a centrifugal steam/water separator at the well site where the steam portion will be vented in the pit through an existing muffler. It will be necessary to construct approximately 1.4 miles of 10" pipe to connect Well 54-3 to Well 82-33 (Fig. 7). Well 82-33 will function as an injection well during the reservoir tests. The liquid portion from Well 54-3 will be piped to Well 82-33 using the produced pressure for injection into the well.

ACKNOWLEDGMENTS

The writers wish to acknowledge the contributions of Stuart Johnson, Robert Wright and Joe Beall in all phases of the exploration at Roosevelt. Permission to publish the paper has been generously granted by Phillips Petroleum Company.

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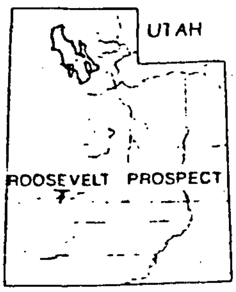

Fig. 1
Utah Index Map

The Roosevelt geothermal field is situated in the western foothills of the Mineral Range in eastern Beaver County, Utah, near the eastern edge of the Basin and Range physiographic province (Fig. 1). The field named for a now dry-hot springs is about 12 miles northeast of the city of Milford and about 18 miles northwest of Beaver, the county seat. Among previous investigations are water studies by Lee (1908), Mundorff (1970) and Mower and Cordova (1974). Earll (1957) geologically mapped portions of the Mineral Range. Condie (1960) investigated the petrogenesis of the Mineral Range Pluton. Recently, Petersen (1974) focused attention on the geology and geothermal potential of the Roosevelt Hot Springs area. In 1975 the University of Utah researchers launched an in-depth program and have published many reports, too numerous to be mentioned here.

Phillips Petroleum Company's exploration activities in Utah began in late 1972 and a chronological listing of the activities at Roosevelt are given in Table 1. As shown, many exploration surveys were completed in the 1-1/2 years preceding the Roosevelt KGRA lease sale. An evaluation of these surveys led to the conclusion that the Roosevelt area showed exceptional promise. The lease sale in July 1974, was the first KGRA put up for bid in the state. The original eight sections in the KGRA had grown to 36.5 sections as a result of the competitive interest shown in the January 1974 noncompetitive acreage filing period. Of twelve tracts offered in the July sale, Phillips acquired nine tracts totaling 18,871 acres at a cost of $798,860. The location of the tracts, the successful bidder, cost of each tract, and cost per acre are shown in Fig. 2. After the leases issued in October 1974, exploration activity shifted to drilling the acquired acreage. During 1975 six exploratory wells and two stratigraphic tests were drilled. The discovery well (3-1), the second well drilled, came in at the end of April. During 1976, efforts focused toward furthering the knowledge of the geothermal system through resevoir tests and a variety of geophysical and geochemical surveys.

TABLE 1

CHRONOLOGY OF PHILLIPS ACTIVITIES AT THE ROOSEVELT PROSPECT

LATE	1972	LITERATURE SURVEY & FIELD RECONNAISSANCE
FEB	1973	RECONNAISSANCE GEOCHEMICAL SURVEY
MAR	1973	GRAVITY SURVEY
MAY	1973	GEOCHEMICAL SURVEY (CONTINUING)
MAY	1973	EARLY LEASING ACTIVITIES (CONTINUING)
JUNE	1973	BIPOLE - DIPOLE SURVEY
JUNE	1973	GROUNDNOISE SURVEY
JULY	1973	TEMPERATURE GRADIENT SURVEY (CONTINUING)
OCT	1973	MAGNETOTELLURIC SURVEY
JULY	1974	COMPETITIVE LEASE SALE (~18,000 ACRES)
OCT	1974	LEASES ISSUE
DEC	1974	REFLECTION SEISMIC SURVEY
FEB	1975	SPUDDED OBSERVATION HOLE #2
MAR	1975	SPUDDED OBSERVATION HOLE #1
MAR	1975	SPUDDED ROOSEVELT KGRA #9-1
APR	1975	SPUDDED ROOSEVELT KGRA #3-1 - DISCOVERY WELL
APR	1975	GROUND LEVEL MAGNETIC SURVEY
MAY	1975	MAGNETOTELLURIC SURVEY
JUNE	1975	PETROLOGIC STUDIES
JULY	1975	SPUDDED ROOSEVELT KGRA #54-3
AUG	1975	SPUDDED ROOSEVELT KGRA #12-35
OCT	1975	SPUDDED ROOSEVELT KGRA #13-10
NOV	1975	SPUDDED ROOSEVELT KGRA #82-33
JAN	1976	WATER OBSERVATION SYSTEM
FEB	1976	MAGNETOTELLURIC SURVEY
FEB	1976	MOST SIGNIFICANT FLOW TEST (#54-3)
MAR	1976	ISOTOPIC STUDIES
APR	1976	WATER APPROPRIATION HEARING
APR	1976	UNIT APPROVED
MAY	1976	HELIUM SURVEY
AUG	1976	SPUDDED ROOSEVELT HOT SPRINGS UNIT #25-15
OCT	1976	MICROEARTHQUAKE AND GROUNDNOISE SURVEYS
OCT	1976	SPONTANEOUS POTENTIAL SURVEY
NOV	1976	HIGH RESOLUTION SEISMIC SURVEY
DEC	1976	LANDSAT IMAGERY STUDY

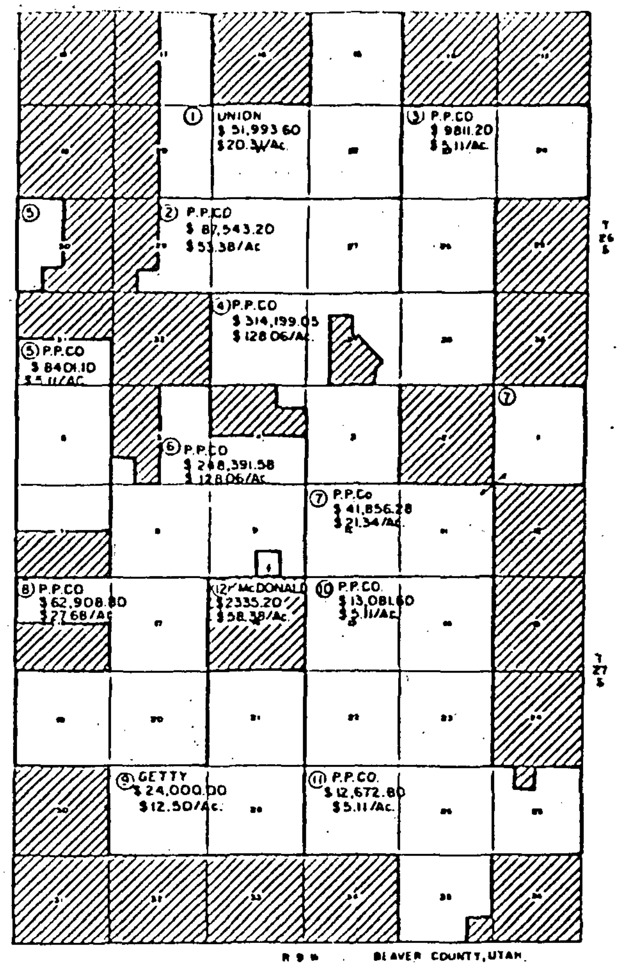

Fig. 2. The Roosevelt Hot Springs KGRA showing the location of 12 tracts offered at the July 1974 lease sale.

GEOLOGY

The Roosevelt geothermal field is located at the junction between Escalante Valley, a north-south trending graben, and the Mineral Range, a horst block paralleling the east side of the valley (Fig. 3). The valley is flanked on the west by a horst forming a number of smaller mountain ranges. The graben is filled with upwards of 5,000 feet of poorly consolidated sediments, volcanics and alluvium resting on more dense consolidated rocks. The valley fill is thickest immediately northeast of Milford.

The Mineral Range is about thirty miles long and six to ten miles wide. Topography is rugged, with steep slopes and high relief. The southern third of the range is composed of folded and faulted Paleozoic and Mesozoic sediments and Tertiary volcanic rocks which have been intruded by small acidic igneous stocks. The central Mineral Range has a granitic central core which is recognized as Utah's largest pluton. The granite has intruded and metamorphosed Palezoic sedimentary rocks now cropping out along the southeast edge of the Range. To the west, granite intruded Precambrian schists and gneisses (Fig. 4). The granite-metamorphic rock contact is gradational with a zone about one-mile wide consisting of metamorphic inclusions within the granite forming the granite-metamorphic rock contact (Earll, 1957). North of Roosevelt Springs, granite is in gradational contact with a granodiorite intrusive which in turn intruded a sequence of upper Precambrian and lower Paleozoic sedimentary rocks at the north end of the range (Liese, 1957). Late Cenozoic acidic ash flow tuffs and lava flows partly fill older erosional valleys cut in the granite and partly cap portions of the granite in the central Mineral Range. These volcanics appear to be younger than the basin-range faulting which exhumed and permitted dissection of the granite pluton. Age dates of 400,000 years to 0.8 m.y. are reported by W. P. Nash (1976) for the volcanics. Bearskin Mountain has been identified as one of perhaps several volcanoes supplying the tuffs and lavas (Earll, 1957). Other possible sources are North and South Twin Flat Mountain and a small siliceous stock in Section 31, T26S, R8W.

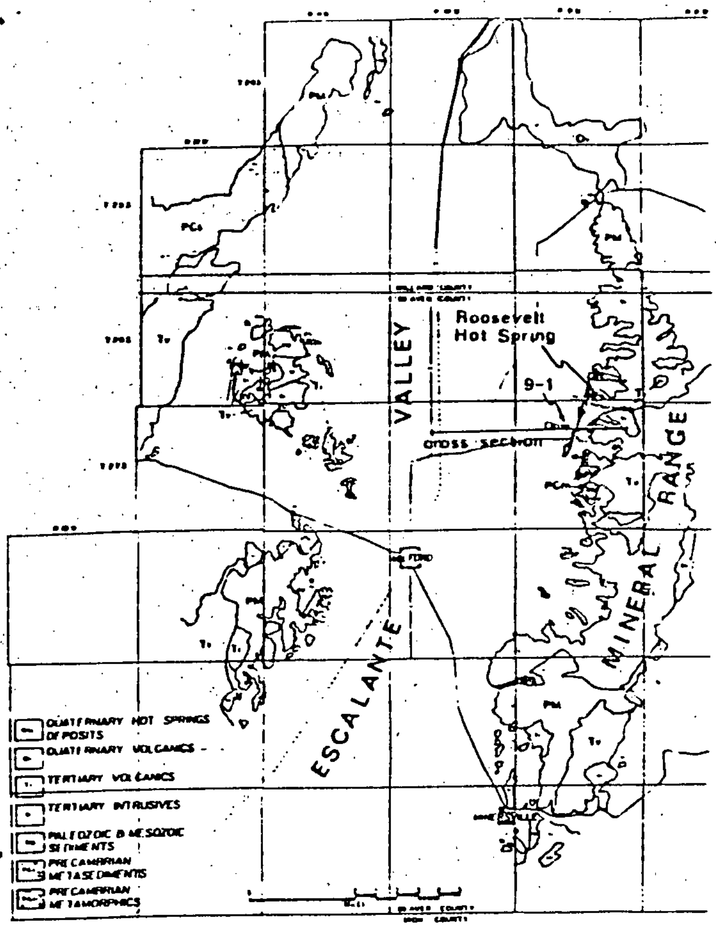

Fig. 3. Geologic Map of Northern Escalante Valley. Modified after Petersen, 1974; Liese, 1957; Earll, 1957; Hintze, 1963.

Faulting is ubiquitous throughout the area. Several faults within the Roosevelt KGRA apparently have a significant influence on the hydrology. These are the Dome Fault, striking NNE through the center of the KGRA, and the east-west striking Negro Mag Wash fault.

The Phillips exploration program has been discussed elsewhere by Berge et. al. (1976) and Lenzer et. al. (1976) and only the results of temperature gradient surveys will be repeated here. In addition, the University of Utah investigating team led by Dr. Ward have published many reports on the Roosevelt area, which will not be discussed. The temperature gradient map (Fig. 5) is based on a total of thirty-nine holes and combines Phillips' results with data from Petersen (1975) and Whelan (University of Utah, personal communication). Depths of gradient holes vary from 60 to 610 m (200 to 2,000 ft). Gradients in five holes in the center of the thermal anomaly exceed 40°C/100m. The anomaly is elongate north-south with a change in trend to the northwest in the northern third of the anomaly. The north-south trace of the Dome Fault centers on the anomaly, and the east-west Negro Mag Wash fault is coincident with the zone of the change in trend. All exploration wells presently drilled fall in areas having gradients exceeding 30°C/100 m. Drilling activity to date totals nine geothermal wells and four stratigraphic test holes (Table 2 and Fig. 7). Seven of the nine wells encountered geothermal resources. Two wells (54-3 & 72-16) are reported to be capable of producing 1 x 10^6 pounds per hour or more total mass flow. One of the seven, (3-1), cannot be produced due to safety considerations.

The rocks encountered in drilling beneath the thin veneer of alluvium, are either igneous intrusive rocks of the Tertiary Mineral Range granitic complex or metamorphic rocks of the Precambrian Wildhorse Canyon series (Fig. 6). These rocks have almost no intergranular porosity or permeability. The geothermal reservoir is associated with interconnected fracture zones and faults lending local high effective permeability to the crystalline rocks. The reservoir is confined beneath a cap varying from 300 to several thousand feet in thickness—the cap apparently formed by precipitated silica sealing the fractures. All the wells drilled to date are considered wildcats since the targets sought are fracture systems whose attitudes are poorly known and are not related to any particular lithology or formation. Using the classification of White and Williams (1975), the geothermal resource is identified as a high temperature, low salinity, liquid dominated type. Geothermal reservoir water is classified as sodium chloride water containing 6000 to 8000 mg/l T.D.S. (Table 3). These waters contain anomalously high amounts of Si, Na, K, Cl, F, B, Li, NH_3 and salinity relative to other basin waters. The Na-K-Ca emperical geothermometer of Fournier and Truesdell (1973) has been applied to the reservoir water from geothermal wells 54-3 and 3-1, Roosevelt Hot Springs water, and present surface water discharging near the old hot springs (Table 3). There is close agreement (within 10%) between the calculated reservoir temperatures and the reservoir temperatures measured in the wells.

ROOSEVELT HOT SPRINGS UNIT AGREEMENT

Efforts to unitize the Roosevelt Hot Springs reservoir have been successful. The

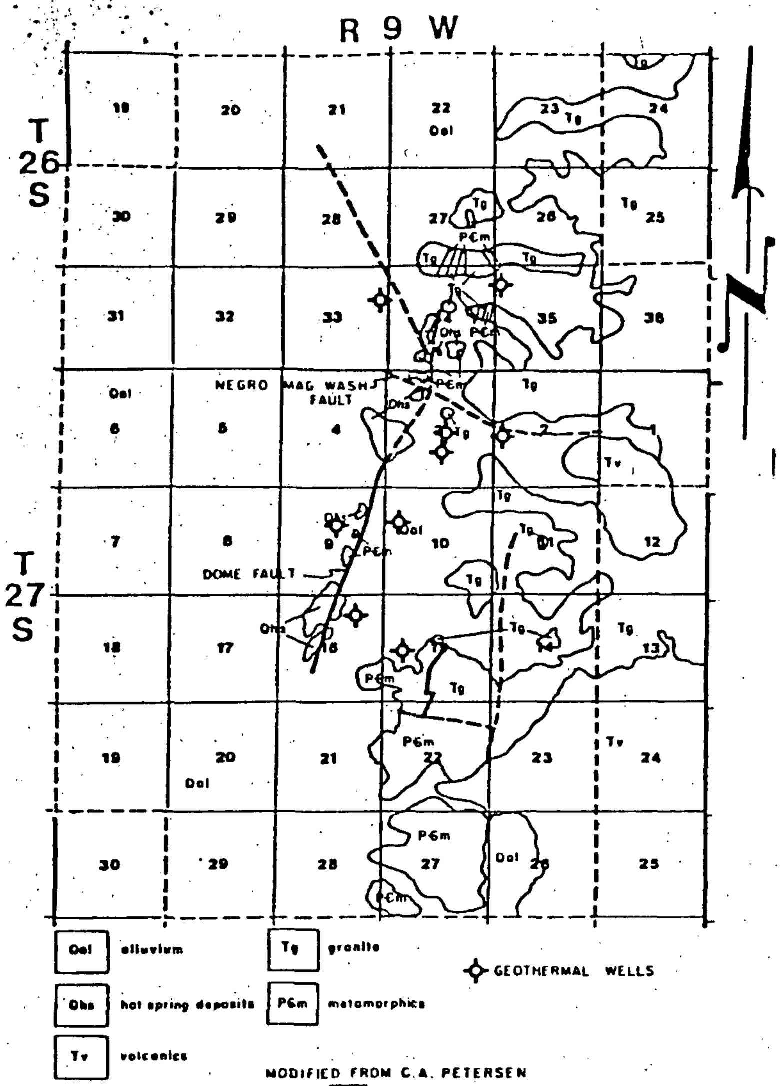

Fig. 4. Geologic Map of the Roosevelt Hot Springs area. Modified after Petersen, 1974.

purpose of forming a geothermal unit is for the same purposes as unitization in oil and gas exploration, and that is the efficient and economic development of the resource. A unit accomplishes this by eliminating lease lines, allowing the field to be developed in the most prudent manner; offset situations are thereby avoided.

The Roosevelt Hot Springs Unit is the first approved Federal geothermal unit in the United States. The unit area is shown in Fig. 7. The formation of any unit can be an extremely involved process, and the Roosevelt Unit, being the first of its kind, took well over a year to write and to receive final approval. The Federal geothermal unit agreement, which states the regulations regarding unit operation, was derived from the basic Federal oil and gas unit agreement. If more than one party holds land in the area to be unitized, as is the case at Roosevelt, a Unit Operating Agreement setting forth the operating conditions must be agreed upon by the different parties.

The fact that the geothermal reservoir at Roosevelt is contained in fractures and the distribution of fractures can be highly erratic led to the adoption of a divided type unit on a tract basis. Under this system, costs and production are apportioned to each party based on the amount of their acreage included within a participating area, and entrance into a participating area is gained by drilling a production well. Each well drilled is credited with a certain amount of acreage which, if the well is a producer, is then included within the participating area. Dry holes do not count and acreage credited to them is not included in a participating area.

WATER APPROPRIATION PROCEEDING

Everyone desiring to develop geothermal resources in Utah is faced with the same problem and that is the appropriation of water necessary to run the power plant. This holds true even if the resource to be developed is on Federal lands, for in the state of Utah, all waters within the state are public property. The basis for granting a water right in Utah is that the water shall be put to beneficial use. Phillips has taken steps to appropriate the necessary water by submitting applications to the State Engineer. The notices of application were published, protests were filed, and a public hearing before the State Engineer was held in Beaver, Utah, in April 1976 to consider the applications. For the State Engineer to approve any application, the following requirements must be met: (1) There is unappropriate water in the proposed source. (2) The proposed use will not impare existing rights, or interfere with more beneficial use of the water. (3) The proposed plan is physically and economically feasible and would not prove detrimental to the public welfare. (4) The applicant has the financial ability to complete the proposed works and the application has been filed in good faith and not for purposes of speculation or monopoly. At the hearing specific testimony was present to meet each of these specific requirements.

As a result of the geothermal discovery and the concern of existing water users in the Valley, Phillips has initiated a monitoring system in Escalante Valley in consul-

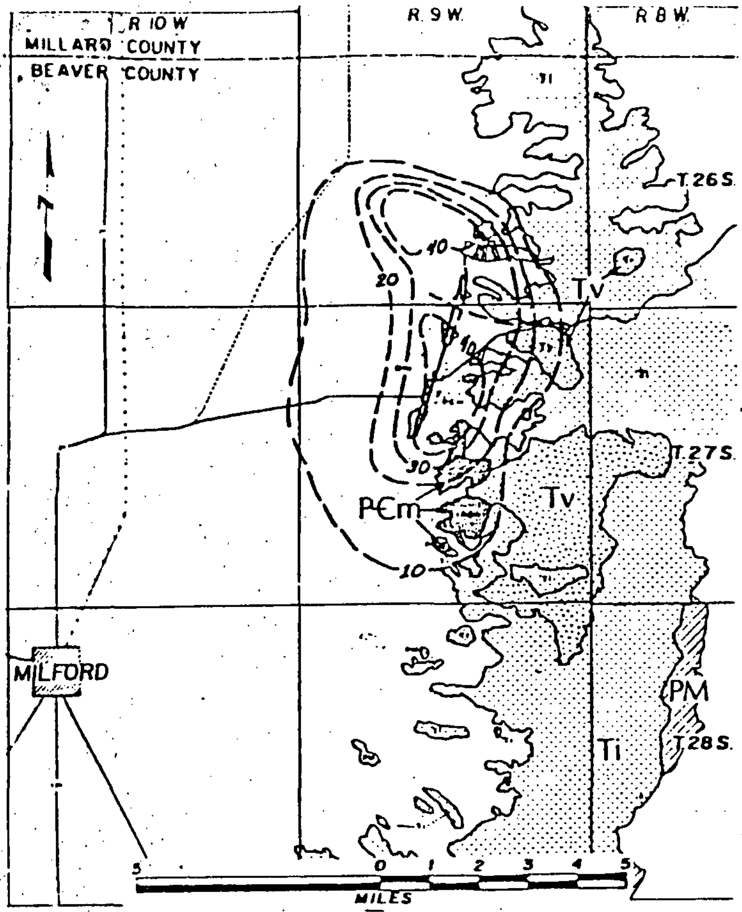

Fig. 5. Temperature gradients in the Roosevelt Hot Springs area. Contour Interval is 10°C/100m (Includes data from Petersen, 1975 and Whelan, 1976, personal communication).

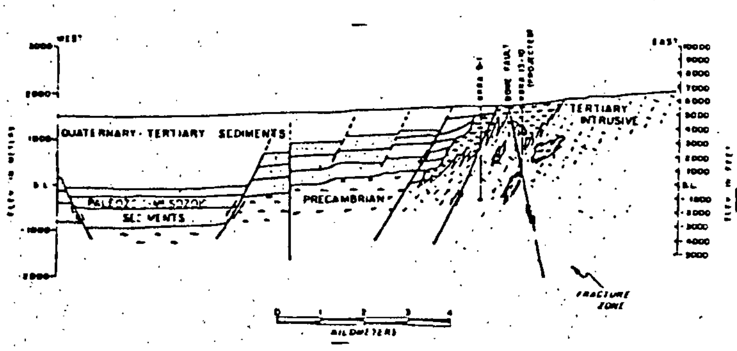

Fig. 6. Generalized Structure section through Well No. 9-1.

tation with the USGS Water Resources Division. At present, the system includes six stock wells, the Roosevelt seep, four water observation wells specifically drilled by Phillips for monitoring purposes, and one stratigraphic test hole modified to act as a water observation well (Fig. 8). The Phillips' wells are located between the geothermal wells and the existing water users points of diversion and penetrate the same reservoir utilized by the ranchers and farmers in the valley. The well sites were located far from existing irrigation wells to minimize or eliminate the effect that present pumping in the irrigation district might have on the water table at the monitoring sites.

The system is an early warning system designed to detect any effect that testing or production would have on existing water users source of supply. Additional monitoring points will be added to the system as necessary.

EXPLORATION ACTIVITY

Most recently, exploration activity at Roosevelt has consisted of drilling several 2000 foot observation holes or deep temperature gradient holes. These have been drilled to test certain ideas concerning the Roosevelt geothermal system. This intermediate depth drilling step has proven extremely valuable in evaluating other prospects.

The chief benefit of drilling a 2000 foot observation hole is the large quantity of information obtained for a relatively low cost. Our average drilling cost is less than $50,000, which is 1/10 that of drilling an exploration well to 6000 feet. Information generated by drilling these holes includes the following: temperature gradients, stratigraphy, hydrology, alteration, drilling problems and structure. These holes are particularly useful in minimizing the risk in picking the proper spot to drill an exploration well. Such a hole might be drilled if it were suspected that the thermal anomaly might be caused by lateral movement of warm waters below depths reached by shallow temperature gradient holes.

ENGINEERING

The engineering program at Roosevelt is a multipurpose program designed (1) to gain experience, (2) to determine the production capabilities of each well drilled, and (3) to characterize the reservoir. Testing has been limited to short term flow tests of about two days duration on the production wells. The longest test was a 3.5 day flow of Well 54-3. With tests of such short duration, we have not reached all our objectives. We have gained invaluable experience and confidence in operating equipment and in interpreting the results and we have been successful in determining each well's capabilities. Two systems have been used for testing. The initial testing at Well 54-3 used

Table 2. Exploratory Geothermal Wells & Stratigraphic

Test Holes, Roosevelt KGRA Utah.

Location	Operator	Well	Status	Depth
SW NW Sec. 10, T.27S., R.9W.	Phillips Petroleum Co.	O.H. 2	Abandoned 1975	2250'
SE NE Sec. 17, T.27S., R.9W.	Phillips Petroleum Co.	O.H. 1	Idle-Strat Test	—
NE NW Sec. 9, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 9-1	Idle Dry Hole	6885'
SW NE Sec. 3, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 3-1	Idle	2724'
SW NE Sec. 3, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 54-3	Idle	2882'
NW NW Sec. 35, T.26S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 12-35	Idle	—
SW NW Sec. 10, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 13-10	Idle	—
NE NE Sec. 33, T.26S., R.9W.	Phillips Petroleum Co.	Roosevelt KGRA 82-33	Idle Disposal	—
SW NW Sec. 2, T.27S., R.9W.	Thermal Power-Natomas	Utah State 14-2	Idle	6108'
NW SW Sec. 15, T.27S., R.9W.	Phillips Petroleum Co.	Roosevelt HSU 25-15	Idle	—
NE NE Sec. 16, T.27S., R.9W.	Thermal Power-Natomas-O'Brien	Utah State 72-16	Testing	1254'
NE NW Sec. 33, T.26S., R.9W.	Phillips Petroleum Co.	O.H. 4	Idle-Strat Test	—
SE NE Sec. 28, T.26S., R.9W.	Phillips Petroleum Co.	O.H. 5	Drilling Strat-Test	—

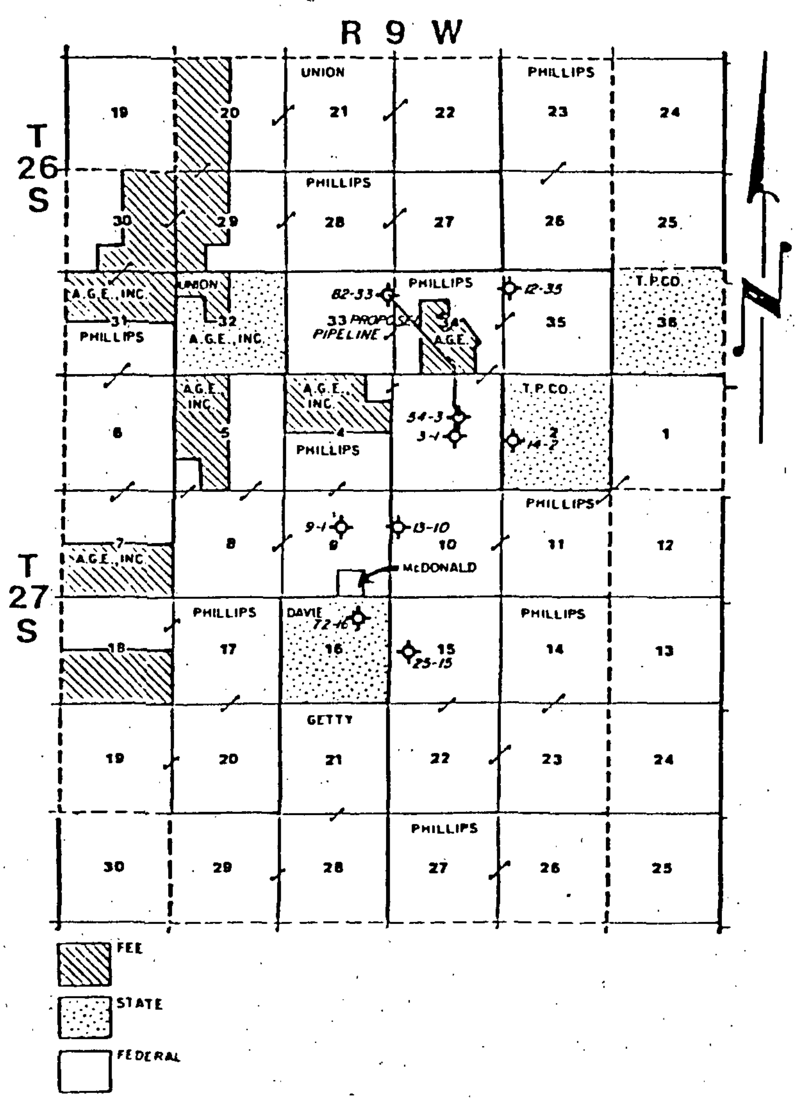

Fig. 7. Roosevelt Hot Springs Unit Area.

for testing. The initial testing at Well 54-3 used a separator to separate liquid and vapor phases so they could each be measured separately. The separator has a capacity of 1 million pounds per hour of total mass flow and it proved to be inadequate to handle the maximum well flow. At the other production wells, flow has been measured using Russell James (1966) method of steam-water measurement employing an orifice plate and a lip critical pressure measuring device.

The limiting factor on the duration of the flow tests is the disposal of the produced liquids. At present the reserve pits adjacent to the wells are used to contain the test fluids. During the 3.5 day flow test of Well 54-3, the liquids produced were discharged into the natural drainage system. It was an experiment designed to measure the effect that reservoir fluids would have on the native vegetation, and was allowed to proceed because the shallow groundwater in the area is similar in quality to the reservoir fluids. The discharge pipe was buried beneath riprap in the center of a large wash. After the test gullying was noted below the outlet pipe for several 100 feet downstream. A second result was the death of trees immediately adjacent to the channel, but not all

TABLE 3.

SELECTED WATER ANALYSES of ROOSEVELT KGRA

	Roosevelt Hot Springs [1]	Roosevelt Hot Springs [1]	Roosevelt Seep	Roosevelt Seep	54-3	3-1
Date	11-4-50	9-11-57	5-9-73	8-15-75	8-26-75	5-25-75
Temperature (°C)	85	55	17	28	> 260	> 205
Silica (ppm)	405	313	76	107	560 •	560 ?
Calcium (ppm)	19	22	113	107	101	8.0
Magnesium (ppm)	3.3	0	17	23.6	0.24	0.01
Sodium (ppm)	2080	2500	2400	1800	2000	2437
Potassium (ppm)	472	488	378	280	410	448
Bicarbonate (ppm)	158	158	536	300	200	180
Sulfate (ppm)	65	73	142	70	54	59
Chloride (ppm)	3810	4240	3800	3200	3400	4090
Fluoride (ppm)	7.1	7.5	5.2	3.3	5.0	5.0
Nitrate (ppm)	19	11	TR	TR	TR	0.1
Boron (ppm)	–	38	37	29	29	25
Lithium (ppm)	–	0.27	–	17	19.0	20.0
TDS (ppm)	7040	7800	7506	5948	6442	7067
pH	–	7.9	8.2	6.43	6.5	6.3
[2] Na-K-Ca geothermometer (°C)	295	285	247	239	294	273
Na-K geothermometer (°C)	307	282	250	248	290	294

[1] [illegible] (1970) [2] β = 1/3

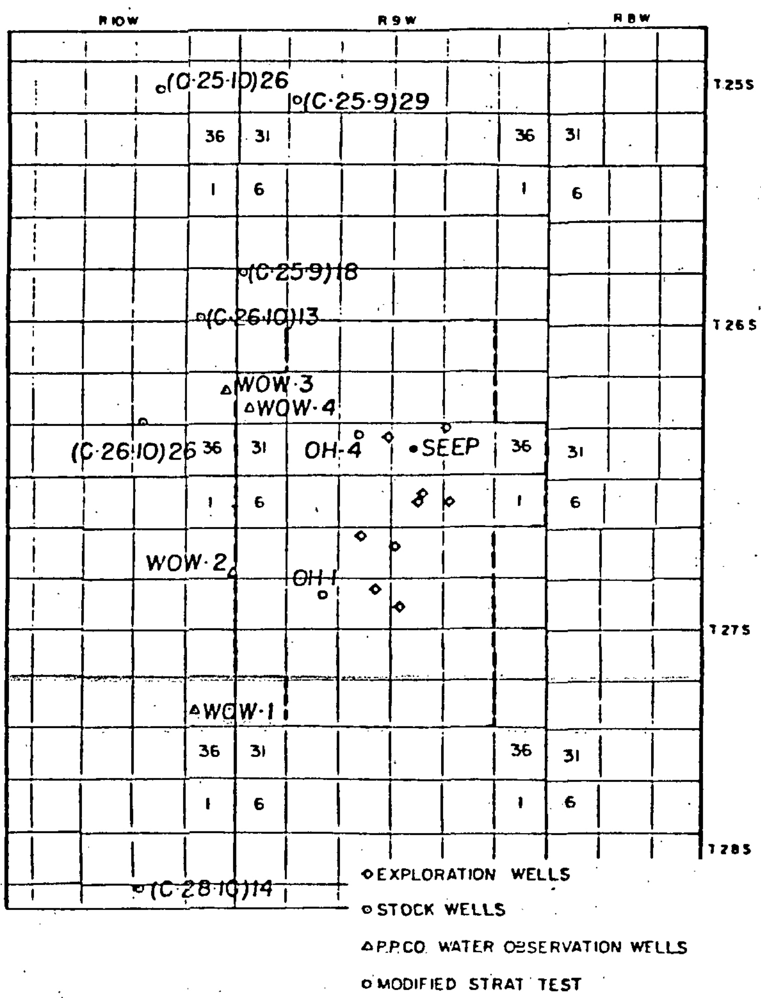

Fig. 8. Water Observation Well System in the area of the Roosevelt Hot Springs Unit.

trees were effected. A recent field check indicates that dead trees are juniper trees, but healthy pine trees are found next to dead junipers. A detailed study of the effect which this test has had on the environment has not yet been made, and until it is, it is unlikely that any further surface disposal will be permitted.

In order to acquire needed reservoir data, there is in preparation a plan for a long term flow test. The proposal calls for flow-testing Well 54-3 for a sustained period of up to six months to determine reservoir size and production characteristics.

The fluids produced at Well 54-3 will be piped through a centrifugal steam/water separator at the well site where the steam portion will be vented in the pit through an existing muffler. It will be necessary to construct approximately 1.4 miles of 10" pipe to connect Well 54-3 to Well 82-33 (Fig. 7). Well 82-33 will function as an injection well during the reservoir tests. The liquid portion from Well 54-3 will be piped to Well 82-33 using the produced pressure for injection into the well.

ACKNOWLEDGMENTS

The writers wish to acknowledge the contributions of Stuart Johnson, Robert Wright and Joe Beall in all phases of the exploration at Roosevelt. Permission to publish the paper has been generously granted by Phillips Petroleum Company.

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AREA
UT
Beaver
Roos
14-2 chem

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Geologic Division
Branch of Experimental Geochemistry and Mineralogy
345 Middlefield Road, Menlo Park, California 94025

March 21, 1977

Jake Rudisill
Thermal Power Co.
601 California Street
San Francisco, CA 94108

Dear Jake,

Here are the chemical analyses of the Utah State 14-2 well fluids. The tritium, deuterium, H_2S, and SO_4 sulfur isotopes and SO_4 oxygen isotopes will be a few months more. The small cyclone separator worked well - only 1-2 ppm Cl in the steam condensate and a liquid-vapor ^{18}O fractionation of 2.5°/₀₀ vs. 2.6°/₀₀ from experiments. Earlier collections with a large separator showed steam in the water and water in the steam. The special port for the calorimeter collected a fluid with $\delta^{18}O = -13.5$ indicating that it contained almost all water ($\delta^{18}O = -13.27, -13.46$) and little steam ($\delta^{18}O = -15.82, -15.87$).

It appears now that Emanuel Mazor and John Bowman will come along for the collection on March 30. We will drive down from SLC on the 29th and connect our separator before you open up on the 30th. If we can sample upstream and downstream of your orifice plate we would like to do so. This would allow us to make an independent estimate of the total fluid enthalpy. For this we would need valves on both sampling points with ½" (or some other agreed upon size) female NPT connections.

Keep me informed of your plans as they develop.

Best wishes,

ALFRED H. TRUESDELL

Enclosure

cc: Stan Ward

$\delta^{18}O = -13.46$

U.S. Geological Survey, Water Resources Division
Quality of Water Branch, Menlo Park, California

ANALYTICAL STATEMENT

Source: Thermal Power Company Well ROT-76-18 Roosevelt, Utah
Lab. No. GT293AT76

Location:
____ ¼ Sec. ________, T. ________, R. ________

Point of coll: Water separate after 2 1/2 hours; 374°F.

WHP 177 psia, Collection Temp. 14°C
Date of coll.: November 1976
Collected by: A. Truesdell

Analyst: Barnes group
Date completed: 3/77
Checked by:
Field Filter: None.
Lab Filter: 0.1 μm.
1:10 silica field dilution
F denotes field determination.

	mg/l	me/l		mg/l	me/l
SiO_2	640		HCO_3		
Al			CO_3		
Fe			OH		
Mn					
As	3.0		SO_4	78	
			Cl	3650	
			F	5.2	
			Br		
			I		
Ca	9.2		NO_2		
Mg	0.6		NO_3		
Sr			PO_4		
Ba			B	29	
Na	2150				
K	390				
Li					
NH_4					
Cation totals:			Anion totals:		

Dissolved solids:
Calculated (mg/l) ________
Residue (180°C) (mg/l) ________
Hardness as $CaCO_3$ (mg/l) ________
N. C. Hardness as $CaCO_3$ (mg/l) ________

Specific conductance (micromhos at 25°C) 9900
F pH 5.9 (paper); Density at 20°C (g/ml) ________
Sulfides as H_2S (mg/l) ________
(Unpublished records, subject to revision. Copied from original record.)

☆ GPO 690-240

$\delta^{18}O = -13.27$

U.S. Geological Survey, Water Resources Division
Quality of Water Branch, Menlo Park, California

ANALYTICAL STATEMENT

Source: Utah State Well #14-2
ROT-76-20

Lab. No. GT295AT76

Location: Roosevelt, Utah

____ ¼ Sec. ________, T. ________, R. ______

Point of coll: Water separate.

Collection
WHP 177 psia, Temp. 9°C
Date of coll.: November, 1976
Collected by: A. Truesdell

Analyst: Barnes group
Date completed: 3/77
Checked by:
Field Filter: None.
Acid: HCl, HNO_3.
1:10 silica field dilution.
F denotes field determination.
Lab Filter: 0.1 µm.

	mg/l	me/l		mg/l	me/l
SiO_2	820		HCO_3		
Al			CO_3		
Fe			OH		
Mn					
As	2.2		SO_4	60	
			Cl	3650	
			F	4.8	
			Br		
			I		
Ca	6.9		NO_2		
Mg	0.08		NO_3		
Sr			PO_4		
Ba			B	28	
Na	2200				
K	410				
Li					
NH_4					
Cation totals:			Anion totals:		

Dissolved solids:
Calculated (mg/l) ______
Residue (180°C) (mg/l) ______
Hardness as $CaCO_3$ (mg/l) ______
N. C. Hardness as $CaCO_3$ (mg/l) ______

Specific conductance (micromhos at 25°C) 10,000
F pH 6.2 (paper); Density at 20°C (g/ml) ______
Sulfides as H_2S (mg/l) ______
(Unpublished records, subject to revision. Copied from original record.)

☆ GPO 690-240

$\delta^{18}O = -15.87$

U.S. Geological Survey, Water Resources Division
Quality of Water Branch, Menlo Park, California

ANALYTICAL STATEMENT

Lab. No. GT296AT76

Source: Utah State Well #14-2
ROT-76-21

Location: Roosevelt, Utah
____ ¼ Sec. ______, T. ______, R. ______

Point of coll: Steam condensate

Collection Temp. 9°C

Date of coll.: November, 1976

Collected by: A. Truesdell

Analyst: Barnes group

Date completed: 3/77

Checked by:

Field Filter: None.

Acid: HCl, HNO_3.

Lab Filter: 0.1 μm.

F denotes field determination.

	mg/l	me/l		mg/l	me/l
SiO_2	<1	---	HCO_3		
Al			CO_3		
Fe			OH		
Mn					
As	<0.01		SO_4	3	
			Cl	2	
			F	<0.1	
			Br		
			I		
Ca	6.6		NO_2		
Mg	<0.05		NO_3		
Sr			PO_4		
Ba			B	0.55	---
Na	<0.5				
K	<0.1				
Li					
NH_4					
Cation totals:			Anion totals:		

Dissolved solids:
Calculated (mg/l) ______
Residue (180°C) (mg/l) ______
Hardness as $CaCO_3$ (mg/l) ______
N. C. Hardness as $CaCO_3$ (mg/l) ______

Specific conductance (micromhos at 25°C) 185
F pH 4.5 (paper); Density at 20°C (g/ml) ______
Sulfides as H_2S (mg/l) ______
(Unpublished records, subject to revision. Copied from original record.)

☆ GPO 690-240

$\delta^{18}O$ = -15.82 ‰

U.S. Geological Survey, Water Resources Division
Quality of Water Branch, Menlo Park, California

ANALYTICAL STATEMENT

Source: Thermal Power Company Well ROT-76-19 Roosevelt, Utah

Lab. No. GT294AT76

Location:

____ ¼ Sec. ______, T. ______, R. ______

Point of coll: Steam condensate.

Collection Temp. 15°C

Date of coll.: November, 1976

Collected by: A. Truesdell

Analyst: Barnes group

Date completed: 3/77

Checked by:

Field Filter None. Acid: HCl, HNO_3.

Lab Filter: 0.1 µm.

F denotes field determination.

	mg/l	me/l		mg/l	me/l
SiO_2	<1	---	HCO_3		
Al			CO_3		
Fe			OH		
Mn					
As	0.02		SO_4	2	
			Cl	1	
			F	<0.1	
			Br		
			I		
Ca	52		NO_2		
Mg	<0.05		NO_3		
Sr			PO_4		
Ba			B	0.6	---
Na	<1				
K	<0.1				
Li					
NH_4					
Cation totals:			Anion totals:		

Dissolved solids:

Calculated (mg/l) ______

Residue (180°C) (mg/l) ______

Hardness as $CaCO_3$ (mg/l) ______

N. C. Hardness as $CaCO_3$ (mg/l) ______

Specific conductance (micromhos at 25°C) 220

F pH 4.9 (paper); Density at 20°C (g/ml) ______

Sulfides as H_2S (mg/l) ______

(Unpublished records, subject to revision. Copied from original record.)

☆ GPO 690-240

DOE/BARRINGER RESOURCES INC COOPERATIVE AGREEMENT DE-FC07-79ID12062

The Application of Soil Geochemistry to Exploration for Concealed Geothermal Fields: Roosevelt Springs, Utah

SUMMARY

Under the terms of the cooperative agreement, a two phase sampling program was undertaken over the Roosevelt Springs geothermal area. The purpose of the first phase was to test the practical application of surface-microlayer geochemistry as a low-cost exploration method for detecting blind geothermal reservoirs by carrying out both conventional soil and surface-microlayer sampling at sites along traverses across the geothermal area. Multi-element analysis of the two sets of samples confirmed that surface-microlayer material was an effective medium for detection of mobile elements associated with the hydrothermal activity. Mercury, antimony, cesium and arsenic proved to be particularly advantageous for use in the surface microlayer when compared to conventional soil samples.

The earth's surface is covered by a microlayer of particulate materials that is composed of a mixture of organic and inorganic constituents. This surface microlayer reflects the geochemistry of the underlying soils, and when collected in the appropriate size fraction, can provide high quality and definitive geochemical information. The surface microlayer on exposed soils has a fairly obvious connection with the geochemistry of the parent soil material; however, it has also been discovered that particulate material occurring on the surface of vegetation and having an entirely biological origin also exhibits a chemical composition that is closely related to the geochemistry of the underlying soils. Furthermore, the surface particulate material is in contact with the atmosphere and is therefore exposed to oxidation, radiation, weathering, evaporation, photochemical reactions, and microbiological phenomena that are unique to the atmospheric interface. This surface activity provides a means of immobilizing mobile components that rise as gases and solutions from underlying mineralization and hydrocarbon accumulations. In particular, the process of evaporation

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The earth's surface is covered by a microlayer of particulate materials that is composed of a mixture of organic and inorganic constituents. This surface microlayer reflects the geochemistry of the underlying soils, and when collected in the appropriate size fraction, can provide high quality and definitive geochemical information. The surface microlayer on exposed soils has a fairly obvious connection with the geochemistry of the parent soil material; however, it has also been discovered that particulate material occurring on the surface of vegetation and having an entirely biological origin also exhibits a chemical composition that is closely related to the geochemistry of the underlying soils. Furthermore, the surface particulate material is in contact with the atmosphere and is therefore exposed to oxidation, radiation, weathering, evaporation, photochemical reactions, and microbiological phenomena that are unique to the atmospheric interface. This surface activity provides a means of immobilizing mobile components that rise as gases and solutions from underlying mineralization and hydrocarbon accumulations. In particular, the process of evaporation results in the formation of a residue or coating of mineral and organic salts on particles exposed at the surface that can enhance the geochemical patterns related to microseepages from mineral deposits, geothermal areas and hydrocarbon reservoirs.

SURTRACE[R] equipment for sampling the surface microlayer is manufactured by Barringer Resources in both airborne and ground versions. The airborne equipment utilizes a helicopter with a specially designed sampling probe for continuous sampling of the surface particulates at flight speeds varying between 25 and 50 miles per hour. For ground surveys, a portable backpack version of the SURTRACE[R] system, consisting of a lightweight vacuum device driven by a chain-saw motor, provides a convenient means of collecting the surface microlayer. By use of this technique, surface particulate samples are collected into plastic vials over pre-determined intervals. Sufficient material is collected to allow for a variety of analytical methods to be used. Where adequate roads are available, the backpack unit can be mounted on a four-wheel drive vehicle for spot sampling at regular intervals.

Following on the encouraging results from the orientation survey, a more extensive second phase of surface microlayer sampling was undertaken over an area of 100 square miles surrounding Roosevelt Springs. All samples were analyzed for 34 elements using a variety of methods including induction-coupled plasma emission, ion chromatography and atomic absorption. Contour mapping of the survey data has confirmed the importance of cesium and antimony in defining the leakage zones associated with faulting in the geothermal area. Factor analysis of the data set has considerably enhanced the geochemical interpretation of the surface microlayer.

For further information contact: Dr. W.T. Meyer
Vice President
Geochemistry
Barringer Resources Inc.
1626 Cole Blvd, Suite 120
Golden, Colorado 80401

9-1 SWNWNE SEC 9 27 W DRY

PHILLIPS PETROLEUM COMPANY
DEL MAR, CALIFORNIA 92014
BOX 752 714 755-0131

NATURAL RESOURCES GROUP
Energy Minerals Division
Geothermal Operations

AREA
UT
Beaver
Roos
PO-PPC

January 2, 1976

Le-1-76GO

Mr. Reid T. Stone
U. S. G. S.
Conservation Division
Area Geothermal Supervisor
345 Middlefield Road
Mail Stop 36
Menlo Park, CA 94025

Dear Mr. Stone:

A recheck of our Proposed Plan of Operation for Roosevelt KGRA exploration drill holes, dated December 29, 1975, has disclosed a number of drafting errors. Two wells, 13-14 and 48-27, are incorrectly located on Exhibit A. The correct locations are shown on the attached sheets. On Exhibit B-4, the Proposed Drill Site Layout Roosevelt KGRA 87-28, the letter y should be omitted from the second word in the description of the northwest trending access road.

Please call us if additional corrections are necessary.

Sincerely,

Richard C. Lenzer

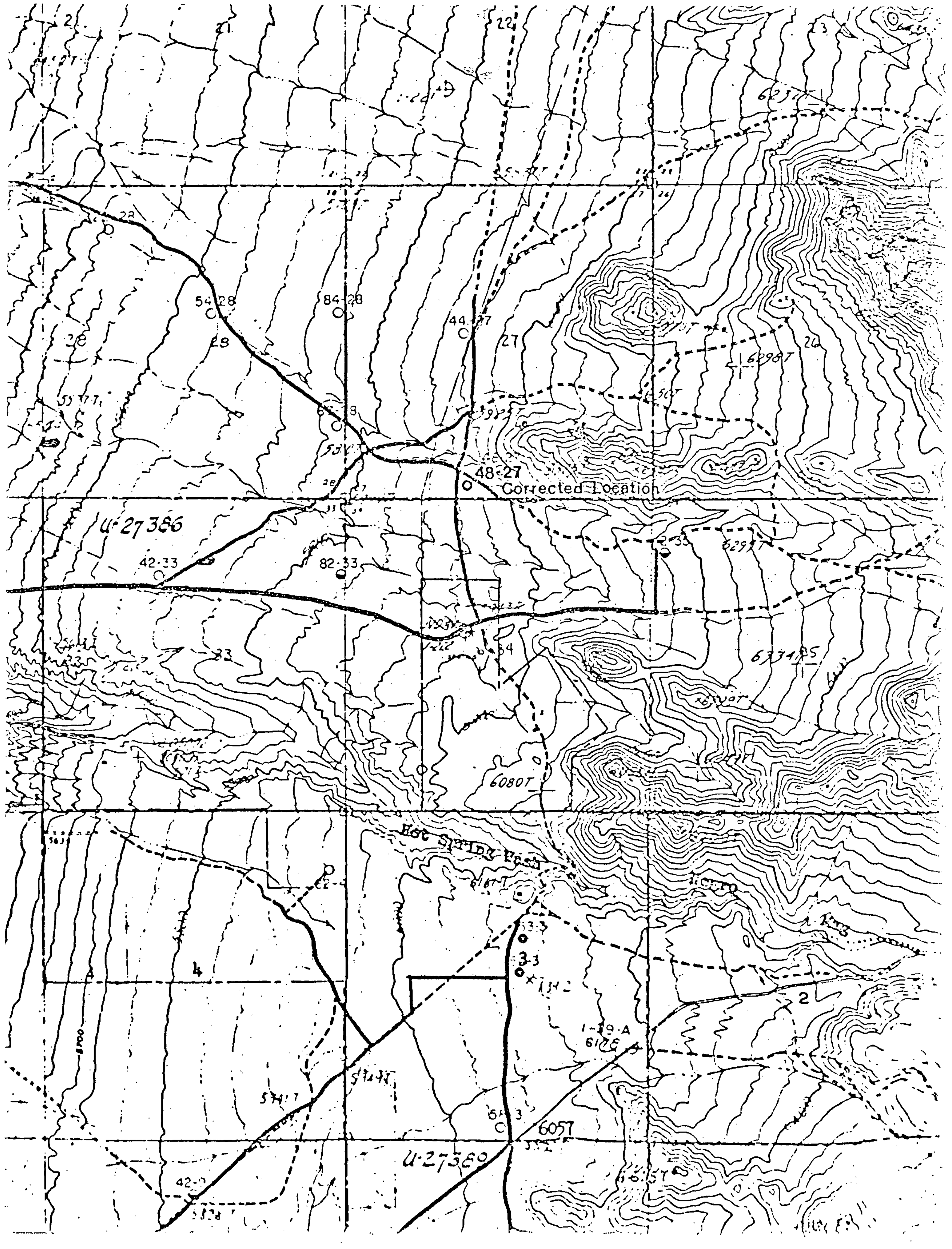
Richard C. Lenzer
Geologist

RCL:jm

Enclosures

RECEIVED
JAN - 5 1976
AREA GEOTHERMAL SUPERVISOR'S OFFICE
CONSERVATION DIVISION
U.S. GEOLOGICAL SURVEY
MENLO PARK, CALIFORNIA

6057
U-27389
6075
10
6070
U-27382
13-14
Corrected Location
Big Cedar Cove
Little Cedar Cove
6115
15
14
13
11
12
2
1
22
23
U-27393
Canyon


54-28
84-28
44-27
48-27
Corrected Location
U-27386
42-33
82-33
6080T
6297T
6298T
6734.85
Hot Spring Wash
1-39-A
U-27389
6057
4
2

PHILLIPS PETROLEUM COMPANY
DEL MAR, CALIFORNIA 92014
BOX 752 714 755-0131

NATURAL RESOURCES GROUP
Energy Minerals Division
Geothermal Operations

December 30, 1975
Be-232-75GO

Mr. Reid T. Stone
U. S. G. S.
Conservation Division
Area Geothermal Supervisor
345 Middlefield Road
Mail Stop 36
Menlo Park, CA 94025

Dear Mr. Stone:

Transmitted herewith is our proposed Plan of Operation covering the drilling of the next sixteen exploratory wells on the Roosevelt KGRA, Utah. Also enclosed are Applications for Permit to Drill the first three of the sixteen wells, namely, Nos. 46-10, 25-15, and 58-3. The purpose of these wells is to define the extent of the reservoir and determine if it is capable of commercial production. All of these sixteen locations will probably not be utilized. They are submitted to allow diligent exploration and anticipate possible future sites instead of submitting further operating plans during the exploration phase.

The Plan and APD's describe state-of-art technology; moreover, our personnel have acquired considerable expertise now in drilling exploration for the geothermal resource. We are confident that we can explore the Roosevelt field in a manner consistent with maximum resource conservation, diligent exploration, and multiple land-use policy.

Please call on us if additional documentation will serve to expedite the proposals.

Sincerely yours,

C. W. Berge, Manager
Geothermal Operations

JJ
Enclosures

PROPOSED PLAN OF OPERATIONS, Phillips Petroleum Co's

~~UNITED STATES~~ GEOTHERMAL LEASES at Roosevelt KGRA, Beaver Co., Utah

U-27384, 27385, 27386, 27387,

27388, 27389, 27390, 27392, 27393

Berge, C.W.

33p.

December 29, 1975

PROPOSED PLAN OF OPERATIONS, ROOSEVELT KGRA, UTAH

In accordance with 30 CFR 270.34, the Phillips Petroleum Company submits the following proposed plan of operation as required.

Attached map "Exhibit A", shows topography of the leased land and surrounding lands, drainage patterns, present road and tract locations, proposed road and tract locations, and proposed well locations.

This map was prepared from the following materials:

1. The topography and drainage patterns are located on four 7-½ minute USGS topographic quadrangle maps (Minersville 2 NE, Black Rock 3 SE, Black Rock 3 SW, Ranch Canyon) at a scale of 1:24,000.
2. Lease tracts were plotted from BLM MT Plats.
3. Present roads and trails not originally included on the topographic maps were identified from aerial photographs flown for the University of Utah on October 10, 1974 by Olympus Aerial Surveys Inc., Salt Lake City, Utah 84115.

The following exploration plan is proposed by the Phillips Petroleum Company on leased Public Domain land within the Roosevelt KGRA.

I. Phillips proposes to perform the following exploration operations:

1. Exploratory Drilling Phillips proposes to drill up to sixteen exploratory wells at locations shown on Exhibit "A" to test for geothermal resources production on

leased land. As of December 1, 1975, five wells (9-1, 3-1, 54-3, 12-35, 13-10) have been drilled on the leased lands at locations shown on Exhibit "A". Well 9-1 was dry; wells 54-3, 3-1 and 13-10 appear capable of commercial production; and well 12-35, while not a dry hole, may not be capable of commercial production. We are presently drilling well 82-33.

The sixteen well proposal is designed to test reservoir size by means of limited step outs in sequence from completed wells capable of commercial production. With such a plan, the drilling of one or more dry holes in the sequence would result in a temporary suspension of drilling operations and a reevaluation of the drilling program. Should prospects of success diminish below a level acceptable to the Phillips Petroleum Company, the remaining wells would not be drilled. It is mutually understood that our request for permission to drill these sixteen exploratory wells does not constitute a firm obligation on the part of the Phillips Petroleum Company to actually drill same.

Drilling will be conducted in early 1976, conditional on obtaining the following: (1) Approval by the Area Geothermal Supervisor of the plan of operation and the applications for permit to drill, (2) approval by the State of Utah Water Engineer, (3) construction or improvement as necessary of access roads, lateral roads, and drill site locations, and (4) drilling equipment and auxiliary equipment and services.

II. Drilling Proposal:

1. Phillips proposes to drill up to sixteen ±6000 foot exploration wells at the locations shown on Exhibit "A". Placement of the equipment at each location is

shown on plats attached as Exhibits "B-1" through "B-16".

2. Well locations given in feet and direction from the nearest section or tract lines are listed below by lease number.

Lease No. U-27384

Well Number	Exhibit Number	
Well 44-27	B-11	Section 27, T26S, R9W, SLM. 2519.34' S along section line and 2012.61' E at right angles to said line from NW corner of section 27.
Well 48-27	B-6	Section 27, T26S, R9W, SLM. 2137.36' E along section line and 205.59' N at right angles to said line from the SW corner of section 27.
Well 22-28	B-14	Section 28, T26S, R9W, SLM. 1147.92' E along section line and 741.18' S at right angles to said line from the NW corner of section 28.
Well 54-28	B-5	Section 28, T26S, R9W, SLM. 2269.85' W along section line and 2155.93' S at right angles to said line from the NE corner of section 28.
Well 84-28	B-10	Section 28, T26S, R9W, SLM. 2163.56' S along section line and 148.96' W at right angles to said line from the NE corner of section 28.

Lease No. U-27384

Well 87-28	B-4	Section 28, T26S, R9W, SLM. 1252.47' N along section line and 150.19' W at right angles to said line from the SE corner of section 28.

Lease No. U-27386

Well 42-33	B-12	Section 33, T26S, R9W, SLM. 2076.25' E along section line and 1309.04' S at right angles to said line from the NW corner of section 33.

Lease No. U-27386

Well Number	Exhibit Number	
Well 58-3	B-1	Section 3, T27S, R9W, SLM. 2646.44' W along section line and 197.91' N at right angles to said line from the SE corner of section 3.
Well 82-4	B-13	Section 4, T27S, R9W, SLM. 1146.60' S along section line and 266.09' W at right angles to said line from the NE corner of section 4.

Lease No. U-27388

Well 57-8	B-15	Section 8, T27S, R9W, SLM. 2910.33' E along section line and 915.44' N at right angles to said line from the SW corner of section 8.

Lease No. U-27389

Well 46-10	B-2	Section 10, T27S, R9W, SLM. 1710.05' N along section line and 2553.40' E at right angles to said line from the SW corner of section 10.
Well 83-10	B-7	Section 10, T27S, R9W, SLM. 1854.95' S along section line and 369.90' W at right angles to said line from the NE corner of section 10.

Lease No. U-27390

Well 55-20	B-16	Section 20, T27S, R9W, SLM. 2822.23' S along section line and 2303.47' W at right angles to said line from the NE corner of section 20.

Lease No. U-27392

Well 13-14	B-8	Section 14, T27S, R9W, SLM. 1944.02' S along section line and 60.31' E at right angles to said line from the NW corner of section 14.

Lease No. U-27392

Well Number	Exhibit Number	
Well 25-15	B-3	Section 15, T27S, R9W, SLM. 2719.06' S along section line and 1094.26' E at right angles to said line from the NW corner of section 15.
Well 31-15	B-9	Section 15, T27S, R9W, SLM. 1525.68' E along section line and 470.17' S at right angles to said line from NW corner of section 15.

3. Well sequence. Anticipated well sequence if all wells are successfully completed as producers is as follows:

1.) 58-3 Lease U-27386
2.) 46-10 Lease U-27389
3.) 25-15 Lease U-27392
4.) 87-28 Lease U-27384
5.) 54-28 Lease U-27384
6.) 48-27 Lease U-27384
7.) 83-10 Lease U-27389
8.) 13-14 Lease U-27392
9.) 31-15 Lease U-27392
10.) 84-28 Lease U-27384
11.) 44-27 Lease U-27384
12.) 42-33 Lease U-27386
13.) 82-4 Lease U-27386
14.) 22-28 Lease U-27384
15.) 57-8 Lease U-27388
16.) 55-20 Lease U-27390

III. Existing and planned access and lateral roads.

The road net with proposed well locations is shown on Exhibit "A". Existing roads will be used with one exception for access to all the wells. The single exception requires the construction of 900 feet of new road. All access roads have been classified into three types:

Type 1 - Existing, improved access roads. These are either county roads or roads improved by Phillips as part of operations in the Exploration Plan recently completed. To aid identification, this road type is colored yellow on Exhibit "A" and labeled with the number 1.

Type 2 - Existing, unimproved access roads. These are tracks or trails and require some degree of improvement for utilization as access roads. This type is shown in green on Exhibit "A" and each segment is given the number 2 followed by a hyphen and an alphabet letter for identification.

Type 3 - New access road. Construction of a short segment of road is necessary to provide access to a well site in an area devoid of preexisting roads. This road type is colored blue and is designated with the number 3 on Exhibit "A".

All necessary road improvements and new construction will comply with specifications set by the BLM as specified in section 9113 BLM manual.

As specified in each geothermal lease, an approved competent archaeologist has examined the lands to be disturbed. His report, providing an inventory and evaluation of archaeological and historical values is included as Exhibit "C". Phillips Petroleum Company is prepared to follow the recommendations of the consulting archaeologist.

General access to the drilling sites from the pipe and equipment storage yard at Milford will be by Utah State Highway 257 and by the system of county and BLM roads improved as part of the previous plan.

The access roads to each well site are described in the following paragraphs.

Well 57-8 (T27S, R9W, Sec.8) Lease U-27388

The well site is adjacent to the county road. No improvements are required.

Well 55-20 (T27S, R9W, Sec.20) Lease U-27390

Access to the well site is by county road, improved dirt road, and unimproved road labeled 2-A on Exhibit "A". Length of road 2-A needing improvement is 10,200'.

Well 13-14 (T27S, R9W, Sec.15) Lease U-27392

Access is by county road and unimproved road 2-B. Length of 2-B needing improvement is 9300'.

Well 31-15 (T27S, R9W, Sec.15) Lease U-27392

Access is by county road and unimproved road 2-B. Distance on road 2-B from 31-15 to county road is 4000'.

Well 25-15 (T27S, R9W, Sec.15) Lease U-27392

The well site is reached by county road, and unimproved roads 2-B and 2-C. Length of 2-C requiring improvement is 2500'.

Well 46-10 (T27S, R9W, Sec.10) Lease U-27389

Access is by county road and unimproved road 2-C or alternately by county road, and unimproved roads 2-B and 2-C. Total length of 2-C requiring improvement is 7000'.

Well 58-3 (T27S, R9W, Sec.3) Lease U-27386

The well site is adjacent to county road and improved dirt road; therefore no road improvements are necessary.

Well 83-10 (T27S, R9W, Sec.10) Lease U-27389

Access is by county road, and unimproved roads 2-C and 2-D. 2500' of road 2-D requires improvement.

Well 82-4 (T27S, R9W, Sec.4) Lease U-27386

Two access routes are planned. One route connects the improved access roads going to well 9-1 with the unimproved roads 2-E, 2-F and the short segment of new road construction 3. The second route uses new road 3, unimproved roads 2-F and 2-E and connects with the access roads to well Roosevelt KGRA 3-1. 10,000 feet of road improvements are required: 3,000 feet on road 2-F; 7,000 feet on road 2-E. New construction totals 900 feet.

Well 42-33 (T26S, R9W, Sec.33) Lease U-27386

Access to the well site is by county road and improved dirt road. No additional improvements are required.

Well 54-28 (T26S, R9W, Sec.28) Lease U-27384

and

Well 22-28 (T26S, R9W, Sec.28) Lease U-27384

Both wells are located adjacent to unimproved dirt road 2-I which connects with the county road system. 18,000 feet of road 2-I requires improvement.

Well 87-28 (T26S, R9W, Sec.28) Lease U-27384

and

Well 84-28 (T26S, R9W, Sec.28) Lease U-27384

Both wells are located adjacent to unimproved dirt road 2-J. Access to wells is by county road, improved dirt road, and unimproved roads 2-H and 2-J. Lengths of 2-H and 2-J to be improved are 6000 feet and 3000 feet respectively.

Well 48-27 (T26S, R9W, Sec.27) Lease U-27384

and

Well 44-27 (T26S, R9W, Sec.27) Lease U-27384

Access is by county road, improved dirt road, and unimproved roads 2-H and 2-G. The well sites are adjacent to road 2-G. Improvement of road 2-G for a distance of 5000 feet is required.

IV. Location and Source of Water Supply and Road Building Material

Water for construction and all associated operations, will be purchased from the city of Milford, Utah and trucked to the drilling sites.

Road building material will be purchased from county of Beaver sources.

V. Location of Camp Sites, Air Strips and Other Supporting Facilities

No camp sites or air strips are proposed. Arrangements for an equipment storage yard at Milford have been completed.

VI. Other Areas of Potential Surface Disturbance

Other than road improvements and drill pad preparations, no other areas of potential surface disturbance are planned or can be foreseen at present. The pediment, where all proposed operations are planned, slopes gently to the west. Slope angles range from 2° to 10° over much of the area. Steeper slopes are encountered along the sides of washes, draining the pediment; however, these are rarely more than a few feet or tens of feet in relief. Mass-movements, such as landslides, will not present a significant hazard to operations on the pediment.

VII. The Topographic Features of the Land and the Drainage Patterns

Topographic features and drainage patterns are depicted on Exhibit "A" a composite map made from four USGS $7\frac{1}{2}$ minute topographic maps (Minersville 2 NE, Black Rock 3 SE, Black Rock 3 SW, Ranch Canyon).

VIII. Methods for Disposing of Waste Material

At each well site, fluids will be contained in a reserve pit located adjacent to the pad. The reserve pit will be a gel-sealed earth reservoir, the surfaces of which being dressed with $\frac{1}{4}$ pound per square foot of drilling type natural bentonitic clay gel.

Fluids not salvaged for use on subsequent wells will be confined in the reserve pit. The suspended solids will be allowed to settle. The fluid will then be picked up by vaccuum truck and used to maintain the county roads. If salt has been added to the drilling fluids, or if geothermal reservoir water is diverted into the reserve pit, the contained fluids will be evaporated to dryness.

The dry reserve pit will be reclaimed and drill cuttings, mud and any salt residue will be buried. Garbage and foreign debris will be disposed of at an authorized dump site.

XI. Protection of the Environment

This section describes the measures proposed to effectively minimized environmental damage and conduct operations in a manner consistent with rules and regulations and specific actions required by the Authorized Officer regarding prevention and control of:

1. Fire

1. Fire fighting equipment will be located at the sites of proposed operations.

2. Vegetation on the drill site location will be cut back.

3. Every reasonable effort will be made to prevent, control or suppress any fires started on or near lands occupied by Phillips by taking initial attack action including making available such construction equipment and maintenance forces that are available.

4. The authorized officer shall be informed as soon as possible of all fires in the lease area.

2. Soil Erosion

1. Due care shall be exercised to avoid scarring or removal of ground vegetative cover.

2. Vehicular travel shall be confined to roads and trails. Any up-grading of roads shall be made in accordance with BLM road standards which may include ditching, draining, culverts and graveling or capping of the road bed.

3. Activities employing wheeled or tracked vehicles will be conducted to minimize surface damage.

4. Disturbed areas shall be restored by shaping the surface to as near as possible to the original form and reseeding with a mixture of 4 lbs. crested wheatgrass, 2 lbs. yellow sweet clover, nomad or alfalfa, and 2 lbs. bitter brush seed per acre. Application will be by drill and will be made during the period from October 1 to November 30.

5. Reserve pits will have a surrounding berm to prevent overflow.

3. Pollution of Surface and Groundwaters

1. No surface water protection is required due to a lack of permanent streams or springs in the area of proposed operations.

2. The well will be cased to prevent contamination of the principal groundwater aquifers.

3. The reserve pits will be lined with a mud gel to prevent leakage of well fluids into underground waters.

4. During testing, all produced fluids will be confined in gel sealed test pits.

4. Damage to Fish and Wildlife

1. Unattended reserve pits containing fluids will be fenced to keep out livestock and wildlife.

2. Surface disturbance will be kept to a minimum to limit destruction of wildlife habitat.

3. Well discharge lines will be directed away from nearby vegetation to prevent injury or contamination.

5. Noise and Air Pollution

1. Phillips shall control noise levels and air emissions from operations in accordance with federal and state noise emission and air quality standards and any applicable local air quality or noise emission standards.

2. During reservoir tests, muffling devices shall be used to keep noise emissions at or below the level required by the authorized officer.

6. Hazards to Public Health and Safety

Phillips will regulate access, with approval of the Supervisor, in those areas where unrestricted access would unduly interfere with operations under the lease or would constitute a hazard to health and safety.

ATTACHMENT

Exhibit "C"

An Archeological Sampling Survey in the Escalante Valley of Western Beaver County, Utah

Submitted to the

Bureau of Land Management

and to the

Antiquities Section of the

Utah State Division of History

by

Richard A. Thompson

in behalf of the

Phillips Petroleum Company

San Diego, California

December 11, 1975

An Archeological Sampling Survey in the Escalante Valley of Western Beaver County, Utah

This report summarizes an archeological survey conducted on the eastern side of the Escalante Valley approximately ten miles northeast of the town of Milford in the western half of Beaver County, Utah. The federally owned lands subject to this study are administered by the Cedar City District of the Bureau of Land Management. The land is currently under lease to the Phillips Petroleum Company for the purpose of exploring the geothermal potential of the area. It was in behalf of the Phillips Company that this survey was conducted. The work was authorized by Department of the Interior Antiquities Permit No. 75-EM-028 and by Utah State Antiquities Permit No. 154.

Representing an extension of archeological survey work previously carried out by personnel of the Bureau of Land Management and by members of the Department of Anthropology at Brigham Young University, the assignment in this instance called for an archeological survey of 16 drill pad sites of 10 acres each and an examination of the margins of approximately 11 miles of existing roads which are to be redeveloped as access roads to the proposed drilling sites.

The effect of the project requirements was to create an occasion for a random sampling survey. Within this framework, the drill pads may be regarded as small quadrats while the survey of the roads creates, in effect, long and very narrow transects. The survey was random in the sense that the areas studied were selected by exploration geologists on the basis of criteria that appear to be unrelated to variables affecting prehistoric settlement or use. A degree of sample stratification within the limits of the east bench area is achieved in the fact that the project design placed 5 of the 16 pads in zones of mixed juniper-pinon and sage brush while the remainder are in open areas dominated by sage brush. Approximately 5 of the 11 miles of road are in the juniper-pinon zone.

In the entire project area the gradient ranges from 3° to 10° in a decline to the west. This variable does not appear to correlate with any element of prehistoric use. The elevation of the drilling sites extends from a low of just over 5500 feet at Pad 14 to a high of slightly more than 6200 feet at Pad 7 in Little Cedar Cove. All road right-of-ways fall within this elevational range.

The project area divided into northern and southern sectors, both in terms of the local terrain and in terms of the arbitrary survey. The entire northern section of the survey area is contained within T26S, R9W while the southern unit is confined to T27S, R9W. The two areas are also separated by Hot Spring Wash,* a deeply entrenched intermittant watercourse which effects a rather steep westerly descent from the Mineral Mountains to the floor of the Escalante Valley where it joins the channel of the northerly flowing Beaver River.

Substantial evidence exists that, by Great Basin standards, prehistoric inhabitants or users of the area could rely upon abundant water resources. Prior to its modern diversion, the Beaver River maintained a year around flow except in the driest part of some weather cycles. Further, the Beaver Bottoms, some 12 miles northwest of the project area, was still marshland at a time within the memory of the older residents of the area. Indications are that it was a lake of fluctuating levels up to the time of European settlement.

The mineral content of the water coming from a number of hot springs in the vicinity appears to have rendered it unfit for culinary or agricultural use. At the same time, however, both the western slope of the Mineral Mountains and the floor of the Escalante Valley were once dotted with a considerable number of usable springs of substantial flow. As late as the early 1950s, for example, a group of springs 3 miles south of Milford sustained a hydrophylic environment of perhaps 10 to 15 acres.

Local farmers tend to discount postulated climatic cycles when these are offered as an explanation for the still-declining number of springs. The loss of springs is generally attributed, and apparently with some good reason, to the long-term use of pump wells for irrigation which has resulted in a substantial lowering of water tables.

In terms of prehistoric use, at least, the most unique and significant natural feature of the area is the extensive range of obsidian deposits found in the western canyons of the Mineral Mountains. These deposits appear to have been a major source of prized lithic raw materials which would have attracted man to the area even without the well-watered environs.

* Negro Mag Wash

While the deposits have a considerable north-south distribution, the most important and most striking part of the feature is found in Wild Horse Canyon where extensive ledges of the shinning, black glass are to be seen above talus slopes of flakes and cores that appear to be the result of many centuries of human exploitation. Future research will doubtless demonstrate that utilization of this material was spatially as well as temporally extensive. So important has the Wild Horse Canyon quarry site, 42-Be-52, come to be regarded, steps have been initiated to place it on the National Register of Historic Places.

Although the obsidian "mother lode," is east of the project area, it affects sites within both the northern and southern segments in ways that directly affected prehistoric use. Over much of the east bench of the Escalante Valley, particularly in the regions below the mouths of Wild Horse and Ranch Canyons, the alluvial effluence contains, in addition to soil and granitic gravels, streamworn obsidian nodules in great abundance. When weathered by natural forces, the nodules assume a matte black appearance analagous to that observed on nodules of some of the denser basalts noted in areas farther south.

Deposits of these obsidian nodules cover extensive areas that often attain an extent of several hundred acres. The presence of flakes, cores, and occasional artifact fragments in these areas of nodular concentration argues that at least some of the prehistoric peoples made perhaps as much use of the east bench secondary deposits as they did of the more dramatically abundant obsidian sources up the canyons. This fact is of critical importance to the pattern of site location within the survey area.

METHODOLOGY

The requirements of the survey involved an intensive examination of each of the 16 proposed drilling sites located as shown on the accompanying map. The area of each pad was to encompass 10 acres of land to take the form of a square 220 yards (201.168 m.) on each side. The position of each 10 acre quadrat was determined from the location of the drill point marker previously placed at each site. In so far as possible, the quadrat was laid out so that the drill point was exactly centered. In cases where drill markers were less than 110 yards from a road, the marker was centered on the axis parallel to the road and then the axis perpendicular to the road was marked off using the road as the base line. This adjustment was made because the company representative indicated that none of the pads would be laid across existing roads. Pads already graded in the earlier phase of this project have adhered to this principle.

The road right-of-ways surveyed are also marked on the accompanying map. In all cases, the proposed road development is to follow the route of existing roads. Although not regularly maintained, all of the roads examined have, at some time in the past, been graded. The Phillips Petroleum Company does not anticipate widening these roads but will, rather, concentrate on improving existing surfaces. Road improvements completed at the time this survey was conducted were found to have conformed to this standard in every instance observed.

Drill site areas were examined by a four member team crossing each unit at 15 yard intervals. Artifacts recovered as random finds under conditions that did not suggest the existence of a site were collected at each pad and are recorded as coming from that area. Sites found on pads have been recorded with reference to one of the corner points of each quadrat and they are also located to the nearest 1/16 of a section.

Survey of the roads was accomplished by a single worker walking each route, all of which have been flagged, at a distance of from 2 to 3 meters of each side of the road. This provided intensive coverage of a strip 5 meters wide on each side of all roads surveyed. Sites discovered during the road surveys are located to the nearest 1/16 of a section and are also plotted in terms of measured yards from readily identifiable points. These points are usually intersections with other roads.

The survey produced a total of 12 sites of identifiable prehistoric activity. Of these, 5 were found in the southern sector of the project area while the remaining 7 were located in the northern unit. Basically, all sites proved to be lithic scatters indicative of quarrying and/or flaking activities. In two instances a concentration of obsidian flakes in combination with a few Southern Paiute sherds suggested the possibility of a camp site. As will be noted below, further investigation ruled out the camp possibility and prompted the conclusion that each site represented a secondary deposit of material from higher ground to the east.

A records search for sites previously recorded in the sections of land involved in this study was requisitioned from the office of the State Archeologist. The search produced the records of 27 sites within the area. Of these, 11 were plotted by the Bureau of Land Management personnel and 16 were recorded by a Brigham Young University survey team. These sites are marked on the accompanying map and all are listed in an appendix to this paper. Of this number, only sites 42-Be-116, 118, and 121 proved to be directly involved in the project area. These sites will also be evaluated along with those recorded during the course of the current project.

One methodological innovation for the SUSC archeological survey group should be noted. Following discussion with officers of the Bureau of Land Management, it was decided that a procedure of minimal site testing should be incorporated into the original survey. This was accomplished through the excavation of "probing," holes 30 cm. square which were cleared to depths ranging from 20 to 30 cm. The actual depth of these probes and the number to be used in the examination of each site is, of course, to be determined by an appraisal of on-site conditions.

A number of considerations prompted the experimental addition of this step. First, it affords an expanded dimension of knowledge in site reporting from which to base recommendations for additional work. It also makes possible for more expeditious move from the original survey to extensive testing or excavation where needed. Such a method shows promise of at least a partial elimination of a middle step and thus reduces the time needed to provide the client with a more precise statement of his future obligations to obtain the antiquities mitigation required in the environmental impact study.

The SUSC group feels that the method has proven especially valuable in dealing with sites in the current project area. All sites directly related to this phase of the project have, with the exception of two small Paiute sherd scatters, proven to be lithic sites. It is believed that the use of the probing test under these conditions has been especially valuable in obtaining prompt and reasonably accurate site evaluation.

THE SITES

The following is a brief description both of the 12 sites recorded by the SUSC group and of the 3 sites relevant to this project that were logged by earlier workers. In each instance the number of probes made is given and the results of these tests are summarized. All sites in the project area are plotted on the enclosed map. An evaluation of the sites, together with recommendations, concludes the paper.

42-Be-273. This area was labeled a site only after considerable indecision occasioned by difficulties of definition. Identified along the borders of the proposed access road to Pad 16 in T27S, R9W, the northern edge of the site was delineated on the south bank of a large wash which the road crosses in the northwestern corner of the SW1/4 of Section 16. Identified only along the road, the site passes through the extreme southeastern corner of Section 17 and extends across much of the NE1/4 of Section 20 to a point 110 yards north of the right angle turn at which point the road turns west towards Pad 16.

The site area, extending for 9/10 of a mile on a north-south line and for an unknown distance on an east-west dimension, is one of the major areas of secondary deposit of obsidian. Although there is some variation in the density of the material, its distribution is clearly continuous for the full distance. Nodules, flakes, and cores are even found on the banks of some six washes that cross the road at right angles. Throughout the entire area examined, the obsidian nodules are accompanied by the flakes and cores indicative of human activity. Four rather large and casually flaked knives of "tear drop" form were found together with the fragment of what appears to be a fifth of the same form. Although all were found in the SW1/4 of Section 16, they were not associated. No other artifactual evidence was recovered.

A total of ten probes extending to a depth of 30 cm. in each case were made. These were placed in a series of 5 pairs located with one on each side of the road at 5 of the high points between washes. No evidence of midden was found in any of the tests but 7 of the probes exposed either flakes or cores at depths of between 10 and 20 cm.

42-Be-274 (NW1/4 of SE1/4 of Sec. 20, T27S, R9W). The entire quadrat of Pad 16 shows evidence of flaking activity. However, a wash enters the pad area near the eastern end of the southern boundary and curves to the west to exit the unit at about the mid point on the western boundary. Obsidian nodules appear to concentrate most heavily in the area to the south and west of the wash while cores and flakes are more common to the north and to the east. Evidence of flaking activity does occur on the southern part of the pad, however. Although two or three flakes might be classed as blades from prepared cores, no actual artifact fragments were found. Six probes were cut to a 30 cm. depth in randomly spaced pairs in the northwest, southwest, and southeast quarters of the pad. While no midden was found, flakes and small cores were noted to a depth of 20 cm.

42-Be-275 (SW1/4 of NW1/4 of Sec. 14, T27S, R9W). Located in the northeast quarter of Pad 8, the site is situated in what was, before chaining, a moderately dense juniper-pinon stand combined with some sage brush and grass. An obsidian point fragment associated with a small cluster of flakes seemed to indicate a site. It was thought that the material might have worked out from the area around the base of an uprooted tree. Further east in the pad, three small Paiute sherds and a sloping shouldered Pinto point were recovered as random finds. A test probe in the area of flake concentration failed to produce any sign of a camp site while another probe set at a more easterly point on the pad similarly failed to produce cultural evidence. It should be noted that Be-117, 256, and 257 are all located up slope from Be-275. Although none of these other sites yielded a large assemblage, they point to the possibility that Be-275 was formed by a secondary deposit of cultural debris from other sites at higher levels.

42-Be-116 (SE1/2 of NW1/4 of Sec. 15, T27S, R9W). Recorded earlier by BLM workers, the site report noted obsidian detritus, worked "stone slate," and quartzite nodules. Re-examination of the site failed to produce obsidian or slate but some of the apparent quartzite was much in evidence. It seemed to the survey team that the material observed earlier had been in the process of a downhill movement along a small drainage. Quartzite similar to that in the site area was noted on the slope of a shoulder or spur ridge that jutted north just to the southeast of the site. Cultural debris noted by BLM workers could not have come directly down the slope from the ridge since a shallow wash intervened between the ridge and the site. Inspection revealed, however, that the materials could have gone down the eastern slope of the spur and then carried around it to the north within the wash to be deposited in the site area during periods of heavy rain. The fact that an obsidian flaking station was identified on the ridge (see below) lent some credence to the thesis. No probes were made at this site.

42-Be-284 (SE1/4 of NW1/4 of Sec. 15, T27S, R9W). The site rests on a ridge or spur at a point just southeast of 42-Be-116. The top of the ridge is comparatively level but cut into segments by linear strips of what seem to be the edges of a tilted granitic upthrust. Some highly impure cryptocrystalline nodules were noted on the lower slopes. The ridge top provided good, level areas for work or for camping between the granite alignments. The area was covered with some sage brush and a scattered or open juniper-pinon stand. A decomposed granite gravel covered the surface. Cultural evidence was limited to a scatter of moderately large obsidian flakes. Since the site was not threatened by any planned activity in the area, no probes were made.

42-Be-118 (NE1/4 of NW1/4 of Sec. 15, T27S, R9W). The BLM site report notes that this site is "Located on the periphery of a small arroyo leading out of Big Cedar Cove, a small quantity of chipping detritus, a fairly large metate fragment, and a large charcoal and ash deposit was observed. The burned material could be, however, recent, a function of burning after chaining..." While the metate fragment was absent, the same or other transient obsidian flakes were noted. Further, the burned areas were examined in probes to a depth of 30 cm. The BLM report did not note that the center of each of the burned areas (there were actually several within a compass of from 150 to 200 feet) a small mound 10 inches high and about 4 feet in diameter is to be seen. Probes revealed that the evidence of burning penetrated only 1.5 cm below the surface but that it extended for an area of some 5 or 6 feet around the mounds. The burning influence does not appear to have penetrated any deeper into the mounds although this should perhaps have been the case if, as is here assumed, the burning results from recent chaining work. In present perspective, the burned areas are thought to represent the elimination of trash accumulated during chaining while the mounds are evidence of the gathering together of the last smouldering fragments which were covered with soil as a precautionary measure at the end of the process.

42-Be-121 (SW1/4 of NE1/4 of Sec. 10, T27S, R9W). Also recorded by the BLM, the site, plotted on the Adamsville 15" quadrangle, places it near the start of a road extending to the east into Little Cedar Cove. Although this road also appears on the more recent Minersville 2 NE 7.5" Quadrangle (proof only), no trace of the road was found. Examination of this general area as well as the area around the junction of the Little Cedar Cove Road now in use some 300 yards to the north, failed to produce any evidence of a flaking area. The survey group assumes that this is simply indicative of the ephemeral nature of secondary deposits.

42-Be-276 (Midpoint, NE1/4 of Sec. 10, T27S, R9W). The site is located 420 yards east of the starting point of the access road to Pad 7 in Little Cedar Cove. The activity area is identified by a liberal scatter of flakes over an area of some 65 yards parallel to the road and extending nearly 50 yards up the slope on the base of a ridge on the north side of the road. Above the point of the flake scatter, the slope steepens and the flakes become very rare. It appeared to be possible that the flakes may have washed down from the top of the ridge where a gently sloped gravel area appeared to promise a good camp site. No flakes were found at the top of the ridge, however. The area of flake concentration at the base of the ridge is in a moderately dense juniper-pinon stand with a surface of soil mixed with limestone fragments. Since the area is not threatened by pending projects, no probes were made.

At this point notice should be taken of another very large secondary deposit of obsidian. This is located in the area of Pad 1 where the county road runs in a northeasterly direction towards Negro Mag Wash and is intersected by the north-south access road from Little Cedar Grove and Big Cedar Cove. The point of intersection of the roads is almost on the line between sections 3 and 10 and only a few yards east of the quarter section marker.

The road grading for about 400 yards north, east, and west of the intersection and for about 100 yards to the south of it, reveals obsidian deposits. Drainage channels recently reworked along the margins of the roads expose flakes and cores to a depth of about 40 cm. Although the area approximates the conditions found on 42-Be-273, no attempt was made to designate the area as a site since it has been observed by other workers whose judgement seemingly differs.

Survey of the access road that extends from the NW1/4 of the NE1/4 of Sec. 9 to the midpoint of Sec. 3 revealed several concentrations of obsidian flakes. These were not recorded as sites since a study of the terrain and limited probing seemed to indicate that this material was in the process of being washed down from higher levels to the east and to the northeast.

42-Be-277 (SE1/4 of SW1/4 of Sec. 27, T26S, R9W). A flake concentration 120 yards east southeast of the drill point and a concentration of Paiute sherds 30 yards south of the flakes. The slope is down gently to the west. A surface of granite gravel is covered with a moderately dense growth of sage brush and an open stand of juniper-pinon. Two probes were made to a depth of 20 cm. No midden or cultural debris was observed.

42-Be-278 (NE1/4 of SE1/4 of Sec. 28, T26S, R9W). Area marked by a scatter of obsidian flakes lying on a surface of decomposed granite gravel. The area has a moderately dense cover of low sage brush with some grass and rabbit brush in the interspaces between the sage. The site area is in a level zone between the road and a bluff which forms the south bank of a wash flowing down to the northwest. The bluff is approximately 40 feet above the floor of the wash. A single 30 cm. test probe failed to produce midden or cultural evidence. The site has also been somewhat disturbed by a road grader passing over the southwestern edge of the flaking area.

42-Bc-279 (NE1/4 of NE1/4 of Sec. 33, T26S, R9W). This site was found at a point where the road curves up over a bluff forming the south bank of a wide wash. The bottom of the wash is some 35 to 45 feet below the bluff. The granite gravel surface slopes generally down to the west northwest at a moderately steep angle of 10°. Vegetation is in the form of widely spaced and stunted sage brush. The site revealed only flakes and cores. Nodules seemed to be missing. Two 30 cm. test probes were cut into the site area, both on the east side of the road. This procedure was used because this is on spot where a slight realignment of the road is indicated by the markers. Neither midden nor cultural debris was found.

42-Be-280 (NE1/4 of NE1/4 of Sec. 33, T26S, R9W). The site area is situated on a low rise between two shallow swales. The general slope is down to the west northwest at about 10°. Gravel of decomposed granite underlies a moderately dense sage brush cover into which some grass is mixed. The presence of unmodified obsidian nodules and an apparent lack of artifact fragments suggests that this site may have been more important as a resource area for the procurement of larger flakes than it was for the manufacture of artifacts. A 20 cm. probe was cut on both the west and the east side of the road. Neither produced midden or cultural debris.

42-Be-281 (NW1/4 of NE1/4 of Sec. 33, T26S, R9W). Granite gravel covers the surface of the site while vegetation takes the form of a moderately dense sage brush cover with some tufts of grass and a few open spaces. The site is characterized by rather small obsidian nodules to the east of the road while flakes appear to be more prominent to the west. The area appears to have been marked previously by someone who took a fragment of surveyor's flagging and wrapped it around an obsidian core and placed it just to the east of the road. Two 30 cm. probes, one on each side of the road, failed to produce cultural evidence of any kind.

42-Be-282 (NW1/4 of NE1/4 of Sec. 33, T26S, R9W). The customary granite gravel is covered with a moderately dense sage brush start and a few tufts of grass. The general slope of the terrain is down to the west at about 5°. The entire site area involves a rather thin scatter of flakes which are slightly more abundant west of the road. The site appears to have been marked previously by someone using a fragment of surveyor's flagging to wrap around a limestone fragment which was found east of the road. The 2 30 cm. test pits produced no cultural evidence.

42-Be-283 (NE1/4 of NW1/4 of Sec. 33, T26S, R9W). The gravel-covered slope drops to the west at about 4^{o}. The moderately dense sage brush cover is interspersed with considerable grass and rabbit brush. The extensive area of flakes, cores and nodules noted here makes this seem to have been the most heavily used of the 5 sites recorded along this road. Most activity seems to have concentrated west of the present road. The site was marked by a person who scratched an X in the ground to the west of the road. The mark was quite fresh on the day that the site was logged. Two 20 cm. probes produced neither midden nor cultural debris.

RECOMMENDATIONS

The findings of the archeological surveys conducted by the Bureau of Land Management, Brigham Young University, and Southern Utah State College reveal quite clearly the limited resource function of the project area. While this part of the east bench of the Escalante Valley must also have served as a source of game and of seeds, its primary value lay in the beds of obsidian nodules which were, perhaps, more readily exploited than the primary sources in Wild Horse and Ranch Canyons.

In his notes on 42-Be-52, Wiede (1964) urged the importance of searching for campsite and workshop areas in the vicinity of known spring localities in the Mineral Mountains. He clearly assumes that, when prehistoric man quarried obsidian, he then moved to nearby water to fabricate his tools. A study of the 7.5" maps of the area reveals that live water existed higher in the Minerals to the east and, to the west, on the floor of the Escalante Valley. The east bench itself seems to have been devoid of perennial water. Hence, it would seem that Wiede's model accounts for the vast quantity of flakes and cores and the most limited assortment of artifact fragments found.

Test probes seem to support this position. While the possibility of east bench sites of extended use such as the prehistoric site that may underlie the historic site at Roosevelt Hot Spring is acknowledged, a transient lithic exploitation is the most accurate description of the modal activity of the east bench.

The failure to produce any significant evidence of prehistoric use or occupation in the test probes justifies the view that, with the exception of sites 42-Be-273 and 274, no further archeological investigation is needed. The evidence of limited human activity at all other sites is confined to surface manifestations and excavation or more extensive testing holds no realistic promise of yielding data.

Some special consideration of sites 42-Be-273 and 274 is needed, however. The first of these sites, 42-Be-273, represents a very large secondary deposit of obsidian identified along the access route to Pad 16. Just to the southwest, 42-Be-274 is a similar deposit which covers all of Pad 16 and extends for an undetermined distance beyond the boundaries of the pad. Probes in both sites produced no midden but they did expose flakes and cores to a depth of 20 cm. The limited size of the probes leaves reason to suspect that similar material may also be found at greater depths. At the same time, it is assumed that deeper materials will have the same casual distribution noted on the surface.

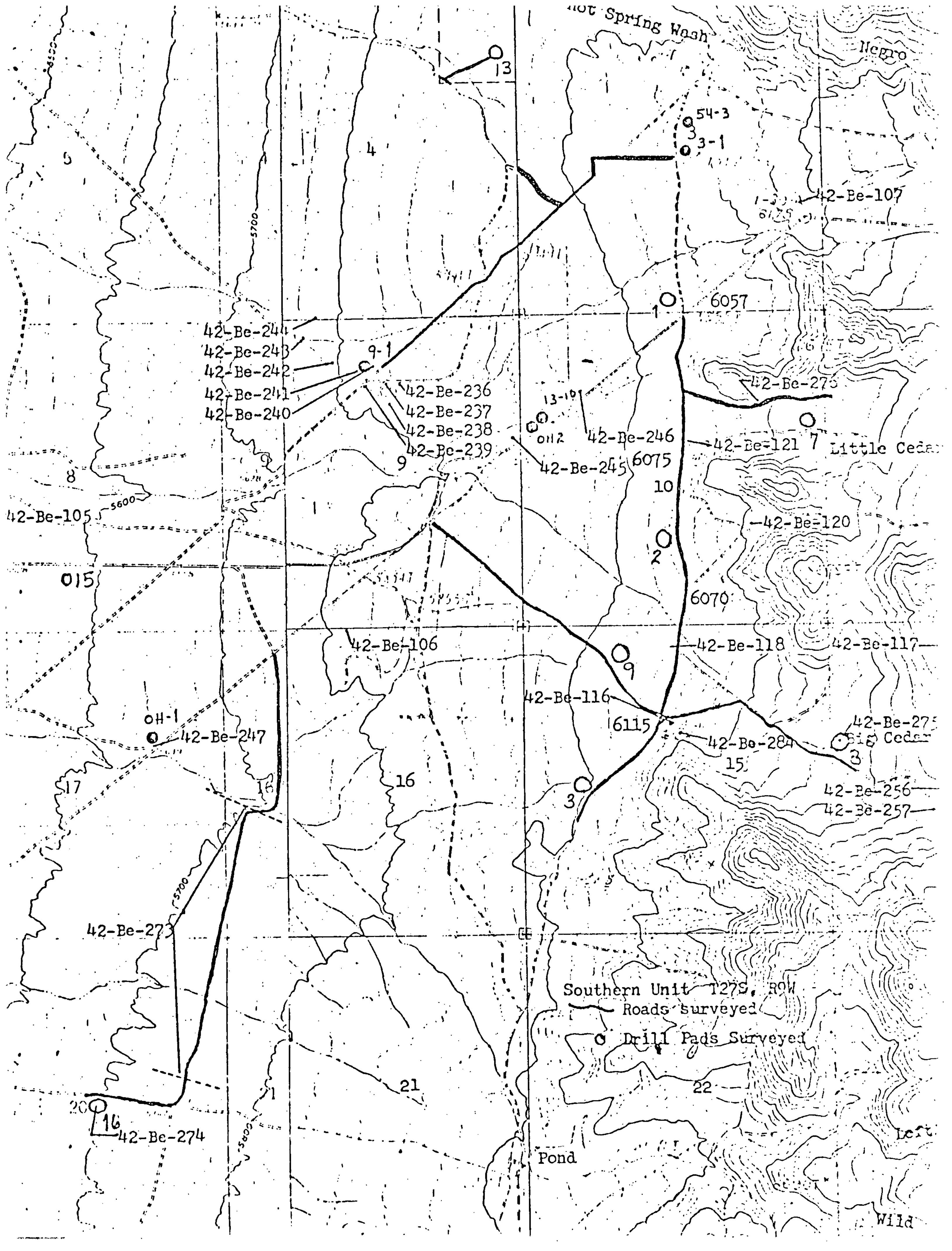
The concern of the antiquities investigation is to minimize the destruction of evidence of prehistoric patterns of culture and, in cases where destruction cannot be avoided, to insure maximum recovery of data relevant to those patterns. Using this concern as a guideline for recommendations, the question is, then, one of the kind of knowledge that might be gained from extended excavation. The lack of evidence of the repeated use of any one spot suggests that the most valuable data may well come from some insight into the depth at which flakes and cores produced by human agency may be found. This would be an initial step in the direction of ascertaining the antiquity of human activity in the area.

In view of the scattered and amorphous distribution of the minimal evidence thus far observed, the recommendation is made that no further testing or excavation be required on 42-Be-273. It should be recognized that this road was graded in the past and that its redevelopment will but slightly increase existing disturbance of a site of very great areal extent.

At the Pad 16 site of 42-Be-274, however, a situation obtains in which it may prove most efficient and least expensive to secure some data in connection with the development of the pad rather than be requiring excavation in advance of development. It can be argued that the most promising extension of knowledge may be had by any process that affords the opportunity to examine a cross section of one of the secondary obsidian deposits.

It is recommended, then, that the Phillips Petroleum Company be asked to give assurance that, when Pad 16 is to be graded, the company will undertake to excavate 40 meters of french, either as a single unit or in four 10 meter segments, to a depth of not less than two nor more than three meters below the modern surface. The company should also be asked for assurance that sufficient time will be allowed after these trenches are cut for Bureau of Land Management archeologists or an archeologist approved by them, to examine the profiles of the trenches and to prepare them for such photographing and diagramming as may seem advisable.

This stipulation should not negate clearance at other sites in the sense that the company should have the right to decide against the development of Pad 16 and the access road to it should it so desire.



Hot Spring Wash
Negro
13
54-3
3-1
4
42-Be-107
6057
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Big Cedar
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5700
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Southern Unit T27S, R9W
Roads surveyed
Drill Pads Surveyed
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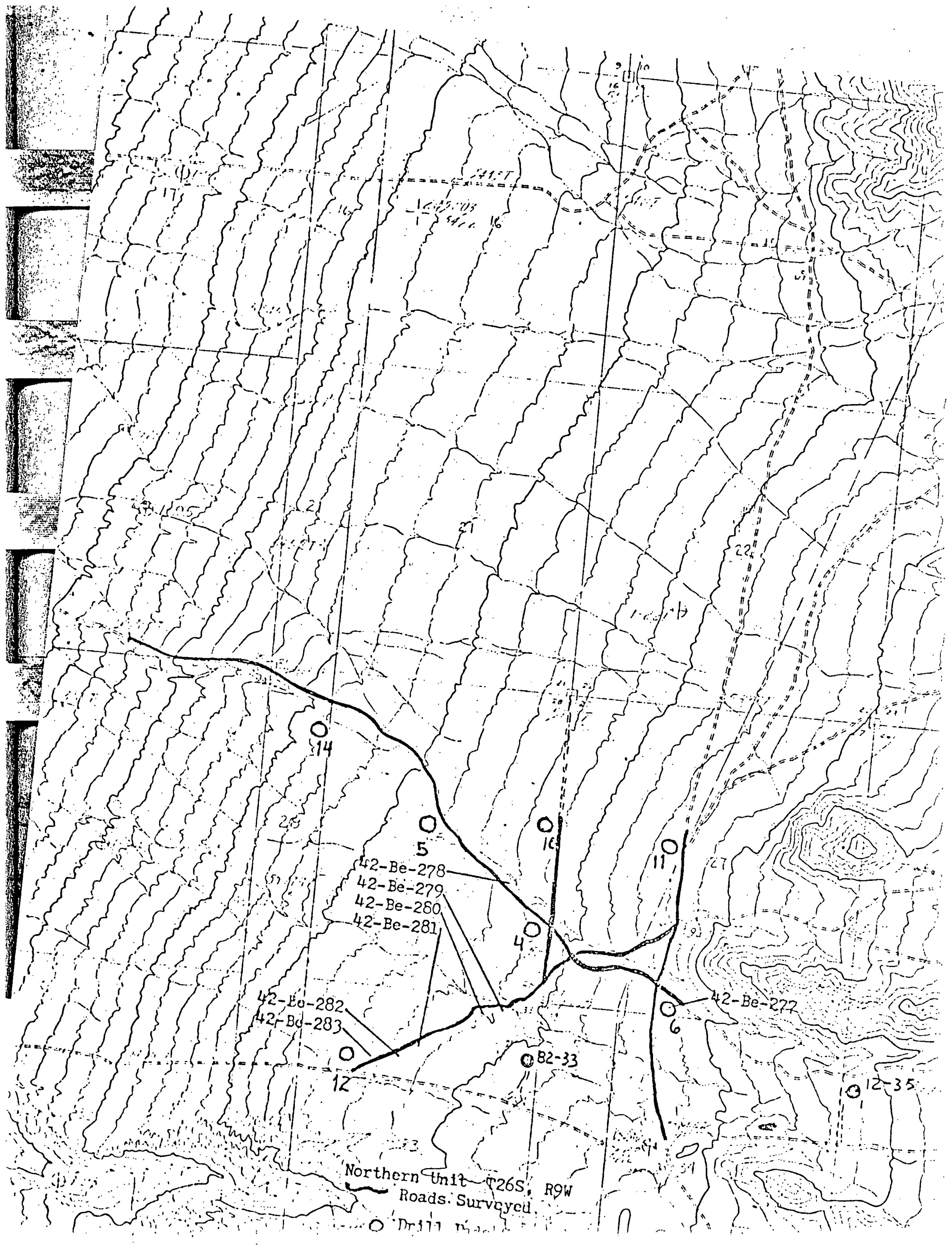
22
20
16
42-Be-274
Left
Pond
Wild



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42-Be-281
4
42-Be-282
42-Be-283
42-Be-277
6
12
B2-33
12-35
Northern Unit T26S, R9W
Roads Surveyed
Drill

APPLICATION FOR PERMIT TO DRILL

GEOTHERMAL RESOURCES LEASE U-27386

TEST WELL

ROOSEVELT KGRA 58-3

RECEIVED
JAN - 2 1976
AREA GEOTHERMAL SUPERVISOR'S OFFICE
CONSERVATION DIVISION
U.S. GEOLOGICAL SURVEY
MENLO PARK, CALIFORNIA

APPLICATION FOR PERMIT TO DRILL

GEOTHERMAL RESOURCES LEASE U-27389

TEST WELL

ROOSEVELT KGRA 46-10

APPLICATION FOR PERMIT TO DRILL

GEOTHERMAL RESOURCES LEASE U-27392

TEST WELL

ROOSEVELT KGRA 25-15

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ATTACHMENTS

Form 9-331 C
(May 1963)

SUBMIT IN TRIPLICATE*
(Other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R1425.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK

5. LEASE DESIGNATION AND SERIAL NO.: U-27389
6. IF INDIAN, ALLOTTEE OR TRIBE NAME: ——
7. UNIT AGREEMENT NAME: ——
8. FARM OR LEASE NAME: ——
9. WELL NO.: Roosevelt KGRA 46-10
10. FIELD AND POOL, OR WILDCAT: Wildcat
11. SEC., T., R., M., OR BLK. AND SURVEY OR AREA: 10-27S-9W
12. COUNTY OR PARISH: Beaver
13. STATE: Utah

1a. TYPE OF WORK
DRILL [X] DEEPEN [ ] PLUG BACK [ ]

b. TYPE OF WELL
OIL WELL [ ] GAS WELL [ ] OTHER Geothermal SINGLE ZONE [ ] MULTIPLE ZONE [ ]

2. NAME OF OPERATOR
Phillips Petroleum Co.

3. ADDRESS OF OPERATOR
P. O. Box 752 Del Mar, CA 92014

4. LOCATION OF WELL (Report location clearly and in accordance with any State requirements.*)
At surface 1710.05' N along Section line and 2553.40'E at right angles to said line from the SW corner of Sec. 10, T27S, R9W
At proposed prod. zone
(straight hole) See above surface location

14. DISTANCE IN MILES AND DIRECTION FROM NEAREST TOWN OR POST OFFICE*
11 miles NE of Milford, Utah

15. DISTANCE FROM PROPOSED* LOCATION TO NEAREST PROPERTY OR LEASE LINE, FT. (Also to nearest drlg. unit line, if any) 1710.05
16. NO. OF ACRES IN LEASE 1,961.40
17. NO. OF ACRES ASSIGNED TO THIS WELL 40
18. DISTANCE FROM PROPOSED LOCATION* TO NEAREST WELL, DRILLING, COMPLETED, OR APPLIED FOR, ON THIS LEASE, FT. 2860'
19. PROPOSED DEPTH 6000'
20. ROTARY OR CABLE TOOLS Rotary
21. ELEVATIONS (Show whether DF, RT, GR, etc.) 6,074.9 GR
22. APPROX. DATE WORK WILL START* April 1, 1976

23. PROPOSED CASING AND CEMENTING PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	QUANTITY OF CEMENT
26"	20"	13.3	60'± GR	250 sx
17½"	13 3/8"	54.5, K-55 BT	600'± GR	785 sx
12¼"	9 5/8"	40, K-55 BT	1800'± GR	600 sx

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: If proposal is to deepen or plug back, give data on present productive zone and proposed new productive zone. If proposal is to drill or deepen directionally, give pertinent data on subsurface locations and measured and true vertical depths. Give blowout preventer program, if any.

24.

SIGNED C. W. Berge TITLE Manager, Geothermal Operations DATE Dec. , 1975

(This space for Federal or State office use)

PERMIT NO. ______ APPROVAL DATE ______

APPROVED BY ______ TITLE ______ DATE ______
CONDITIONS OF APPROVAL, IF ANY:

APPLICATION FOR PERMIT TO DRILL GEOTHERMAL RESOURCE TEST WELL TO

APPROXIMATE 6,000 FOOT DEPTH

In compliance with Section 270.71, Chaper II, Title 30 C. F. R., permission is hereby requested to commence drilling test well Roosevelt KGRA 46-10, Section 10, T27S, R 9W, Salt Lake B. and M., Beaver County, Utah.

1. Location of Hole:
   Exactly 1710'N along section line and 2553'E at right angles to said line from the SW corner of Section 10 , Township 27 South, Range 9W. See Attachment I well plat.
2. Elevation of the ground at the well site is 6075', obtained from a second order or better survey conducted under the direct supervision of a registered land surveyor.
3. Elevation of the derrick floor is * '.
4. The hole will be drilled as a straight hole. Bottom hole location is expected to lie directly below surface location as shown on Attachment I.

*Not presently known

DETAILS OF WORK

I. Tools and equipment.

The following equipment will be used to drill and complete the test well:

Information not available at this time. An Addendum describing the equipment to be used will be submitted at such time as a drilling contractor has been selected.

DETAILS OF WORK

II. The proposed depth to which the well will be drilled is 6000 '.

Estimated depths to the top of important markers are:

1. Quaternary and Tertiary alluvium and arkosic sands..............................Surface
2. Tertiary intrusive rocks and/or migmatized Precambrian metamorphic rocks.......................... 350'

The estimated geologic section is alluvium zero to 350 feet, and mixed Precambrian metamorphics and Tertiary intrusive rocks 350 to 6000 feet.

Groundwater, if encountered, should be found above the top of the Precambrian metamorphic rocks or Tertiary intrusive rocks. Geothermal resources may be encountered at depths greater than the alluvium intrusive-metamorphic rock contact.

DETAILS OF WORK

III. Proposed Drilling and Casing Program

1. Drill 24" hole. Bevel bottom, run and set ± 60 ' of 20" OD 133# buttress thread K-55 casing (internal yield 3060 psi and collapse 1600 psi). Center casing in hole with bow type centralizers. Cement to surface. Using 50% excess of the following type: Class B cement with 3% $CaCl_2$.

Estimated quantity of cement required to cement ± 60 ' of 20" OD 133# buttress thread K-55 casing to surface using 50% excess is 250 sacks.

Cut off 20" casing; weld on casing spool with two 2" outlets; install 20" hydril. Test hydril and casing to 200 psi for 30 minutes.

2. Drill 17½" hole to ± 600' (or 150 feet of granitic penetration) with standard drill assembly. Maintain hole within 3° of verticle using drift surveys at 100 foot intervals. Run 13 3/8", 54.5#, K-55 Buttress thread, Range 3 casing (internal yield 2730 psi, collapse resistance 1140 psi) to total depth. Cement to surface with thermal mix 1:1 Perlite cement.

Estimated quantity of cement required to cement ± 600 feet of 13 3/8" OD 54.5# buttress thread K-55 casing to surface using 100%+ excess is 785 sacks.

Cut off casing, install weld on head with two 2" outlets and equip well with 12" series 900 blowout preventer consisting of 3000 psi working pressure double ram and hydril. Test blind and pipe rams and casing to 1000 psi for thirty minutes. Test hydril to 500 psi for thirty minutes. Test results will be shown in the daily report book. (U. S. G. S. will witness prevention tests).

3. Drill $12\frac{1}{4}$ hole with a bottom hole locked drilling assembly to ±1,800'. Drilling will be with minimum weight fresh water system as described in mud program. Mud loggers will maintain continuous surveillance of mud temperature and log gas shows on a maximum of 20' intervals. Drift surveys will be run at each bit change or at 200 foot intervals when deviation increases at a rate greater than $3/4^{\circ}$ per 100' on any bit change survey. Remedial drilling procedures, i.e. reduced weight or rotary speed will be started when any survey shows an increased deviation greater than 1° from vertical. In no event will maximum deviation greater than $12\frac{1}{2}^{\circ}$ be permitted at casing point.

Run directional survey giving both inclination and azimuth to ± 1800'.

4. Run and set ±1800' of 9 5/8" OD 40# K-55 Buttress thread, Range 3 casing (internal yield 3,950 psi and collapse 2,770 psi) with regular guide shoe on bottom and baffle collar on top of first joint. Tack weld and pipe lock bottom two joints. Centralize with bow type centralizers five feet from shoe, baffle collar, and each

third joint to surface. Cement to surface with Thermal type cement.

Estimated quantity of cement required to cement ± 1800 feet of 9 5/8" OD 40# K-55 buttress thread casing to surface using 100% excess is 600 sacks.

5. Remove BOP and casing spool. Cut off 9 5/8" casing, install weld on casing spool with two 2" outlets and blowout prevention equipment as shown in Attachment 2. Test blind and pipe rams and casing to 1000 psi for thirty minutes. Test hydril to 500 psi for thirty minutes. Test results will be shown in the daily report book. (U. S. G. S. will witness prevention tests).

6. Drill baffle collar, cement, shoe and ±90' with 8½" bit and slick bottom hole drilling assembly. Pull out for locked bottom hole drilling assembly. Drill to TD with 8½" bits. Drop drift surveys before pulling out of hole for bit changes.

7. We will test potential producing horizons below casing point and take such steps as are necessary to control such zones before drilling on to total depth.

8. Run logs as temperature will permit.

IV. Mud Program

Surface Hole

Spud Mud: Mix bentonite until a 36-38 visc. is attained, then add 3 to 4 lbs./bbl. flosal and ½ lb. per bbl. lime. Maintain with a ratio of 1 sack flosal to 4 sacks bentonite.

Below Surface Casing

Casing shoe to ±3-500 feet: Use fresh water with minimum salt addition to control penetrated formations. Keep weight down with D-sander and D-silter.

Below 9 5/8" Casing

Use fresh water with minimum salt addition to control penetrated formations. In the event of lost circulation, water will be aeriated to obtain returns.

V. Logging and Testing Program

The mud logging unit will monitor flow line temperatures, collect samples, prepare a lithologic log and log gases. Other logs to be run include:

Formation Density Compensated Log
Compensated Neutron Porosity Log
Borehole Compensated Sonic Log
Gamma Log
Caliper Log
Temperature Log

1. Formation Testing

In the event drilling data and evaluation criteria indicate that a potentially commercial geothermal reservoir has been penetrated, a steam control head will be installed on the Master Gate. The assembly consisting of access port, kill line, and flow choke will be tested to contain maximum well-head pressure of a fully developed flow based on drill pressure confinement with suitable safety allowance for maximum anticipated steam temperatures. Formations to be tested will be opened to the well bore. Minimum flow to characterize formation and well installation will be produced to surface reserve pits.

A typical sampling program is included as Attachments IV and V.

2. Proposed program for determining geothermal gradients and the sampling and analysis of geothermal resources.

a) Geothermal gradients - A wire line temperature survey or surveys will be run in the well to obtain data necessary to calculate geothermal gradients.

b) Sampling and analysis of geothermal resources - Formation testing procedures and assembly are included on Page 5 of A. P. D. A more detailed program is included as Attachments I and II to this addition. Fluid samples are submitted to commercial laboratories and to Phillips Petroleum Company R&D for analysis. We routinely analyze water samples for boron, calcium, magnesium, potassium, sodium, ammonium, chloride, combined nitrate and nitrite, silica, sulfate, combined carbonate and bicarbonate, pH and conductivity. Selected waters are analyzed for all of the above, plus lithium, strontium, arsenic, fluoride, barium, iron, hydroxide, carbonate and bicarbonate.

Emission spectrographic qualitative analysis are run on a limited basis for the elements Ba, B, P, Fe, Mn, Mg, Pb, Cr, Si, Al, Mo, Sn, V, Li, Cd, Cu, Na, Zn, Ti, Zr, Ni, Co, Sr, Ca, As.

BOP EQUIPMENT REQUIREMENTS

1. BOP equipment should conform to specifications set forth in attachments. In addition, the following should be provided or followed:

   a. Water nozzles or sprinklers should be installed to spray on the preventer stack to control temperatures and help preserve rubber elements when circulating temperatures become excessive.

   b. Ram elements should be checked for temperature damage every trip and replaced as needed.

   c. A bleed line should be provided on one of the casing head outlets to vent well during trips when it is necessary to close well in.

2. An accumulator system should be provided with the following minimum specifications:

   a. Large enough to close <u>all</u> of the hydraulically operated equipment, with pumps shut off, and have a minimum (1200 psi) remaining on the accumulator.

   b. A back up of nitrogen bottles or an air compressor driven independently from the rig should be provided. Piping should be such that the nitrogen can be routed through a pressure regulator directly to preventer stack, by-passing the accumulator.

   c. Two operating stations should be provided. A main unit (with a four-way valve) and a remote unit at the driller's station. The main unit should be at least 50 feet from wellbore in a convenient location.

d. All piping should be 1" minimum steel lines with (3000 psi) working pressure. No rubber lines should be used. Swivels should be used to prevent undue stress.

3. All engines are to be equipped with explosion resistant ignition and explosion-proof or water injection exhaust.

4. All rig lighting is to be vapor and/or explosion-proof. Under-floor lights should provide good illumination of wellhead equipment, but should be located as far from the wellhead assembly as possible.

5. Water tanks should be filled with sufficient volume to fill wellbore plus an excess in case lost circulation occurs.

6. The following additional BOP equipment should also be on the rig floor at all times:

a. An inside blowout preventer.

b. A full opening drill string safety valve in the open position.

c. A kelly cock should be used below the swivel and a full opening kelly cock of such design that it can be run through the blowout preventers should be installed at the bottom of the kelly.

In addition, the mud system shall be such that a positive indication can be obtained as to mud volumes required to fill the hole on trips.

PROCEDURES IN THE EVENT
OF AN UNCONTROLLED
BLOWOUT

I. When a well control problem (in this case the well blowing steam or other well effluent with loss of means to shut in or divert the flow) develops or is determined to be impending, the Phillips Foreman is to:

1. Initiate appropriate control procedures. (The specific procedures will vary greatly depending on nature of the problem). If any injuries have occurred make arrangements to care for the injured party (parties).

Ambulance

Fire Chief Ray Whiting
Milford, Utah

Business: (801) 387-2411

Home: (801) 387-2374

Hospital

Milford Valley Memorial
Milford, Utah

Telephone: (801) 387-2411

Doctor

Dr. D. A. Symond

Office: (801) 387-2471
or (801) 387-2411

If there is a threat to any local residents the Sheriff should be notified as soon as possible.

Beaver County Sheriff Department
Beaver, Utah

Office: (801) 438-2862

Home: (801) 387-2750

2. Because of the sensitivity of an uncontrolled geothermal well in this area, he should advise and consult with the Drilling Superintendent as soon as practical.

B. W. Berthelot
Office: (714) 755-0131
Home: (714) 755-2852

3. He is to initiate any further or supplemental steps which may be necessary or advisable based on consultation with the Drilling Superintendent.

4. He is to be certain that all safety practices and procedures are being followed and that all members of the drilling crew are performing their assigned duties correctly.

5. Contain any spills that may have occurred.

The Drilling Superintendent is to:

1. Brief his immediate supervisor (Operations Manager) on the situation and course of action underway.

   C. W. Berge - Office Manager, Geothermal Operations
   Office: (714) 755-0131
   Home: (714) 753-9678

2. Contact the following agencies or regulatory bodies as soon as practical and in the following order:

   United States Geological Survey
   Conservation Division - Western Region Area Geothermal Supervisor
   345 Middlefield Road
   Menlo Park, CA 94025 (415) 323-8111 extension 2841

   Bureau of Land Management
   Department of the Interior
   154 N. Main
   Cedar City, UT 84720 (801) 586-9443

   Department of Natural Resources
   Division of Water Rights
   State Engineer
   442 State Capitol
   Salt Lake City, UT (801) 328-6071

United States Geological Survey
District Geothermal Supervisor
Room 442 Post Office Building
Salt Lake City, UT

Office: (801) 524-5245

Residence: (801) 532-2642

II. Proposed Containment, Public Health and Safety and Clean-up Measures in the Event of a Blowout

A. Close all roads leading into well and control all traffic going to same.

B. Build earthen dikes down stream going to drainage areas.

C. Use vacuum trucks to transport fluids to disposal pit near proposed injection well (#12-35).

D. Reinject fluids back into injection well with pump set up on location after obtaining approval of district geothermal supervisor and state water engineer.

E. If it is possible to make tie-in to well, kill well with (9.6 ppg.) salt water using rig pumps or Halliburton trucks.

F. Drill directional hole as a last resort to kill well.

G. Clean-up measures will be carried out in accordance with BLM recommendations and surface areas will be returned as near as possible to their natural state and reseeded with native grasses.

PROGRAM FOR DISPOSAL OF WELL EFFLUENT

A. After drilling conductor and surface holes, excess mud is used as an additional sealant in the reserve pit. At the termination of the useful life of the reserve pit, well cuttings and mud are buried and the pit area is returned as nearly as is practical to its preexisting shape.

B. Preferrred drilling fluid for $12\frac{1}{4}$" hole (9 5/8" casing string) is fresh Milford City water. An analysis of Milford water is included as Attachment, this addition. In the event of hole caving, we will switch to mud and disposal will be as above.

C. Below 9 5/8" casing Milford City water will be used as the drilling fluid. We circulate through the reserve pit to cool the water in the event the temperature exceeds 200°F. Additives are added to protect drill pipe if air is used to obtain and maintain circulation. Water not consumed in drilling is transferred to new wells and used again as drilling water. Excess water is used on county roads to help control dust.

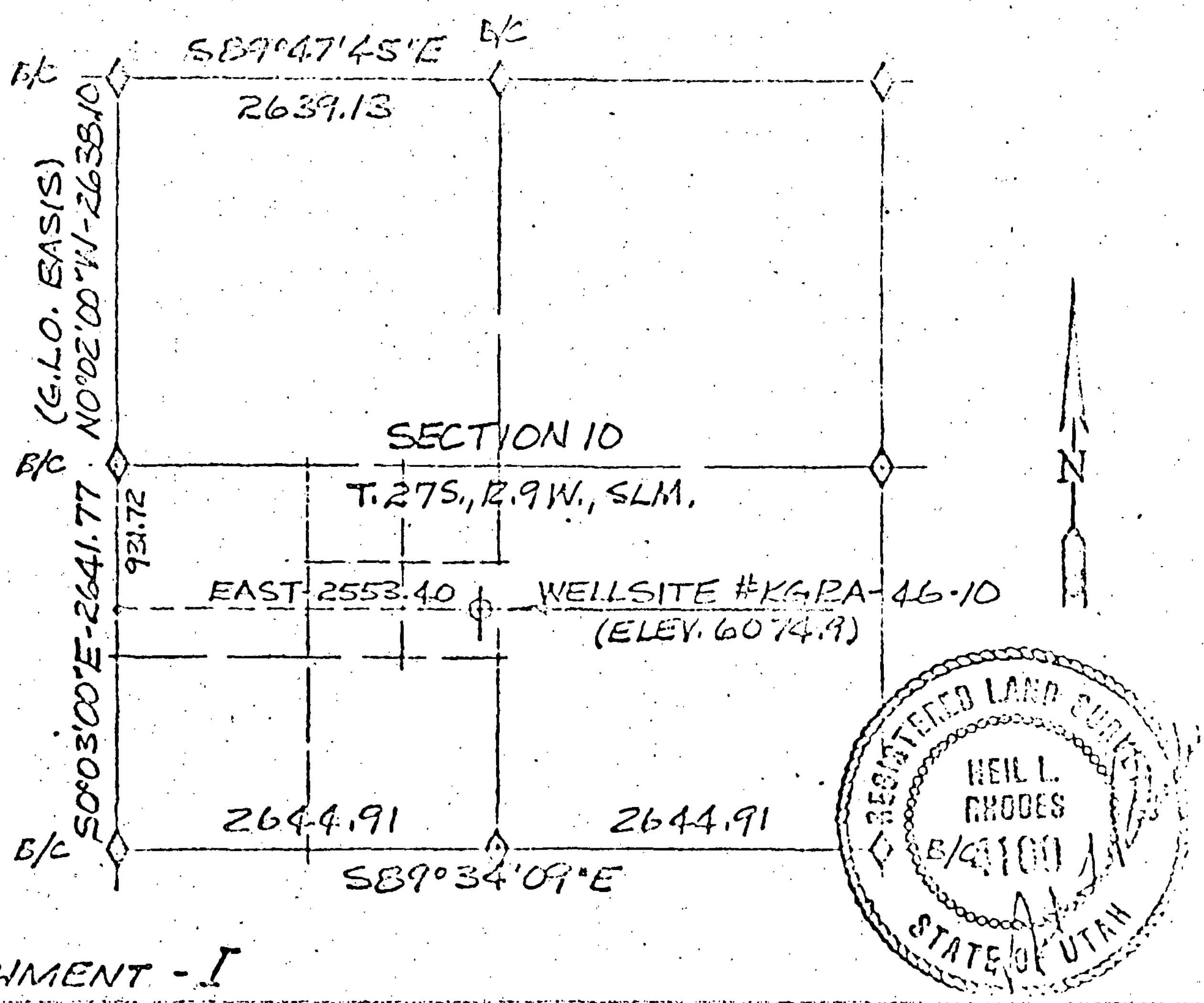
It is sometimes necessary to use salt water as the drilling fluid to maintain well control. Upon completion of the well, the salt water is transferred to new wells and recycled. Excess salt water is allowed to evaporate in the reserve pit and the residue is buried during reclamation of the pit.

SUPPORTING STRUCTURAL AND HYDROLOGIC INFORMATION

Depth to the water table and quality of the groundwater is not known. Water table is presumed to lie in the alluvium above the relatively impermeable intrusive and metamorphic rocks which function as a cap on the geothermal system.

OPERATOR:	Phillips Petroleum Co. P.O. Box 752 Delmar, Calif. 92014
WELL NUMBER:	KGRA-46-10
LOCATION:	Section 10, T27S, R9W, SLM.
COUNTY:	Beaver
STATE:	Utah
ELEVATION:	(Ground Level) 6,074.9 feet above mean sea level.

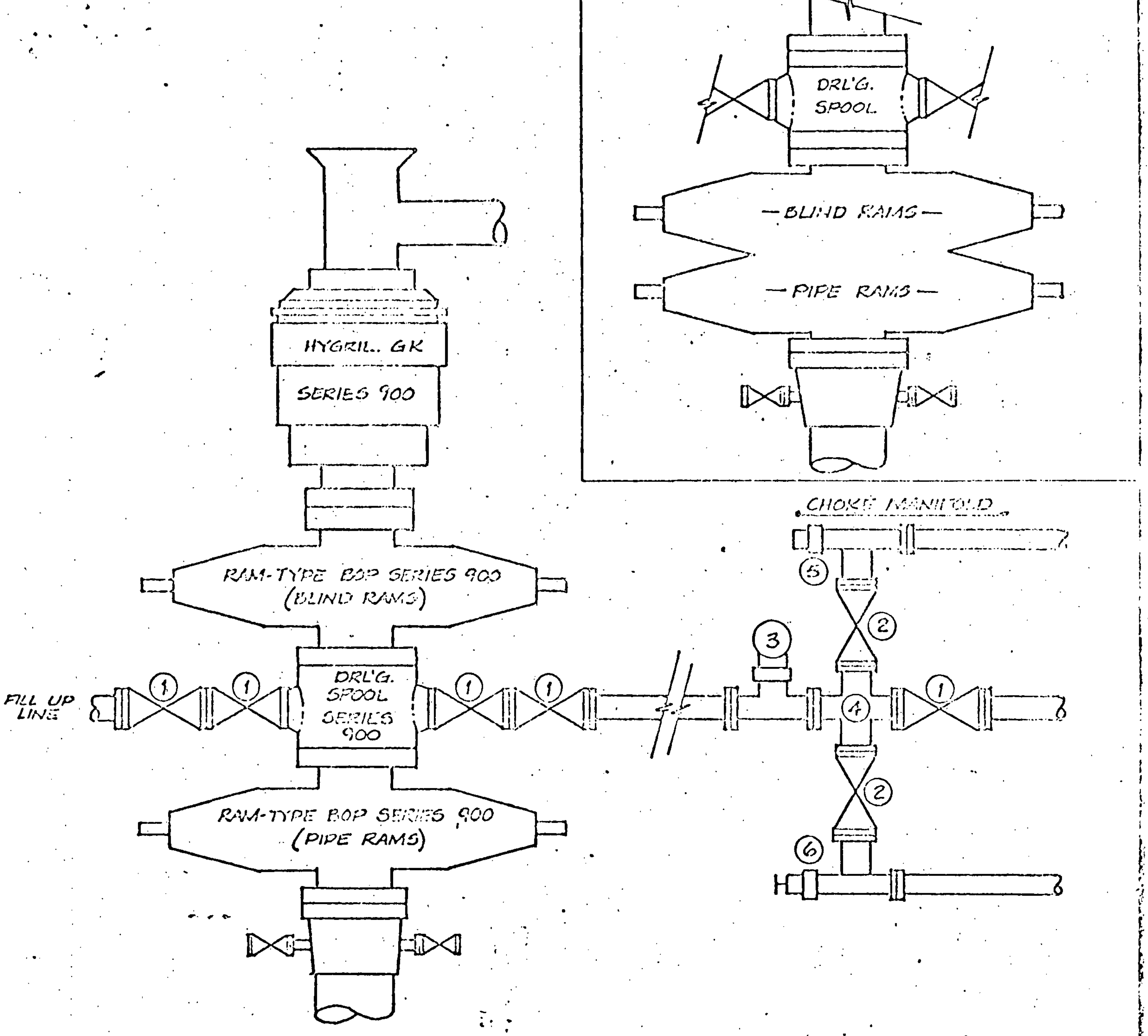
Bench mark = brasscap with steel post alongside; 204 feet Easterly from KGRA-46-10 wellsite = elev. 6094.03



ATTACHMENT - I

BULLOCH BROS. ENGINEERING INC. CEDAR CITY, UTAH	WELL LOCATION MAP FOR PHILLIPS PETRO. CO. DELMAR, CALIF.	DECEMBER, 1975 SCALE 1" = 1320' [illegible] R.T.T.

ATTACHMENT - II

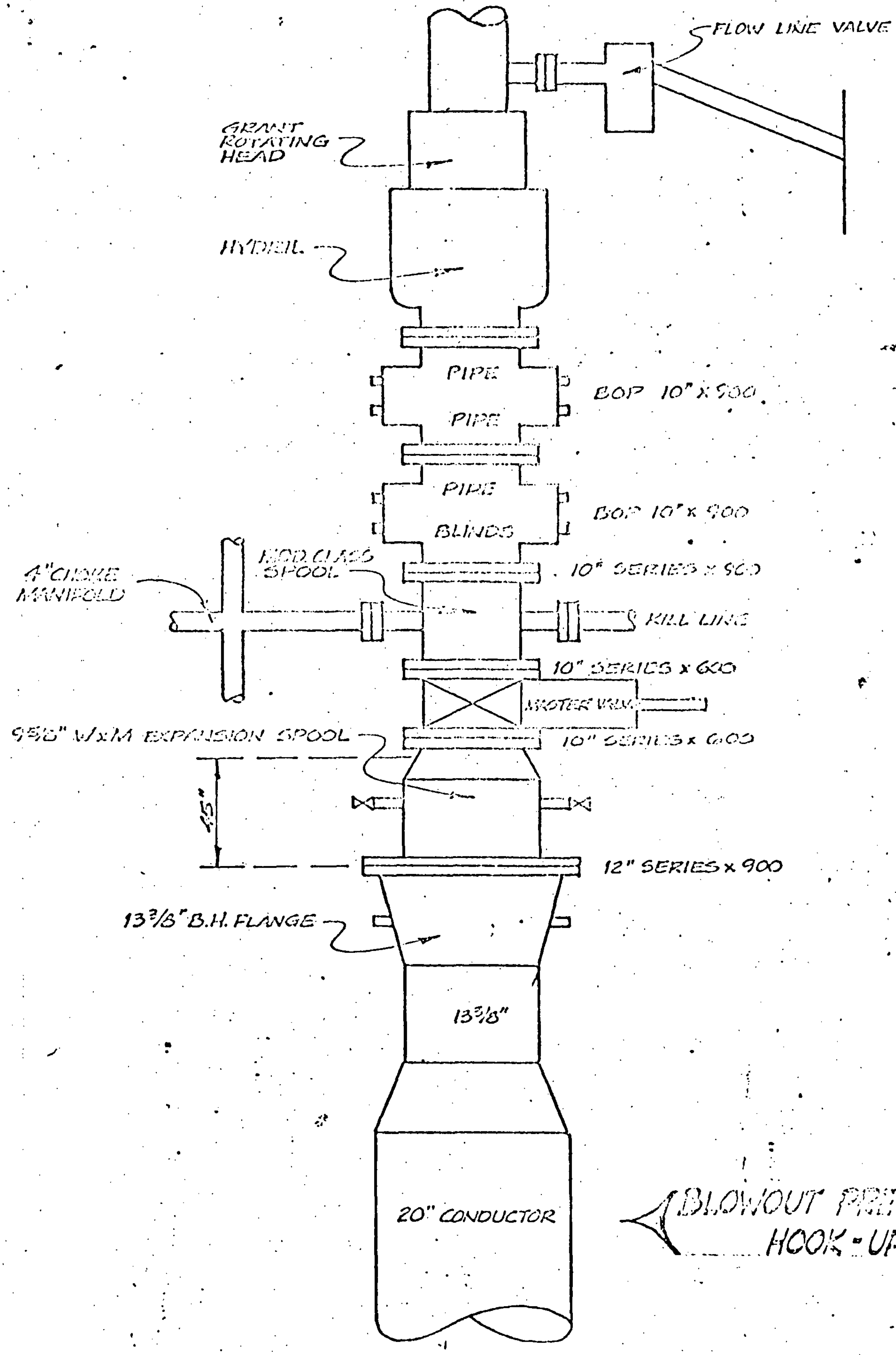


USE TO DRILL FROM SURFACE CASING SHOE TO ±1300'

① 3" SERIES 900 VALVE
② 2" SERIES 900 VALVE
③ 2" MUD PRESSURE GAUGE ON 3"x3" SERIES 900 STEEL TEE
④ 3" SERIES 900 x 2" SERIES 900 STEEL CROSS
⑤ 2" SERIES 900 POSITIVE CHOKE
⑥ 2" SERIES 900 ADJUSTABLE CHOKE

<3000 PSI WORKING PRESSURE BLOWOUT PREVENTER HOOK-UP>

ATTACHMENT



BLOWOUT PREVENTER HOOK-UP

USE TO DRILL FROM 9 5/8" SHOE TO T.D.

ATTACHMENT IV

ROOSEVELT KGRA WELL TEST PROCEDURE

1. Determine status of fluid column in adjacent wells, sample and eliminate any noncondensable gases at the top, and prepare to measure and record pressures continuously (two pressure recorders, calibrated at intervals with a dead weight, should be used to make sure no data are missed) at the wellhead while the testing of the No. 46-10 well is under way. If tubing has been installed, the well fluids should be displaced from the tubing and pressures measured at the tubinghead.

2. Obtain wellhead and bottom-hole pressures and temperatures and temperature gradient on the Wildcat well while the well is shut in and after the well fluids have been displaced from the tubing. (It is important to obtain initial reservoir pressure and temperatures).

3. Start well to flow at nearly the capacity of the well at a constant rate. This flow will be a cleanup flow and should be considered as one point of an isochronal test. Duration of flow should be approximately 72 hours.

4. Take wellhead pressures (both annulus and tubing), temperatures, measurements and orifice meter flow rates including pressures and temperatures on separator at log scale time (i.e., 1 min., 5 mins., 10 mins., 15 mins., 30 mins., 45 mins., 1 hr., etc.) and obtain samples as shown on Attachment II.

RECORDING PRESSURE GAUGES ARE RECOMMENDED.

5. When well is shut in, get wellhead pressure buildup and temperatures at the same frequency as drawdown test, including instantaneous

shut-in pressures to catch peak wellhead pressure. Continue shut-in until wellhead pressures and temperatures stabilize or a maximum of probably not more than 24 hours.

6. After initial flow tests have been analyzed, conduct a three-point isochronal test at rates of 1/3, 2/3, and finally, again at maximum flow capacity. Each flow should be followed by a shut-in period to a stabilized shut-in pressure as was done for the shut-in after the cleanup flow. Same data and data-taking frequency should be used for drawdowns and builups as described for the cleanup flow.

ATTACHMENT V

SAMPLING SCHEDULE

Description of Sample

Test Time (hrs)	Surface Water Samples(2)	Drilling Mud(1)	Condensed Steam(2)	Separated Liquid(2)	Noncondensable Gases(3)	Silica Test
0	X	X				
0	X	X				
1/2			X	X	X	
1			X	X		
2			X	X		X
6			X	X		
10			X	X		
14			X	X		
18			X	X		
22			X	X	X	X
32			X	X		
42			X	X		
52			X	X	X	X
62			X	X		
72			X	X	X	X
Total Samples	2	2	13	13	4	4

Notes: (1) Drilling Mud sample when hole is bottomed out and again during completion
(2) "T" Type kit
(3) "F" Type kit
(4) Test to be made in field

Helium Sniffer

12 January 1976

AREA
UT
Beaver
Roos
Helium
Sniffer

Ted Denton, Isotope Geology, USGS

Lab Note: Preliminary field trip to Roosevelt Hot Springs, Utah, 23-4 October 1975.

Lab notes for "Helium Sniffer Tests at Roosevelt Hot Springs, UT" 1976, Denton

On each of the two days, 23-4 Octobe ... seen to
twenty samples of soil gas at Roose ... ng an
east-west line that had been laid o ... of Utah
and designated "2200 North". Please ... sed maps.
All samples were taken from the soi ... surface
and analyzed for their helium conte ... collec-
tion. A plot showing the excess of ... e over
the helium normally found in air is

The sensitivity of our detecting system in the field at that time was such that the smallest detectable output signal from the instrument corresponded to 10 parts per billion helium in air: that is, the system could resolve the difference in helium composition between an unknown and a reference gas with a precision of ± 20 ppb. Calibration of the detector was performed at least three times on each day against two standard air mixtures that had been certified by the U.S. Bureau of Mines. However, the reference gas used in evaluating each sample was taken directly from ambient air, because the helium content of the air above ground was found to be indistinguishable, to within the precision of our calibrating technique (± 9%), from the fraction of helium regularly found in the atmosphere (5.24 ppm).

Although the variations in helium abundance along the sampling line did not exceed the limits of uncertainty associated with any one measurement, a trend of increasing helium abundance may be discerned within these limits, reaching a maximum somewhere near the position "500-west". This maximum may be associated with the intersection of our sampling line with a north-south fault which we understand lies somewhere under the "2200 North" line.

Also apparent in the data plots is the fact that all samples collected contained at least one percent more helium than is normally found in air. In addition, the average excess of helium on the first day was about 2% above normal, whereas on the second day it was only about 1%. This decrease in helium abundance in the soil gases on the second day may have been caused by the simultaneous increase by about eight millibars (≈ 1%) in ambient barometric pressure.

The conslusions that may be drawn from this preliminary visit to the Roosevelt Hot Springs are:

a) Since helium was readily detected everywhere along the line "2200 North", there is no reason to doubt that our system could be used to map the extent of the reservoir that underlies that area. The magnitude of the effort that would be required to do so may be estimated from the observation that four persons, with a truck-mounted Sniffer and an auxiliary field vehicle, can collect and analyze about 50 samples in the course of a day. If the samples be collected on a half-mile grid, these 50 samples would cover an area which is three miles square (nine square miles).

b) Increasing the resolution of the Helium Sniffer by a factor of two or so, might make it possible to locate subterranean faults, even in a region of enhanced helium content.

c) The interface between the atmosphere and the soil appears to extend at least two feet below the surface in soil of moderate density.

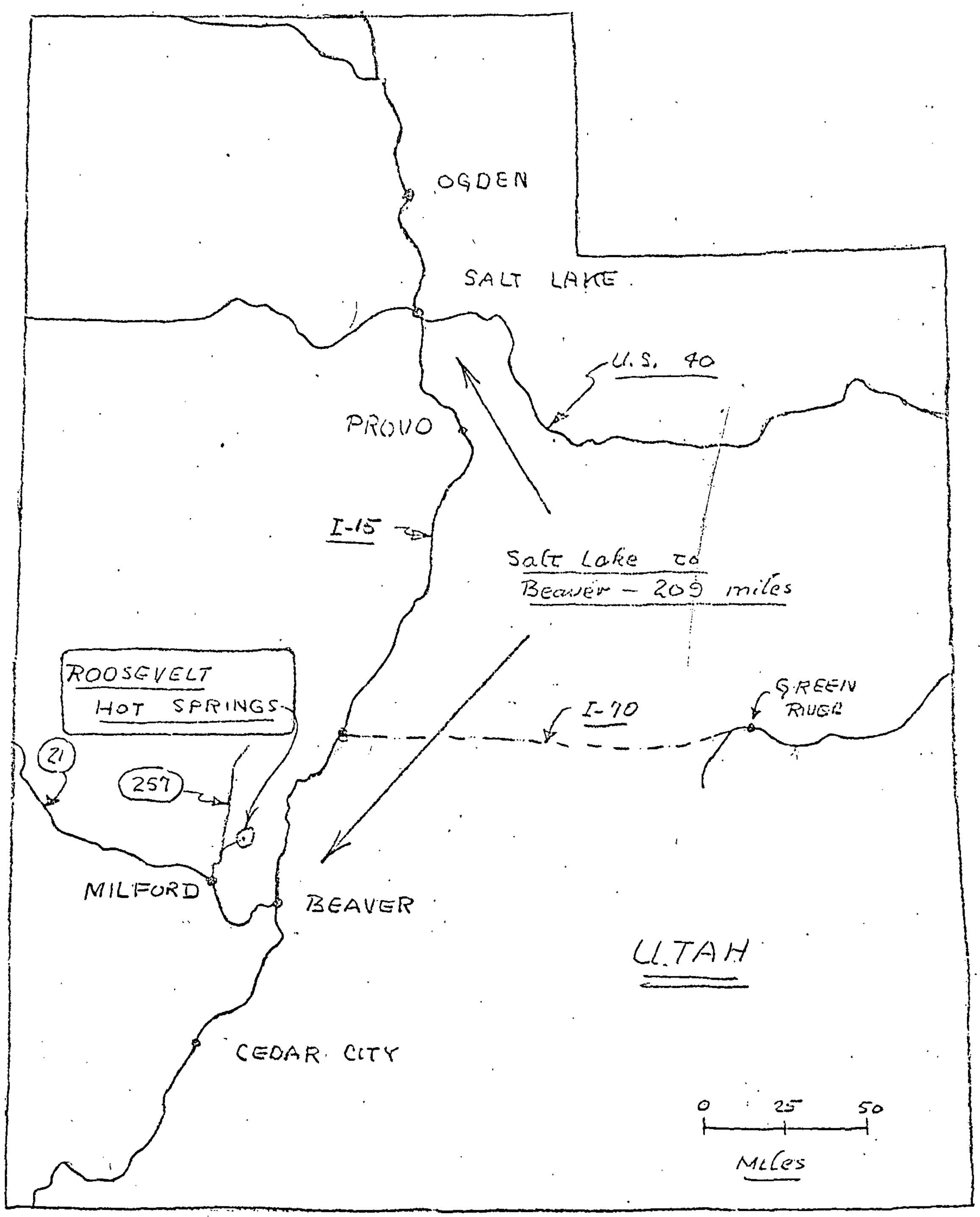
Our thanks are due Professor Stanley Ward, of the University of Utah's Department of Geology and Geophysics, for inviting us to collect our samples along one of the University's base lines, and for his interest in our helium detecting system.

Alan Roberts of the Oil and Gas Branch, USGS, and his two associates, Mary Dalziel and John Lubeck, participated in the collection of samples at this site. The Oil and Gas Branch has provided the principle funding for the development of the Helium Sniffer.

The truck-mounted Helium Sniffer used on this trip was lent to us by Mike Reimer, of the Uranium and Thorium Branch, USGS, who modeled his instrument after the one originally developed by the Isotope Branch.

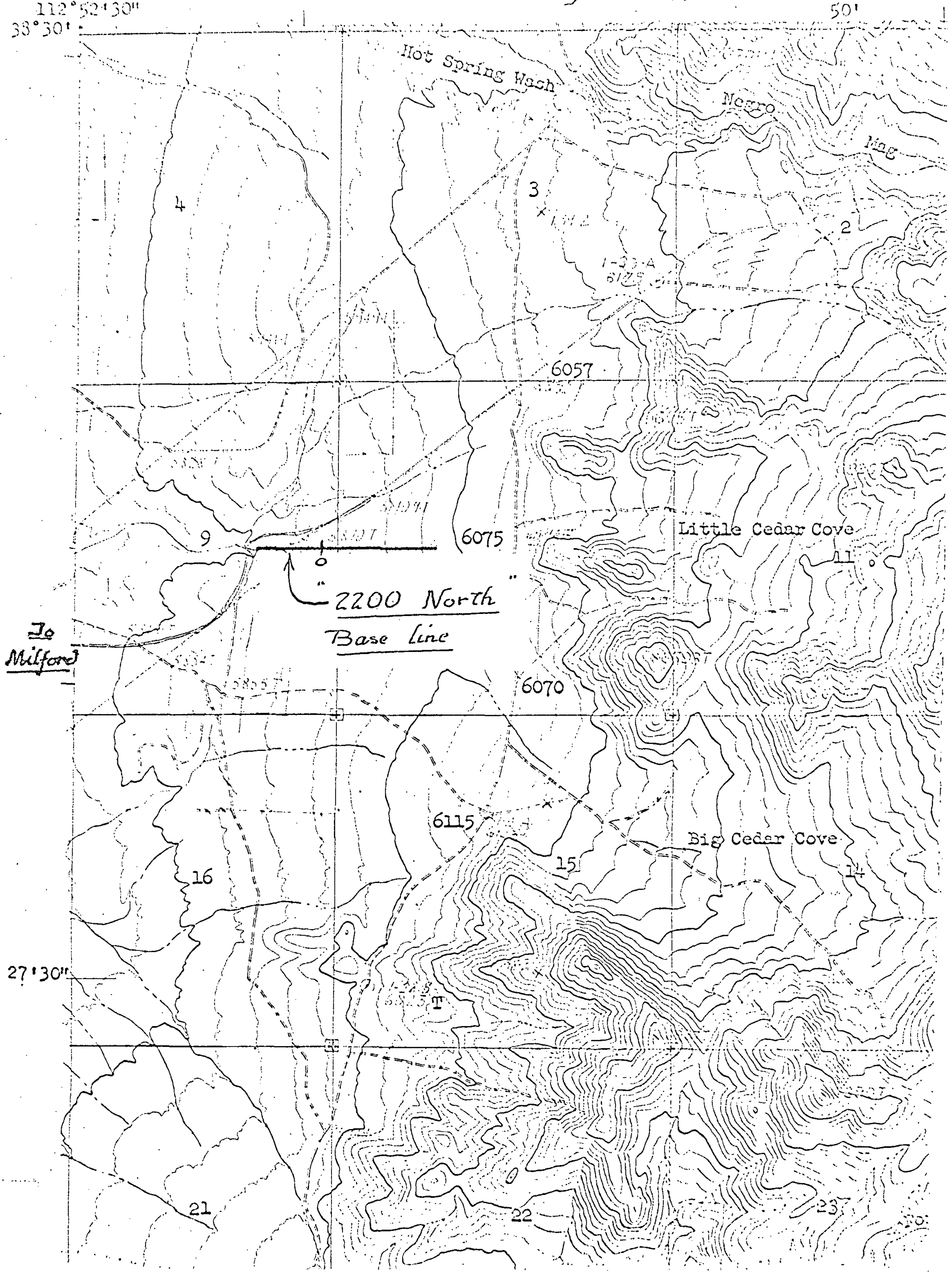
enclosures
ehd

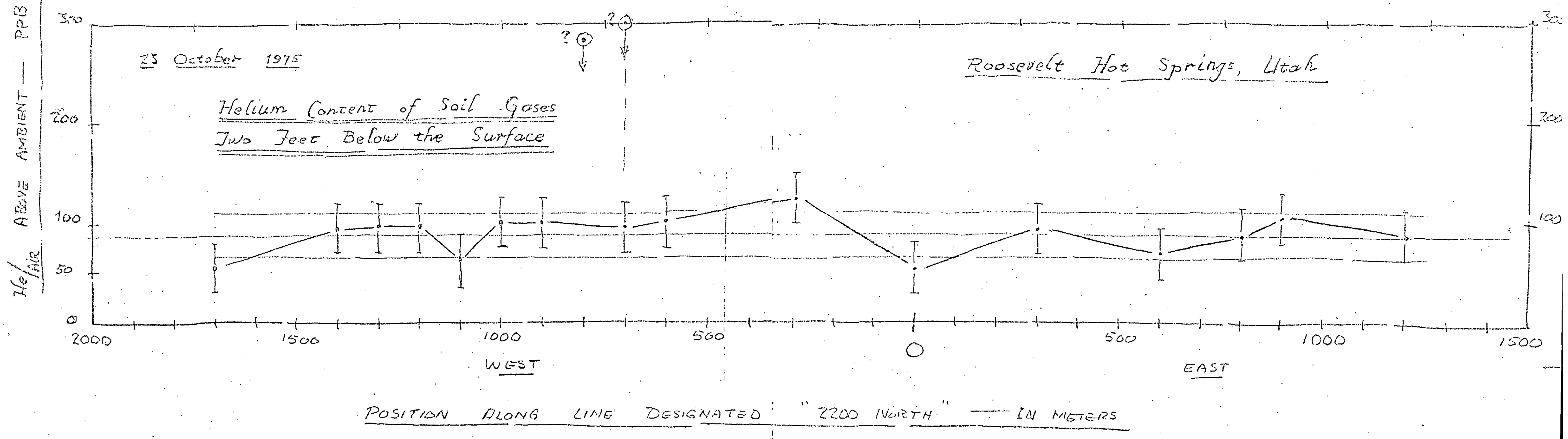
Helium Sniffer ehd 12 Jan '76

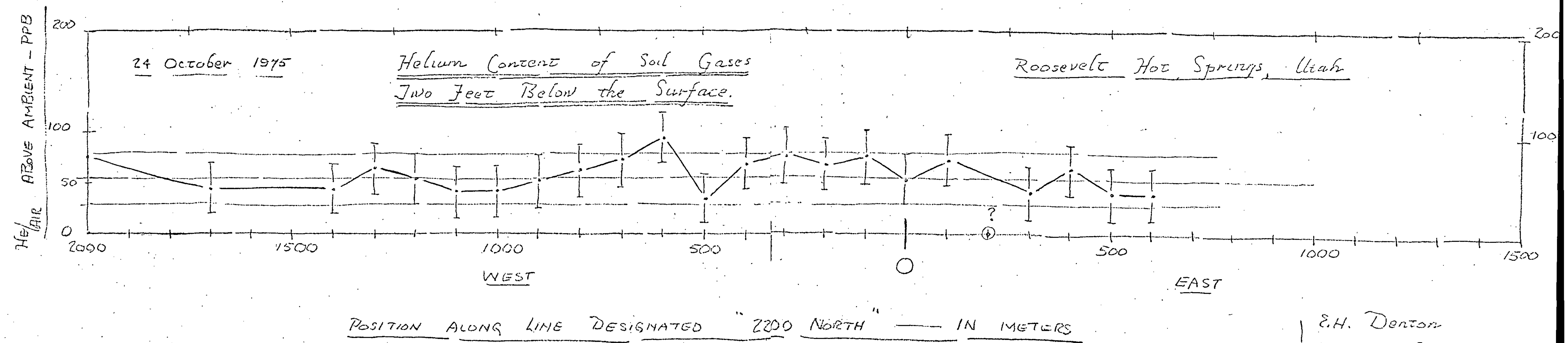


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Minersville 2 NE, Utah
Beaver County 1:24000







E.H. Denton
Isotope Geology
U.S.G.S. - 12 Jan. 1976