SHELL'S ACTIVITY IN THE GEYSERS AREA

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Shell has drilled one dry hole and one commercial discovery in The Geysers area of northern California. The dry hole was hot (± 447°F) but failed *to* encounter fractures necessary for commercial steam recovery. The discovery producer, located one and one-half miles south of The Geysers field, encountered dry steam flowing at rates of about 200,000 lb/hr. A confirmation well is currently being drilled.

Temperature gradients range from 2-4°F/100 ft. above 3,000 ft. and from 6-8°F/100 ft. from 3,000 ft. to the steam reservoir. The reservoir temperature (±465°F) and pressure (±500 psia) are typical of The Geysers area. Local concentrations of hydrogen sulfide in excess of 3,000 ppm were encountered in one well.

Shell started acquiring acreage in 1971, and now holds 15,000 acres (Fig. 1). Two Federal leases, U.S. One (2477 acres) and U.S. Two (1600 acres) were acquired in January 1974 in the first Federal geothermal competitive lease sale.

U.S. Geothermal Two-1 was drilled to explore for fractured reservoir conditions in the objective Franciscan graywacke interval below serpentine sealing rocks. Two serpentine beds were encountered at depths of 2,300 ft. and 4,000 ft. in the original hole. Graywacke and interbedded volcanic rocks were penetrated below these beds. Several steam shows were noted below 4,000 ft. and a static temperature of 325°F was calculated from a wire line survey at 4,070 ft. However, stuck pipe forced abandonment of the hole at a true vertical depth of 6770 ft.*

The well was then redrilled from 2,770 ft. to 8125 ft. Several non-commercial steam shows were encountered in the redrilled hole below a serpentine bed at 4170 ft. A wire line survey indicated a formation temperature of 447°F at 6,150 ft. (Fig. 2). The average static temperature gradient in the interval from 3,000 ft. to 6,150 ft. is 5.8°F/100 ft. The well was plugged, and abandoned at 8120 ft. and no temperatures were obtained below 6,150 ft. Geologic and temperature conditions encountered in this hole indicate commercial steam reserves should be present on this U.S. Geothermal leasehold.

Our discovery well, U.S. Geothermal One-1, spudded in June 1975 and encountered commercial steam on July 10, 1975, at 4920 ft. in the fractured Franciscan graywacke (Fig. 3). Bad hole conditions prevented our obtaining static temperature data from the well. However, nine separate readings were taken with maximum reading thermometers. This data shows a gradient of about 8.1°F/100 ft. in the interval from 3000 ft. to 3870 ft. (Fig. 2). This well has a low geothermal gradient (2.3°/100 ft.) above 3000 feet which may be the results of shallow groundwater movement.

*All depths are true vertical depths.

Shell-U.S. Geothermal One-1 was flow tested using three different orifice plates. Average flow data are as follows:

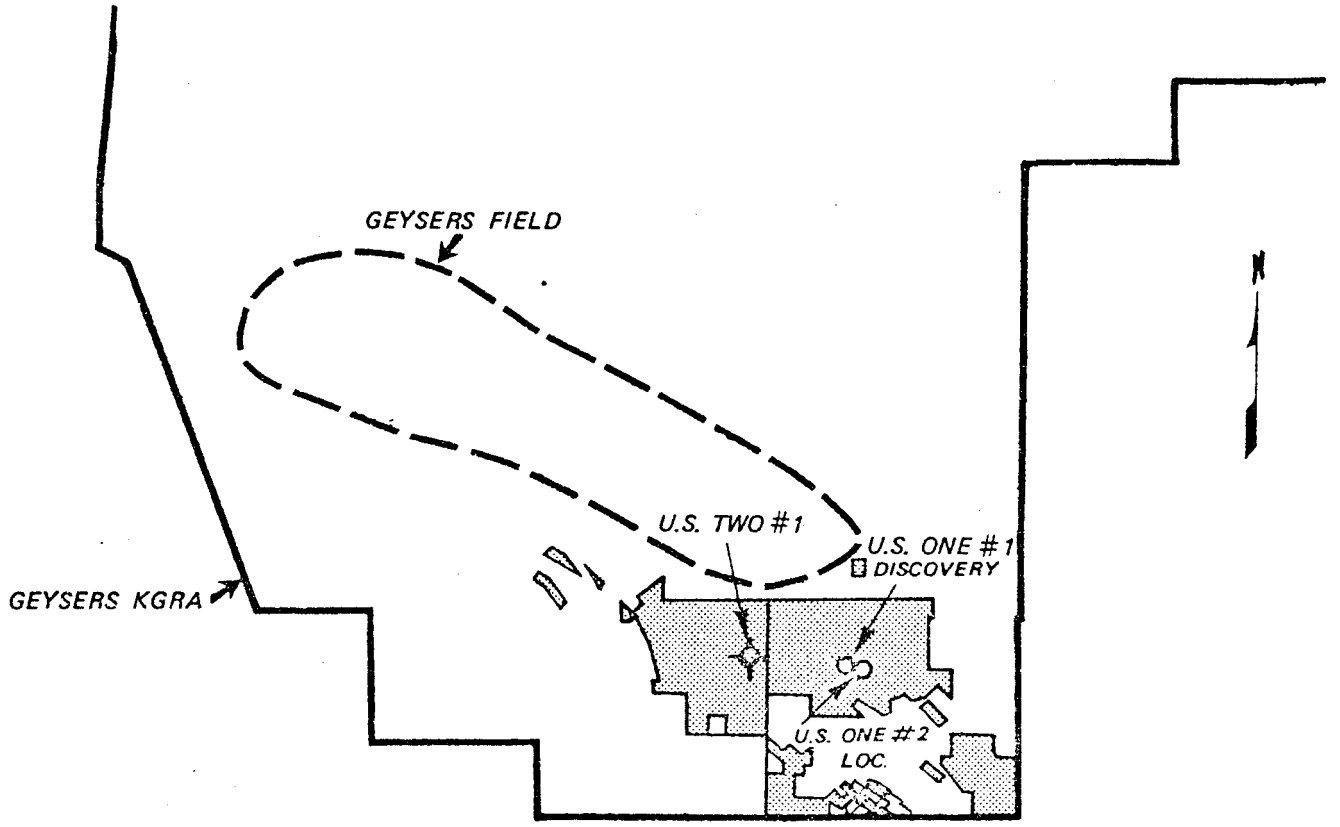
Orifice Size (in.)	Pressure (psia)	Temperature (°F)	Rate MLB/HR	Quality
6	149	353	183	.96
7 1/2	96	320	191	.99
8 3/4	75	306	195	1.00

Flow test and calorimeter data indicate the well has an absolute open flow potential of approximately 200,000 lbs/hr dry steam. However, the range of orifice plate sizes was too narrow to accurately determine the maximum rate or AOFP coefficient and exponent. A flow stream sample had the following composition:

Constituent Gas	Mole Per Cent
Hydrogen	2.292
Nitrogen	9.712
Oxygen	0.012
Carbon Dioxide	48.783
Hydrogen Sulfide	0.000
Carbon Monoxide	0.000
Oxides of Nitrogen	0.000
Methane	28.598
Ethane	0.020
Benzene	0.015
Toluene	0.017
Xylene	0.008
Water	10.543

PARTIAL GEOCHEMICAL ANALYSIS (Water)	
Sulfate, mg/l	10
Chloride, mg/l	14
Bicarbonate, mg/l	88
Borate, mg/l	26
Organic Acids, mg/l	110
Specific Gravity 1.003 @ 60°F.	
Resistivity 5,150 Ohm Cm @ 75°F.	
pH Value	7.20

Our confirmation well, Shell-U.S. Geothermal One-2 was spudded 7/31/75 and drilled to 7680 ft. The temperature gradient (Fig. 2) in this well was 3.8°F/100 ft. above 3000 ft. and 8.1°F/100 ft. in the interval from 3000 ft. to 4490 ft. A small steam flow of 50,000 lbs/hr was encountered at a depth of 6780 ft. The flow stream contained approximately 80 ppm hydrogen sulfide. This bore was plugged back from 7680 ft. and sidetracked from 4560 ft. Another small steam flow of 12,000 lbs/hr. was encountered in the redrill at 4840 ft. Hydrogen sulfide content exceeded 3000 ppm so the redrill borehole was plugged at 5250 ft. and a second redrill commenced at 2080 ft. We are currently drilling below 6000 ft.



-LEGEND-

0 1 2 3 4 5
SCALE IN MILES

SH LL U.S. LEASING UNITS

1974 DRY HOLE

1975 PROGRAM

GEYSERS GEOTHERMAL PROJECT

ZW-66

FIGURE 1

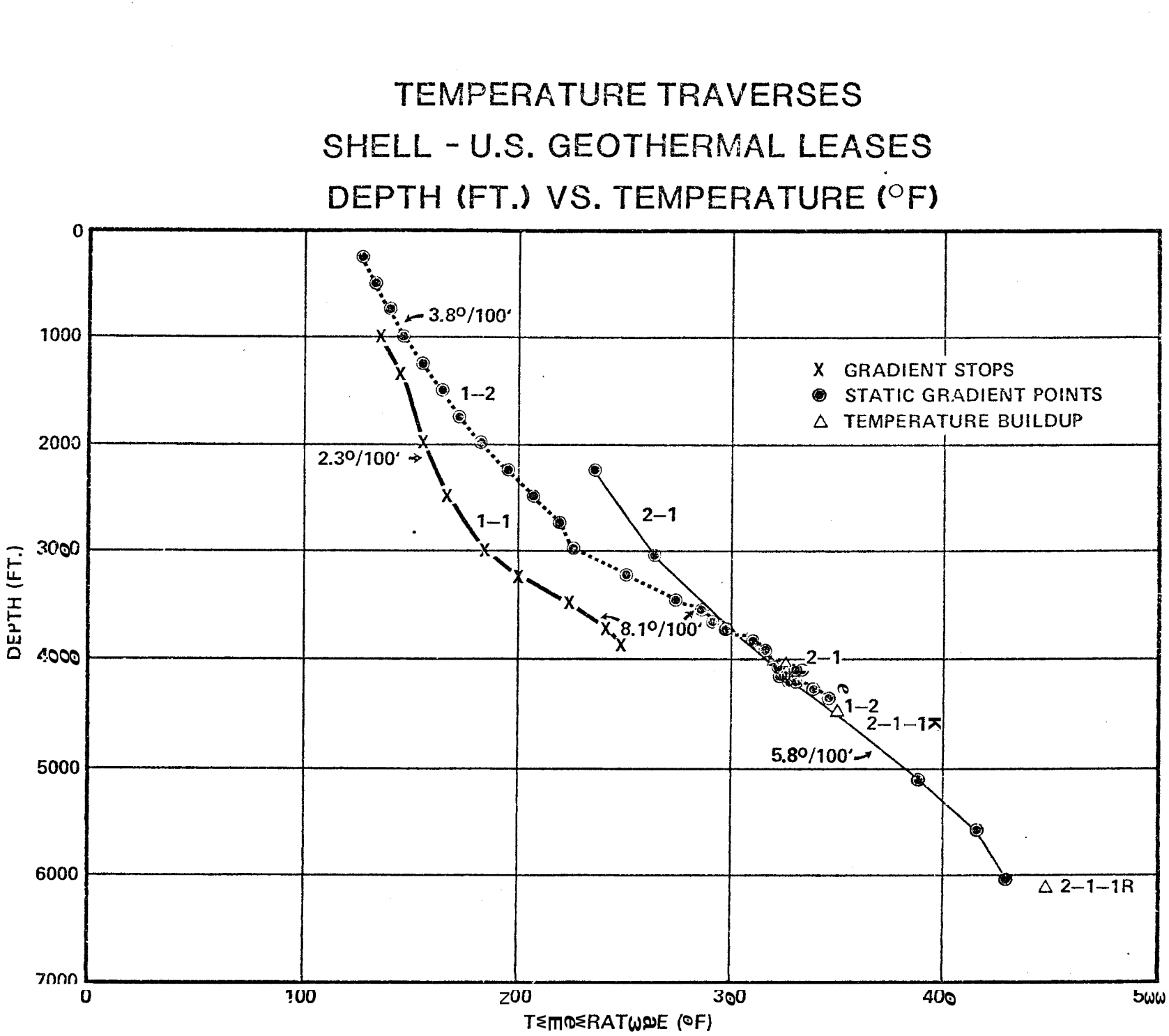

TEMPERATURE TRAVERSES
SHELL - U.S. GEOTHERMAL LEASES
DEPTH (FT.) VS. TEMPERATURE (°F)
DEPTH (FT.)
TEMPERATURE (°F)
0
1000
2000
3000
4000
5000
6000
7000
100
200
300
400
500
3.8°/100'
1–2
2.3°/100'
1–1
2–1
8.1°/100'
2–1
1–2
2–1–1R
5.8°/100'
△ 2–1–1R
X GRADIENT STOPS
STATIC GRADIENT POINTS
△ TEMPERATURE BUILDUP

FIGURE 2

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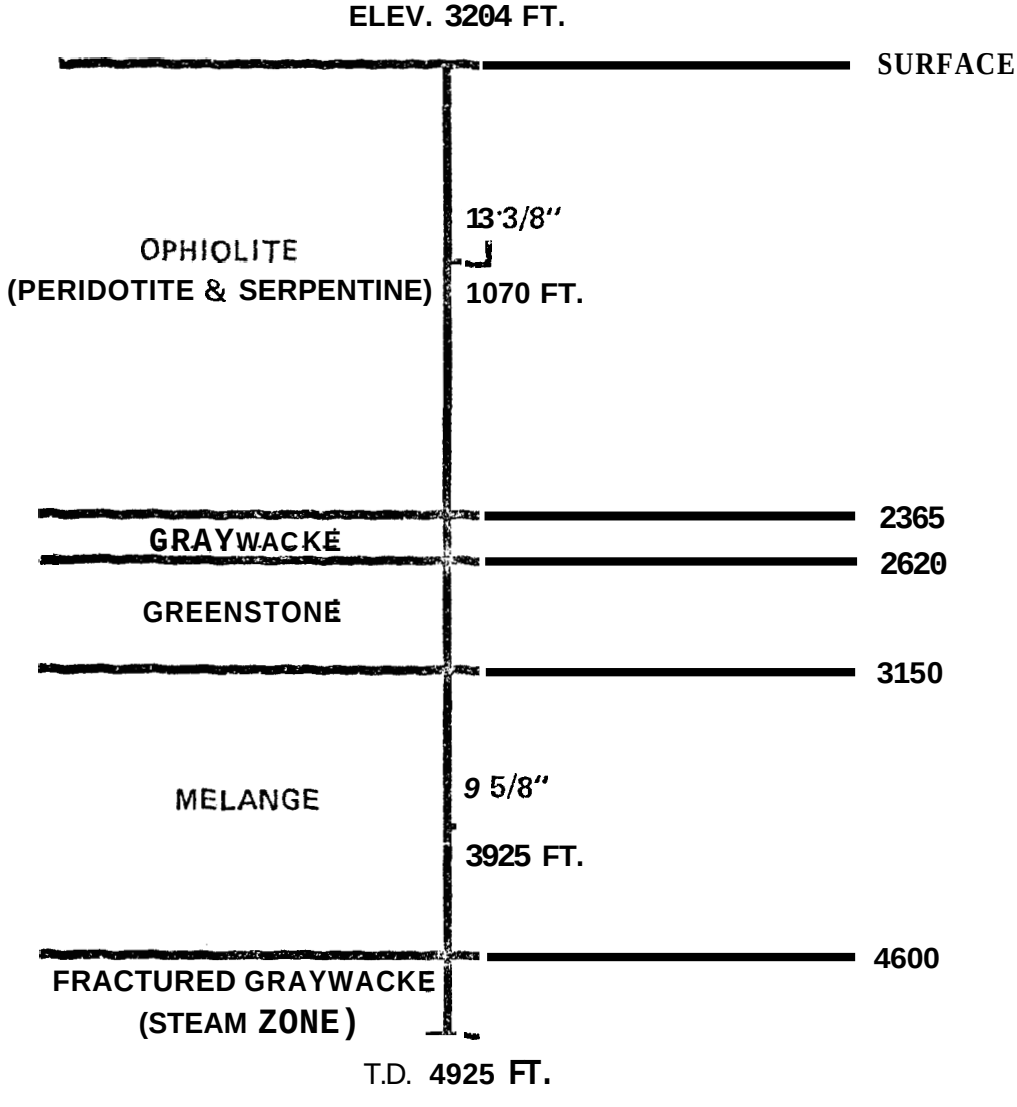
U.S. GEOTHERMAL ONE #1



SEQUENCE OF ROCK TYPES

FIGURE 3