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IMPERIAL VALLEY
GEOLOGICAL INVESTIGATIONS
IMPERIAL VALLEY, CALIFORNIA

MASTER

SITE LOCATION REPORT
DEEP GEOTHERMAL TEST WELL

October 1971

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Ellis L. Armstrong, Commissioner
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GEOHERMAL RESOURCE INVESTIGATIONS

IMPERIAL VALLEY, CALIFORNIA

SITE LOCATION REPORT

DEEP GEOTHERMAL TEST WELL

October 1971

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SITE LOCATION REPORT
DEEP GEOTHERMAL TEST WELL
MESA ANOMALY
Imperial County, California

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CONCLUSIONS AND RECOMMENDATIONS

This report summarizes data for use in siting a deep geothermal test well in the East Mesa area of Imperial County, California. The data relate to a geothermal anomaly known as the Mesa anomaly.

It is concluded that:

1. The thermal feature forming the Mesa anomaly is a manifestation of a sizable convective hydrothermal system embracing an area of about 19 square miles and a considerable volume of saturated sediment in the Salton trough.
2. The upper surface of the thermal feature between depths of 200 and 1,000 feet is irregular being shaped somewhat by ground-water movement. The area of greatest apparent heat flow is in SE $\frac{1}{4}$ of Sec. 6, T. 16 S., R. 17 E., and has a diameter of about $\frac{1}{2}$ mile. This area is an attractive drill site.
3. The convective hydrothermal system regulating heat flow to the shallow subsurface is not known in detail but iso-resistivity maps suggest it exerts direct influence on near surface water temperature and salinity over an area of some 19 square miles.
4. The mineral concentration of the ground water in this system will range from a minimum of about 3,000 ppm to a probable maximum of about 30,000 ppm.

It is recommended that:

1. A geothermal test well be sited in the SW¹₄NE¹₄SE¹₄, Sec. 6, T. 16 S., R. 17 E., SBM.

2. The test well be programmed to a maximum depth of 8,000 feet, but may be completed as a steam well at shallower depth depending upon temperature conditions encountered.

INTRODUCTION

The Bureau of Reclamation has, through cooperative investigations with the University of California at Riverside, defined geothermal anomalies on Federal lands presently withdrawn for Reclamation purposes in the East Mesa area of Imperial Valley, California. The results of these investigations justify drilling an 8,000-foot test well on the Mesa anomaly to obtain steam and hot brine. The purpose of this report is to recommend a site for the test well.

Geologic and geophysical data summarized in this report are evaluated and presented in maps and text in support of the site selection. Geologic data were obtained from subsurface logs including, primarily, geophysical logs of 18 of the shallow test holes and available "wildcat" oil test wells. Geophysical data were obtained through the following field examinations in the period 1969-1971: (1) geothermal gradient measurements in approximately 50 test holes ranging in depth from 100 to 1,406 feet; (2) gravity surveys with station spacing ranging from several miles throughout much of the East Mesa area to $\frac{1}{2}$ mile spacing on the Mesa anomaly; (3) seismic ground noise survey of the Mesa anomaly with one mile spacing between observations; and (4) resistivity surveys with a broad spacing of measurements.

From the data developed and reported herein, it is recommended the test well be sited in the SW $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$, Sec. 6, T. 16 S., R. 17 E. The site is about 10 miles east of Holtville in Imperial County, California, and is accessible over 8.3 miles of two-lane highway and 1.7 miles of sandy trail suitable only for 4-wheel drive traffic.

Approximately 1.7 miles of access road must be constructed. The roadway subgrade and surface would be constructed of clay and silt fines. It would be 20 feet wide and would be compacted by wetting and traffic. A drilling site, roughly 300 feet in diameter, would be bladed and surfaced with silt and clay fines and compacted by wetting and traffic. The site would have room for employee and visitor parking. Materials for the roadway and drill site would be hauled from pits of clay and silty clay developed nearby. Haul distances would range from 1 to 4 miles.

Water for road construction and maintenance, drilling, cooling, and general rig use would be piped from the East Highline Canal and stored in tanks and lined pits at the site.

Drilling supplies, well services, and logging services are available out of the Long Beach, California, area, a distance of about 200 miles.

GEOLOGY

The Mesa anomaly is on the east flank of the Salton structural trough. Seismic refraction profiling indicates that granitic and metamorphic bedrock is at a depth of about 11,000 feet. Wildcat oil test wells have been drilled 3.6 miles northeast and 2.8 miles southeast of the proposed site to depths of 10,624 and 8,017 feet, respectively. These wells penetrated predominantly deltaic sediments. Electric logs of these wells show a sequence of clay and sand beds, with minor silt beds. Sand is predominant throughout the section as indicated by

Map 1241-300-17. The values given for each 500 feet throughout the depth of each hole represent the average percent volume of sand bodies. The values range from 42 to 92 percent. The average in the American Petrofina No. 27-1 well is about 66 percent, and in the Barbara Shafer No. 1 well, about 72 percent.

GEOPHYSICAL SURVEYS

The results of geophysical surveys performed to establish the potential of the site are given in Maps 1241-300-17, 14, 15, 16, 18, 19, 20, and 21.

Map 1241-300-21 is a geothermal gradient map showing increases in temperature with depth. Specially designed test holes were drilled to obtain the geothermal gradient. They were drilled by conventional rotary methods and completed with small diameter (3/4" to 2") pipe, with a seal at the base. The pipe was cemented in place, filled with water, and capped. Temperature measurements were made with a thermistor probe. These measurements were repeated in each test hole until thermal equilibrium was attained.

Temperature measurements were processed and evaluated to produce maps showing the general shape of the upper part of the thermal feature at Mesa anomaly and its drift with depth. Geothermal patterns at 200-, 400-, and 600-foot depths, suggests that the shape of the thermal feature is irregular at shallow depth, disturbed, perhaps, by ground-water movement. Its areal extent becomes smaller with depth. It is recognized that the thermal feature in the SE $\frac{1}{4}$ of Sec. 6, T. 16 S., R. 17 E.,

may be a single manifestation of a deeper, and substantially larger, convective hydrothermal system.

The maximum depth of the test holes on this anomaly is 1,406 feet in DH-127; therefore, these maps show little of the convective hydrothermal system that is regulating the heat flow to the shallow subsurface. If measured geothermal gradients are projected linearly, temperatures of around 400°F. can be expected at 4,500-foot depth.

The complete Bouguer anomaly map (see Map 1241-300-14) shows a positive anomaly in the Mesa anomaly area. After removal of regional effects arising from basement and upper crustal rocks, the residual gravity map (1241-300-15) shows a 4 milligal closure with its center embracing about one square mile in parts of Sections 5 and 6, T. 16 S., R. 17 E.

This anomaly indicates that a mass surplus exists under the area. The mass surplus could be explained by geothermal conditions which cause silica deposition, baking of clay sediments, and possibly low-grade metamorphism.

Although magnetic surveys were not performed in the East Mesa area by the Bureau or its cooperator, some surveys performed by private interests were made available for inspection. There is no evidence of a magnetic anomaly corresponding to the Mesa geothermal anomaly.

The results of a seismic ground noise survey performed by Teledyne-Geotech of Dallas, Texas, is included in this report (see Map 1241-300-16). The map of this survey shows high ground noise in the

southern and southeastern parts of the Mesa anomaly. According to Teledyne personnel, the ground noise map is contoured in terms of total power in the passband between 3.0 and 5.0 Hertz, which Teledyne converted to decibels (dB) of power using:

$$\text{Power (dB)} = 10 \log_{10} (\text{observed power})$$

The original spectra from which these data were obtained are in units of millimicrons per second squared per Hertz $\sqrt{\text{MU}/(\text{Sec})^2/\text{Hz}}$. The physical relationship of this map to the foregoing geophysical maps is readily evident by overlaying all the maps. This map has produced a more complicated pattern for the anomaly.

A resistivity survey was made of a large part of the Imperial Valley, including the Mesa anomaly (see Figure 1). This survey was reconnaissance in character because of limited funds. The results showed a 5 ohm-meter closure embracing the Mesa anomaly as defined by other geophysical methods. The area is approximately 19 square miles, thus giving insufficient definition to site a deep test well because the resistivity contours could not be related precisely to the shape of the thermal feature in the SE $\frac{1}{4}$ of Sec. 6, T. 16 S., R. 17 E.

GROUND-WATER AVAILABILITY

The sediments underlying the Mesa anomaly are saturated from a few feet below land surface to their base. The capacity of these sediments to store and transmit water is estimated from geophysical logs.

LONGITUDINAL RESISTIVITY TO 1000 FT. SUBSURFACE
IMPERIAL VALLEY, CALIFORNIA

FIGURE 1

Porosities were determined by Dr. Jim Combs (University of California, Riverside) from a sonic log of the American Petrofina No. 1-27, using a technique that corrects for shale content and compaction. The values he obtained are shown in Figure 2. These porosities are considered general for the Mesa anomaly; hence, a substantial quantity of water is stored there that can be quantified as we obtain the actual dimensions of the convective system.

More important is the recoverable storage based upon the effective porosity. Geophysical logs, including dual induction, compensated density, and sidewall neutron porosity were run in DH-127 to measure effective porosity and permeability. Data from these logs were processed into a "Saraband" log of porosities. Also values of porosity and permeability were tabulated for each foot of strata penetrated between 204 and 1,400 feet. Effective porosity weighted by lithologic intervals ranged from about 5 to 45 percent and averaged between 20 and 30 percent. The effective porosity of the prominent sand beds ranged between 30 and 40 percent.

The above porosity values are regarded to be closely related to permeability in this geothermal environment wherein formation drainage is enhanced by the occurrence of low density water. The yield of water expected from a well can be estimated on the basis of permeability of the producing formations and the temperature of the water in them.

The mineral quality of the ground water can only be estimated. Water produced from the lower part of DH-127 (1,355 to 1,398 feet) had a total dissolved solids content of 3,320 ppm. predominantly sodium

POROSITY DETERMINATION
FROM SONIC LOG OF AMERICAN PETROFINA NO. 27 -1
IMPERIAL COUNTY, CALIFORNIA

and chloride ions. The iso-resistivity map shows an area of high temperature saline ground water relative to that in the surrounding area. As previously stated, the area covers about 19 square miles including the Mesa anomaly. This suggests the occurrence of a substantial convective hydrothermal system, but the precise range of mineralization within that system is not known. Regional correlation afforded by the iso-resistivity map (Figure 1) suggests it is substantially less saline than the Salton Sea geothermal field to the northwest.

SUMMARY

In the area of the Mesa geothermal anomaly, the subsurface consists of a sequence of predominantly sandy deltaic sediments at least 11,000 feet thick. Geothermal gradient surveys indicate high temperatures in the shallow subsurface. These thermal conditions are associated with a gravity high (which suggests metamorphism and/or mineralization caused by high temperature) high seismic ground noise (possibly caused by high temperatures), and low resistivity values (caused by high temperatures and/or high salinity). Geophysical logs indicate that the prominent sand bodies have effective porosities ranging from 20 to 40 percent. Permeabilities throughout the sand bodies, in addition to the low density of the contained hot water, suggest high yields can be obtained from a properly designed well. In conclusion, the geological, geophysical, and ground-water conditions of the Mesa geothermal anomaly make it an attractive drilling site to explore for steam and geothermal brine.

NOTE
Data Calculated and Interpreted by Walter Randall,
University of California, Riverside, Sept. 9, 1971

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GEOHERMAL RESOURCE INVESTIGATIONS
IMPERIAL VALLEY, CALIFORNIA
MESA ANOMALY
AVERAGE PERCENT VOLUME OF SAND BODIES
IN THE SEDIMENTARY SECTION
GEOLOGIC FENCE DIAGRAM
MAP NO. 1241-300-17
SCALE OF FEET
0 2000 4000 6000 8000 10000
SEPTEMBER 1971

OCTOBER 1951
 SCALE 1:50,000
 MAP NO. 1512-200-4
COMPLETE BOULDER ANOMALY MAP
NEPA ANOMALY
 INDIANIA AVIATION, CALIFORNIA
GEOTHERMAL RESOURCE INVESTIGATIONS
 BUREAU OF RECLAMATION
 DEPARTMENT OF THE INTERIOR
 UNITED STATES

NOTE
 The map is a compilation of data from various sources and is not intended to be used as a basis for legal claims.

EXPLANATION
 * MAGNETIC ANOMALY
 ○ GEOTHERMAL STATION
 ● GEOTHERMAL STATION
 — GEOTHERMAL STATION
 — GEOTHERMAL STATION

- EXPLANATION**
- 100°F Isotherm in Degrees Fahrenheit
 - Contour Interval 5° Fahrenheit
 - Thermal Drill Hole
 - ★ Wildcat Oil Test Hole

NOTE
 Data Compiled and Interpreted by Jim Combs,
 University of California, Riverside, Sept. 8, 1971

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GEOTHERMAL RESOURCE INVESTIGATIONS
 IMPERIAL VALLEY, CALIFORNIA
 MESA ANOMALY
 ISOTHERMS IN DEGREES FAHRENHEIT
 AT DEPTH OF 200 FEET

MAP NO. 1241-300-18
 SCALE OF 1" = 1 MILE
 SEPTEMBER 1971

DECEMBER 1951
SCALE OF FEET
0 500 1000
MAP NO. 1541-200-50
AT DEPTH OF 600 FEET
ISOHERMS IN DEGREES FAHRENHEIT
MAYE-MEDWELER LEXVCO
GEOHERMAL RESOURCE INVESTIGATIONS
BUREAU OF RECLAMATION
DEPARTMENT OF THE INTERIOR
UNITED STATES

NOTE
Isotherms are based on data from the Maye-Medweler Lexvco. The isotherms are based on data from the Maye-Medweler Lexvco. The isotherms are based on data from the Maye-Medweler Lexvco.

EXPLANATION
Isotherms
Wells
Other features

EXPLANATION

— Contours are given in Decibels (dB) relative to 1 (0.0001 microvolts per second) per Hertz in the frequency of 1.0 to 5.0 Hertz.

NOTE

Data compiled and interpreted under the technical direction of E. J. Douse, Telephone Geophysics, Dallas, Texas, August 1971.

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GEOHERMAL RESOURCE INVESTIGATIONS
IMPERIAL VALLEY, CALIFORNIA
MESA ANOMALY
SEISMIC GROUND NOISE

MAP NO. 1041-100-15
SCALE OF FEET
1" = 1 MILE
SEPTEMBER 1971