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INTER-OFFICE CORRESPONDENCE SHEET

SUN OIL COMPANY

SUBJECT: GEOTHERMAL PROJECT **DATE:** April 10, 1967

FROM: G. W. Berry **OFFICE:** Boulder, Colorado

TO: Mr. R. R. Anderson
Philadelphia

Dear Sir:

I forward the attached three (3) copies of Geothermal Project progress report "Thermal Data of the Black Rock Desert Area," dated April 10, 1967, by Hadsell, Grose, and Berry. Drs. Hadsell and Grose are consultants to Sun on this project, so this is a Company report. There is a summary on p. 1 and 2.

Sincerely,

G. W. Berry

GWB:bn

Enclosure

cc: Mr. J. E. Gilbert (w/att)

DISCLAIMER

THERMAL DATA OF THE BLACK ROCK DESERT AREA

HUMBOLDT AND WASHOE COUNTIES, NEVADA

FRANK HADSELL, L. T. GROSE, AND G. W. BERRY

APRIL 10, 1967

Summary:

This is a progress report on analysis of thermal data from the Black Rock Desert of northwest Nevada. Hot springs at Soldier Meadows, Fly Ranch, Gerlach, and Pinto Mountains were mapped, and water flows and temperatures measured, by G. W. Berry and G. R. Downs in 1965 and 1966. These data have been studied further by Frank Hadsell (geophysicist) and L. T. Grose (geologist) at the Colorado School of Mines and with the computer facilities of the School of Mines Graduate Research Center, in an effort to determine geothermal power potentials.

Power generation by hypothetical Carnot engines has been calculated for the four thermal areas. Data from seven prospect holes at Pinto Mountains have been exploited in plotting geothermal gradients and computing heat flows. It is emphasized that this report is to a large extent an exercise in arithmetic and thermodynamics, fraught with assumptions that may not endure. All of the

conclusions are tentative. However, we consider this a valid line of practical research. To the extent that the figures and conclusions are applicable, they are generally encouraging in themselves and in comparison with those of developed geothermal areas, as to the geothermal power potential of Sun acreage in the Black Rock Desert area.

Relative Merit of Hot Springs:

Water flows and temperatures can be interpreted best in terms of an extensive thermodynamic quantity which places proper relative emphasis on them. The quantity adopted for this study is the power of a hypothetical Carnot engine (Figure 1), ideally operating between the hot heat reservoir of a thermal spring and a cool heat reservoir at the mean air temperature of the area. The engine is imagined to extract heat from the hot reservoir at a rate equal to the rate at which heat is transferred from the hot spring to a surface stream at mean ambient temperature by normal flow of water, Q_1, less the rate at which this water transfers heat back into the ground, Q_2. The engine is then imagined to convert the theoretical maximum of the extracted heat into mechanical energy. The existence of this maximum is an expression of the second law of thermodynamics.

In this hypothetical problem the selection of Q as the heat flow into the Carnot engine is arbitrary, made

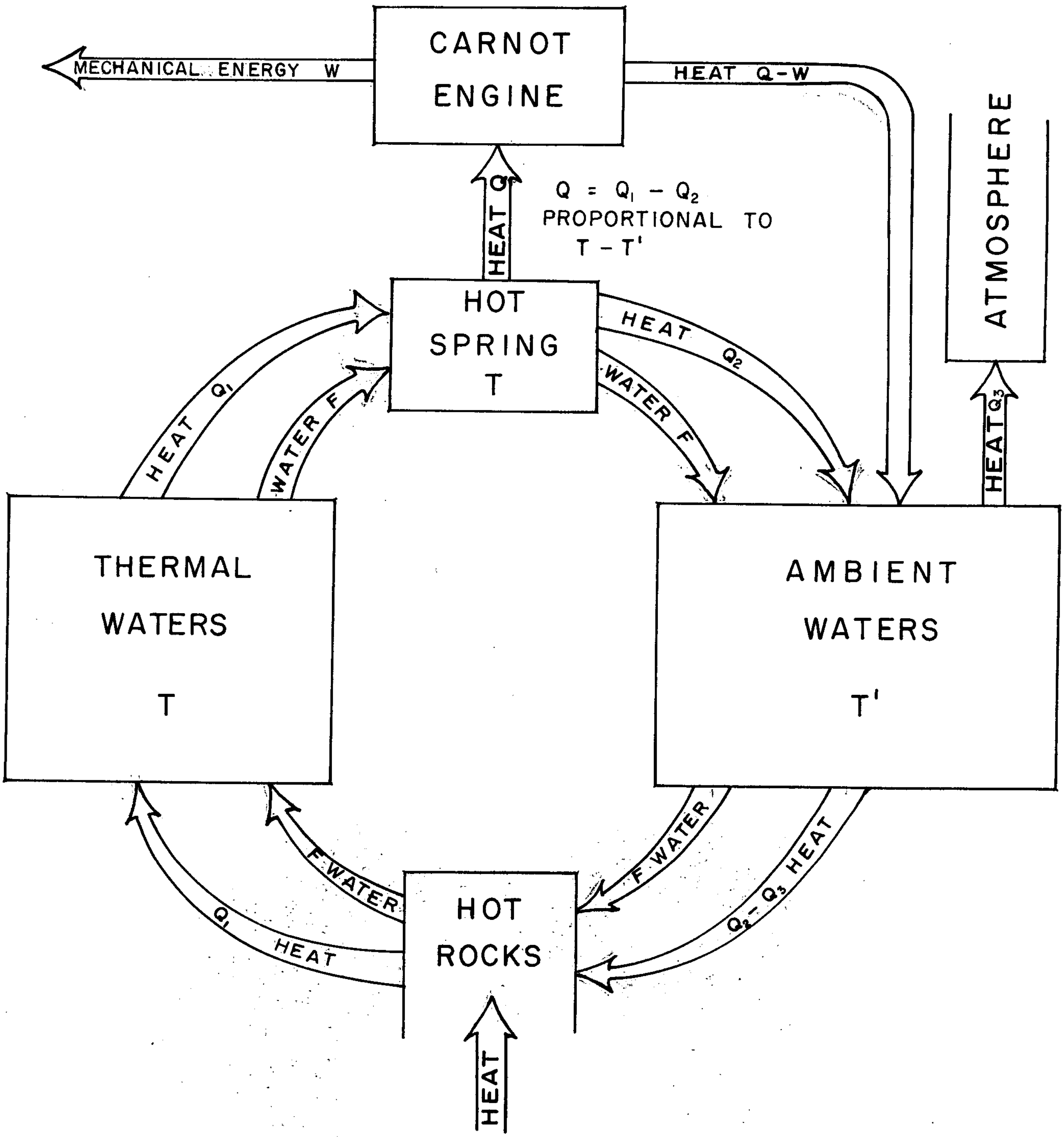

CARNOT ENGINE
MECHANICAL ENERGY W
HEAT Q-W
ATMOSPHERE
HEAT Q
Q = Q1 - Q2 PROPORTIONAL TO T - T'
HOT SPRING T
HEAT Q1
WATER F
HEAT Q2
WATER F
HEAT Q3
THERMAL WATERS T
AMBIENT WATERS T'
Q1 HEAT
F WATER
F WATER
Q2 - Q3 HEAT
HOT ROCKS
HEAT

Figure 1

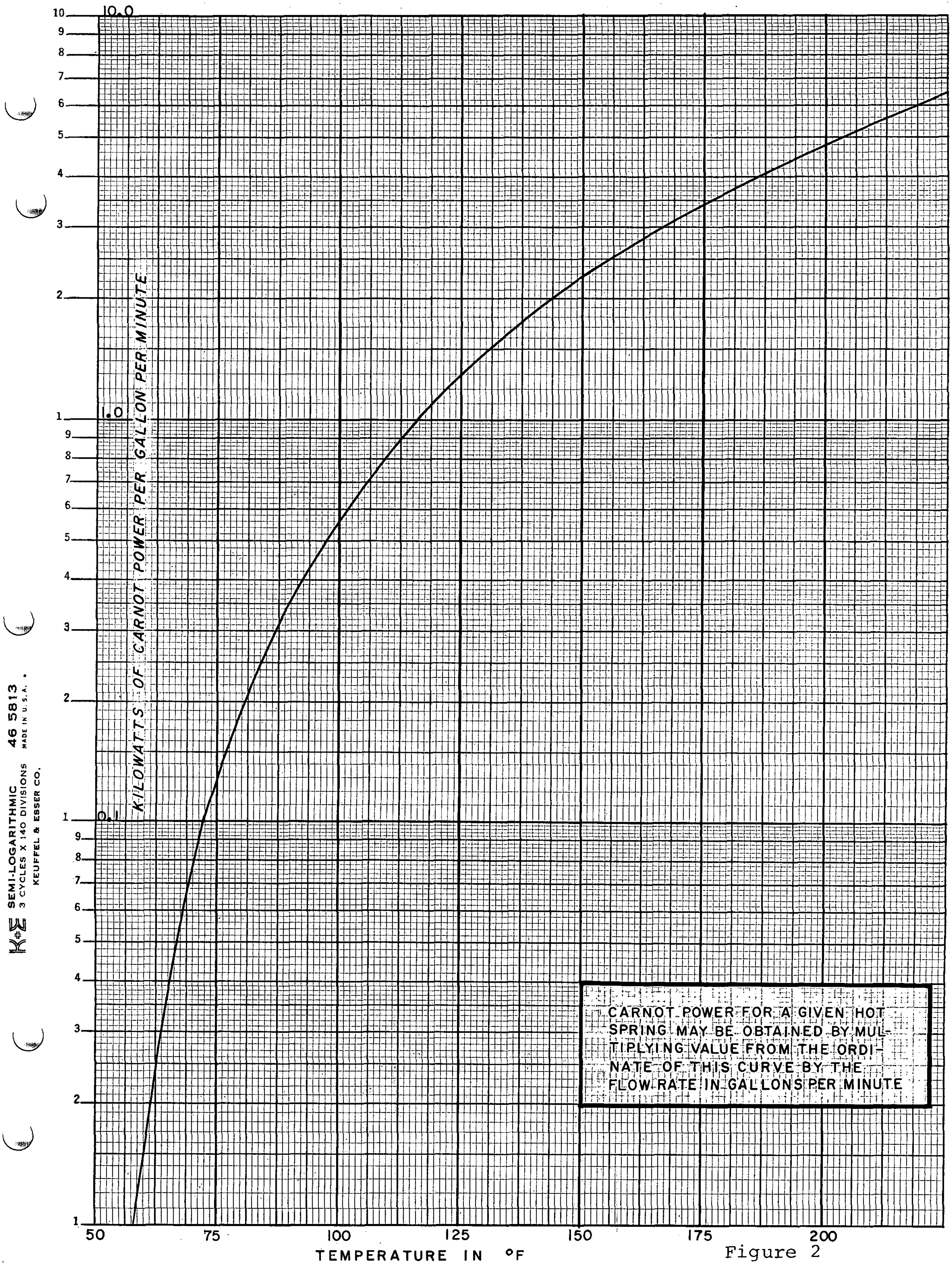

10.0
1.0
0.1
KILOWATTS OF CARNOT POWER PER GALLON PER MINUTE
50
75
100
125
150
175
200
TEMPERATURE IN °F
CARNOT POWER FOR A GIVEN HOT SPRING MAY BE OBTAINED BY MULTIPLYING VALUE FROM THE ORDINATE OF THIS CURVE BY THE FLOW RATE IN GALLONS PER MINUTE
K&E SEMI-LOGARITHMIC 46 5813
3 CYCLES X 140 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

Figure 2

largely on the balanced flow of water it provides; a larger portion of Q_1 could be assumed.

The efficiency, e, of a Carnot engine operating between heat reservoirs with temperatures T and T' is expressed

$$e = 1 - T'/T$$

and the mechanical energy output, W, of the engine is then

$$W = Qe = Q\,(1 - T'/T).$$

If c is the average specific heat between T and T' and m is the mass of water transferred, then,

$$Q = c\,m\,(T - T')$$

and

$$W = c\,m\,\frac{(T - T')^2}{T}$$

and

$$P = 0.081\,G\left(\frac{(T - T')^2}{255 + 5/9\,T}\right),$$

where P is power in kilowatts, G is flow of water in gallons per minute, T is temperature of the hot spring in degrees Fahrenheit, and T' is the mean air temperature of the area in degrees Fahrenheit.

The graph of Figure 2 permits one to obtain the Carnot power output for any spring by a single multiplication.

U. S. Weather Bureau data for northwestern Nevada show mean annual temperatures of 48.2°F to 53.4°F in and near the Black Rock Desert. Downs and Berry (1966) estimated 51°F for Soldier Meadows. Conservatively, we have used 54°F for all of the area in this study.

Summary data for hot springs of the four localities are listed in Table 1. The water flow is from field data by Berry and Downs (1966). Calculations of mean water temperature (flow of all hot springs mixed) and Carnot power are by Hadsell, with computer.

TABLE 1

	Water flow, gpm	Mean water temperature, °F	Carnot power, kw
Soldier Meadows	2842	110	2540
Fly Ranch - natural	934	100	660
Fly Ranch - Western Geothermal well	538	205	2693
Fly Ranch - total	1472	138	3353
Gerlach	253	175	855
Pinto Mountains	142	189	595

The premium which the Carnot power figure of merit places on high temperature is evident in comparison of the Soldier Meadows and Gerlach areas. The water flow of Gerlach is less than one-tenth that of Soldier Meadows, but, because of higher temperature, the Carnot power is more than one-third.

At Wairakei, New Zealand, a wet steam field, drilling has increased mass flow 3 to 5 times and the heat flow 2 to 3.5 times, from natural (McNitt, 1963, p. 39; Grindley, 1965). At The Geysers, California, a dry steam field, drilling (to 1963) has increased mass flow about 20 times and heat flow about 170 times from natural (McNitt, 1963, p. 39). In thermal areas throughout the world, without exception, heat flows have been substantially increased by drilling.

At Fly Ranch, the Western Geothermal well, only 805 ft total depth, has increased the thermal area mass flux 58 percent and the Carnot power output 400 percent.

The Carnot power figures may be useful indicators of relative merit, but they cannot now be equated to geothermal power potential. Such correlation should await development of a catalogue of case histories. If, however, one insists on comparing Carnot power with power sold at a bus bar, he might proceed as follows. Empirically it is sound to assume an increase in heat flow by development drilling, a factor of 170 times at The Geysers. To interpret this increase in terms of Carnot power an assumption must be made concerning the efficiency of a real power plant relative to a hypothetical Carnot engine. Being involved only with orders of magnitude it is reasonable to assume that the efficiency advantage gained by drilling to high temperatures is just offset by the inherently high efficiency of a Carnot engine, 10 to 25 percent in this case. If, then, The Geysers increase in heat flux is representative and the efficiency assumption is valid, one could increase the Carnot power numbers of Table 1 by two orders of magnitude (100X) and get a geothermal power potential for Soldier Meadows of 254,000 kw. Although this is an encouraging number, it should be emphasized again that it is derived with highly tenuous assumptions.

This discussion is limited mainly to analysis of the heat and mass flux of the hot springs. There is additional natural heat flow in the local thermal areas from the relatively dry ground between springs. Stored heat also may be very important. Steamboat Springs, Nevada, is a thermal area at the east foot of the Sierra Nevada, a roughly comparable geological location to the western Black Rock Desert. White (1964, p. 407) has calculated the stored heat in an area of 1.9 square miles at Steamboat, 1.9 miles deep, at approximately 1.6 x 10^{18} cal. This is equivalent to the natural heat flow at the present rate for 7000 years. It is a minimum figure because much excess heat is stored at greater depth and below the surface of surrounding area. Thompson and White (1964, p. 48) have estimated that heat flow in the same 1.9 square miles of Steamboat thermal area is 7×10^6 cal/sec, equivalent to heat from 100 tons of coal or 500 bbl of oil per day.

Power Plant Requirements:

To arrive at an idea of geothermal resource requirements we have arbitrarily assumed a 300,000-kw capacity plant, which, using a rough rule-of-thumb of 1 kw per customer, would supply a city about the size of Dallas or Denver. Gilbert and Berry (1964) concluded tentatively that, for such a plant, the land requirement is in the range of 500-5000 acres, and the water requirement on the order of 20,000 acre-ft per year for dry steam and 50,000 acre-ft per year for wet steam. In their inventory of the water resources of the Sun acreage area in western Black Rock Desert, Gilbert and Berry estimated the perennial yield at 24,500 acre-ft (West arm of Black Rock Desert, Granite Basin, High Rock Lake, Summit Lake, Hualapai Flat). This is legally the maximum that can now be consumed annually. The water flows listed in Table 1 are for four local hot spring areas and certainly are minimum figures. There is considerable additional water discharging in the subsurface in these areas, and there are several additional areas of spring and well discharge. However, at Soldier Meadows, the measured 2842 gpm is 4575 acre-ft per year, or about 10 percent of estimated wet steam requirement. Although water consumption can undoubtedly be lowered by injection, recirculation, and heat exchangers, the availability problem is very real.

Prospect Holes:

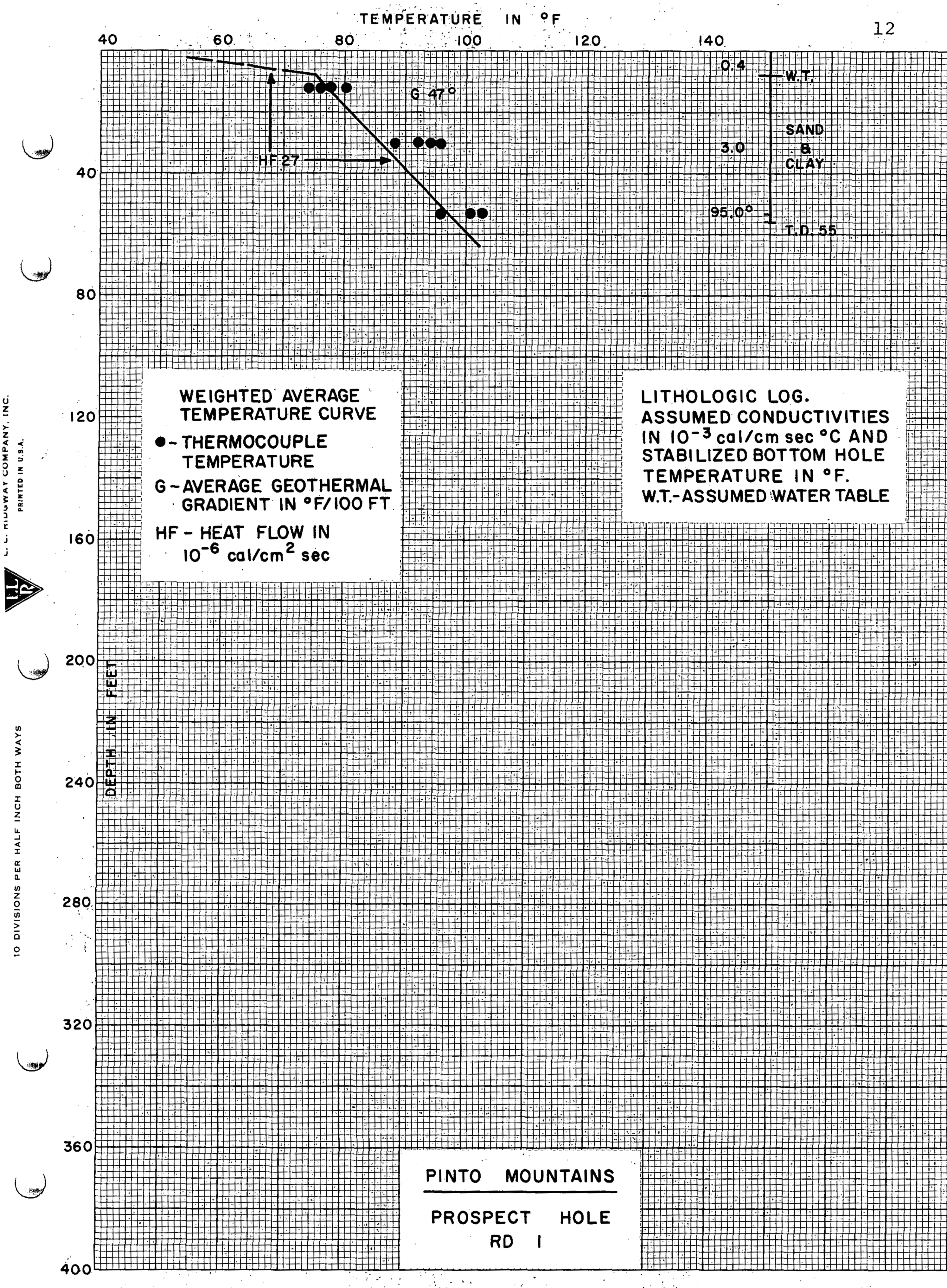
As a first step in analysis of data from prospect holes drilled at Pinto Mountains and Soldier Meadows, temperature instrumentation was tested at the Colorado School of Mines geophysical laboratory. Field procedure has been to run thermocouples into the holes as soon as drilling has been completed and back fill the holes as completely as practicable. Thermocouples are Leeds & Northrup copper constantan (32°F), no. 24, enamel and glass insulated, with Quiktip connectors. Readings have been made with a Leeds & Northrup portable millivolt potentiometer no. 8696. Two thermocouples were boiled in the laboratory for nearly two months, with periodic measurements of thermal emfs. One of the thermocouples had previously been used at Pinto Mountains for several months. Tests indicate that with this equipment temperature of boiling water can be measured with an accuracy better than 1°C (1.8°F) if the temperature of the cool contact is known to this accuracy. No drift of measurements was observed, indicating junction characteristics were not appreciably changed by being in boiling water for nearly two months.

There is significant uncertainty in the field measurements, perhaps as much as 5°F, because the cool junction, the potentiometer terminal, may not have reached thermal equilibrium as rapidly as the mercury thermometer laid alongside. Improvement can be made by placing the cool junction in an ice-water bath, or, where this is impractical, making the cool junction more like the hot so the heat capacity is lower than that of the potentiometer terminal.

Thermal conductivities used in this study are from tables by Clark (1966), using field lithologic logs by G. R. Downs. They are not precise determinations. Laboratory measurements of thermal conductivities of hole samples will greatly enhance the reliability of such calculations in the future.

Temperature measurements made in the Pinto Mountains area and the interpreted temperature distributions and vertical heat fluxes are given in Figures 3-9. From these it is evident the area is thermally anomalous.

The "normal" temperature gradient of the outer 6.2 miles of the solid earth is 1.125°F/100 ft (probably too low in orogenic areas and too high for stable continental areas) (White, 1965, p. 14). Pinto



TEMPERATURE IN °F
40
60
80
100
120
140
DEPTH IN FEET
40
80
120
160
200
240
280
320
360
400
G 47°
HF 27
0.4
3.0
95.0°
W.T.
SAND & CLAY
T.D. 55
WEIGHTED AVERAGE TEMPERATURE CURVE
● - THERMOCOUPLE TEMPERATURE
G - AVERAGE GEOTHERMAL GRADIENT IN °F/100 FT
HF - HEAT FLOW IN 10^{-6} cal/cm^2 sec
LITHOLOGIC LOG.
ASSUMED CONDUCTIVITIES IN 10^{-3} cal/cm sec °C AND STABILIZED BOTTOM HOLE TEMPERATURE IN °F.
W.T.-ASSUMED WATER TABLE
PINTO MOUNTAINS
PROSPECT HOLE
RD 1
10 DIVISIONS PER HALF INCH BOTH WAYS
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Figure 3

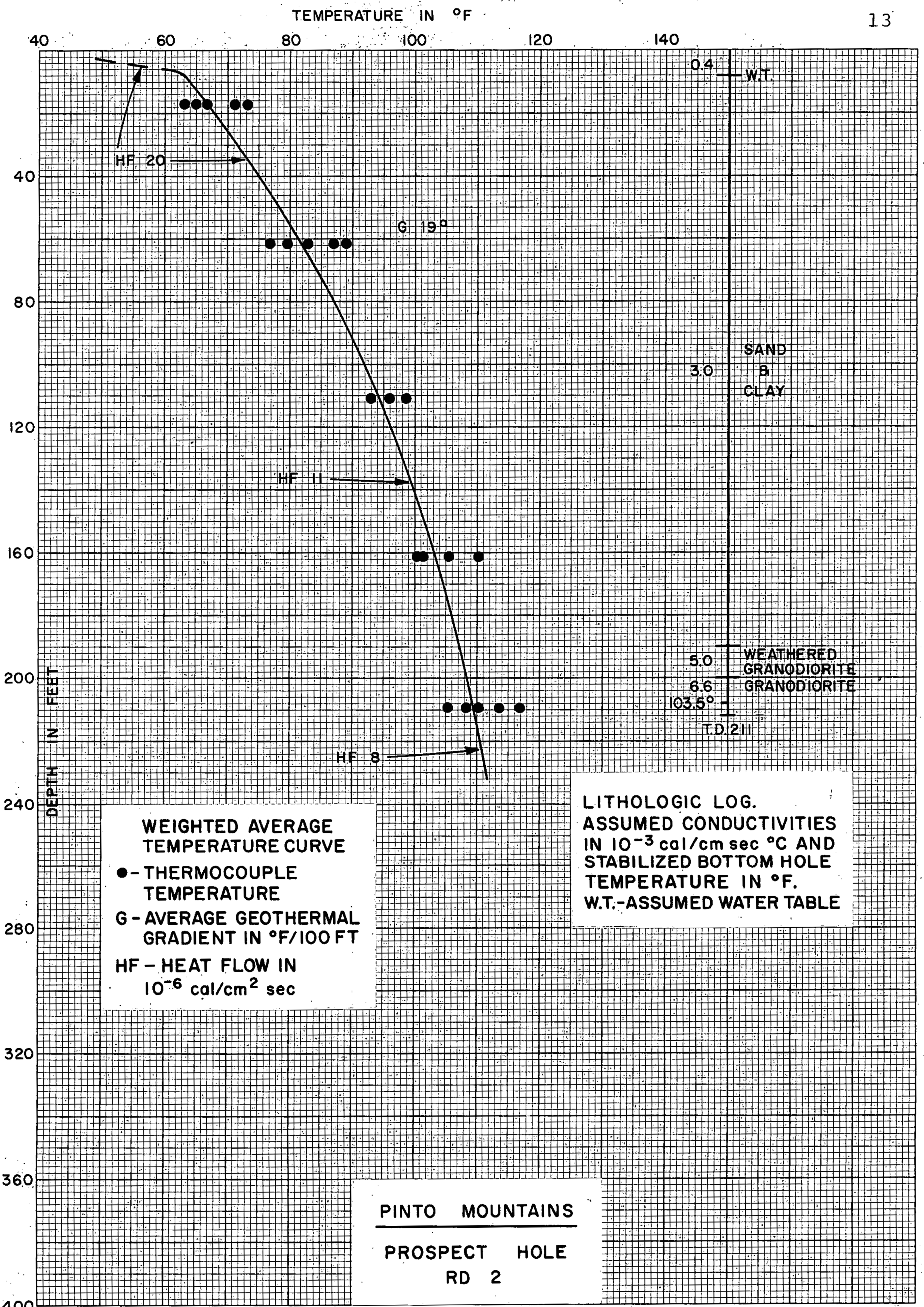

TEMPERATURE IN °F
40
60
80
100
120
140
DEPTH IN FEET
40
80
120
160
200
240
280
320
360
400
HF 20
G 19°
HF 11
HF 8
0.4
W.T.
SAND & CLAY
3.0
5.0
WEATHERED GRANODIORITE
6.6
GRANODIORITE
103.5°
T.D. 211
WEIGHTED AVERAGE TEMPERATURE CURVE
●- THERMOCOUPLE TEMPERATURE
G - AVERAGE GEOTHERMAL GRADIENT IN °F/100 FT
HF - HEAT FLOW IN 10^{-6} cal/cm^2 sec
LITHOLOGIC LOG. ASSUMED CONDUCTIVITIES IN 10^{-3} cal/cm sec °C AND STABILIZED BOTTOM HOLE TEMPERATURE IN °F.
W.T.-ASSUMED WATER TABLE
PINTO MOUNTAINS
PROSPECT HOLE
RD 2

Figure 4

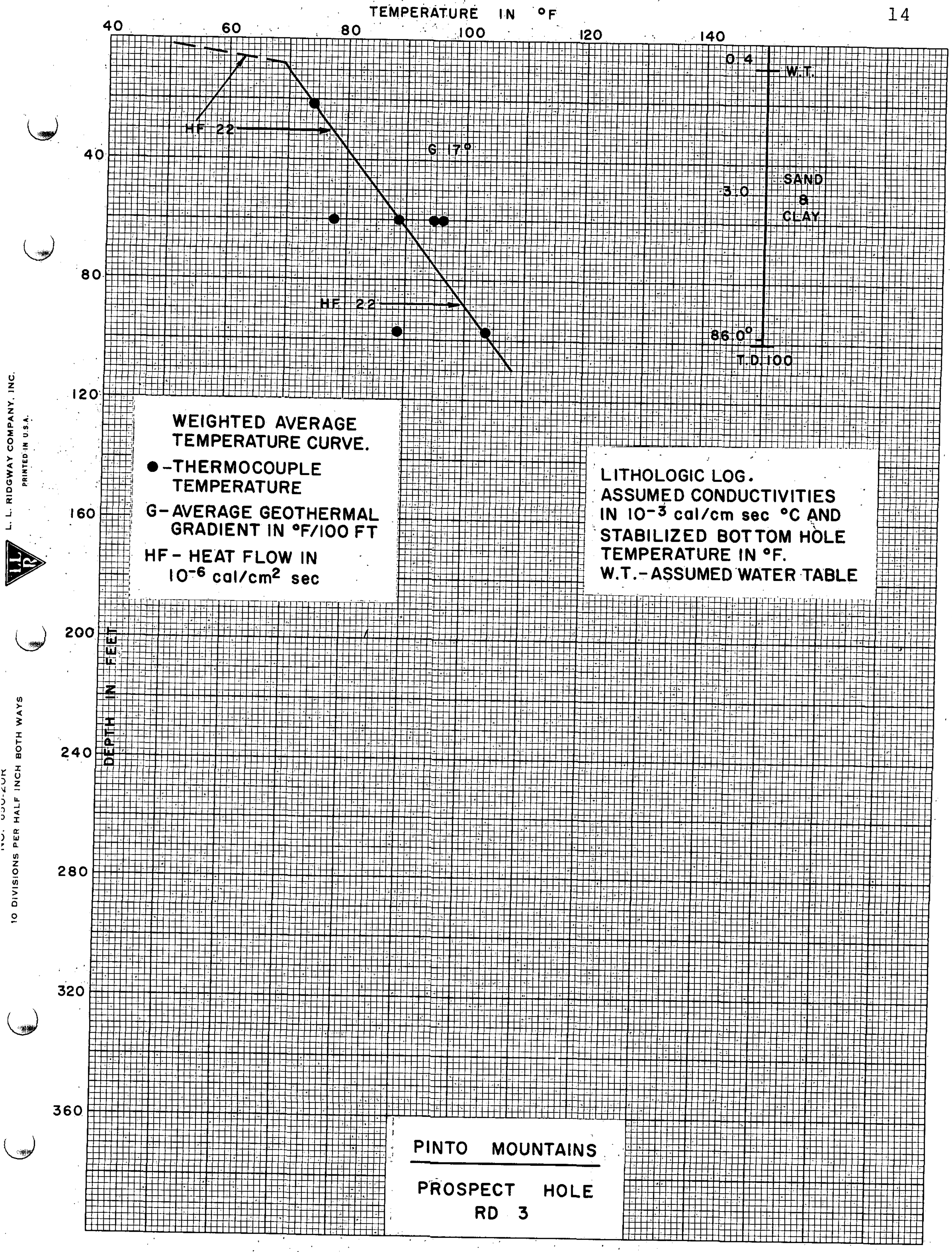

TEMPERATURE IN °F
40
60
80
100
120
140
DEPTH IN FEET
40
80
120
160
200
240
280
320
360
HF 22
G 17°
HF 22
0.4
W.T.
3.0
SAND
&
CLAY
86.0°
T.D. 100
WEIGHTED AVERAGE TEMPERATURE CURVE.
● -THERMOCOUPLE TEMPERATURE
G - AVERAGE GEOTHERMAL GRADIENT IN °F/100 FT
HF - HEAT FLOW IN 10^{-6} cal/cm^2 sec
LITHOLOGIC LOG.
ASSUMED CONDUCTIVITIES IN 10^{-3} cal/cm sec °C AND
STABILIZED BOTTOM HOLE TEMPERATURE IN °F.
W.T.-ASSUMED WATER TABLE
PINTO MOUNTAINS
PROSPECT HOLE
RD 3
L. L. RIDGWAY COMPANY, INC.
PRINTED IN U.S.A.
10 DIVISIONS PER HALF INCH BOTH WAYS

Figure 5

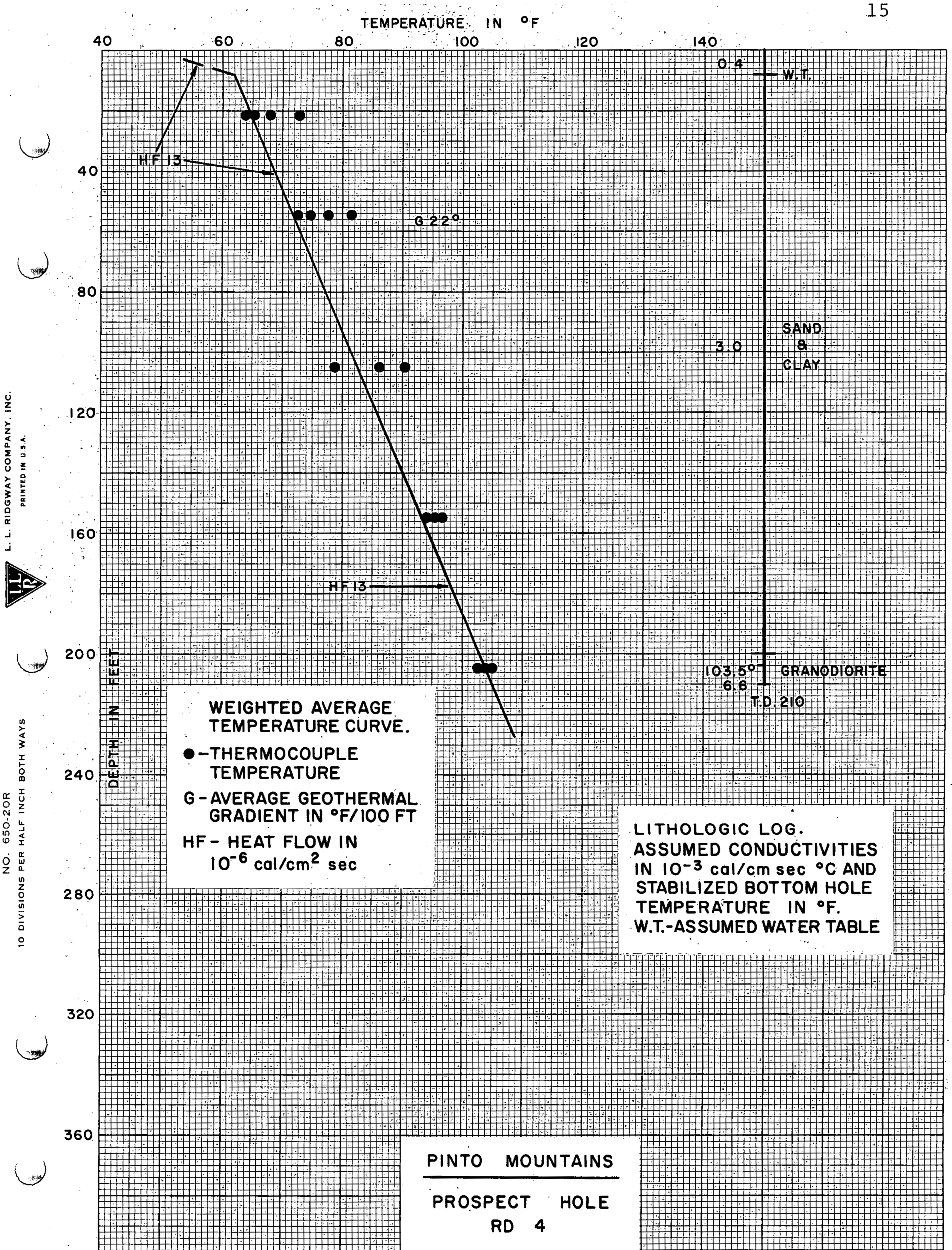

TEMPERATURE IN °F
40
60
80
100
120
140
DEPTH IN FEET
40
80
120
160
200
240
280
320
360
400
HF 13
G 22°
HF 13
0.4
W.T.
3.0
SAND & CLAY
103.5°
GRANODIORITE
6.6
T.D. 210
WEIGHTED AVERAGE TEMPERATURE CURVE.
●-THERMOCOUPLE TEMPERATURE
G-AVERAGE GEOTHERMAL GRADIENT IN °F/100 FT
HF- HEAT FLOW IN 10^{-6} cal/cm^2 sec
LITHOLOGIC LOG.
ASSUMED CONDUCTIVITIES IN 10^{-3} cal/cm sec °C AND STABILIZED BOTTOM HOLE TEMPERATURE IN °F.
W.T.-ASSUMED WATER TABLE
PINTO MOUNTAINS
PROSPECT HOLE
RD 4
NO. 650-20R
10 DIVISIONS PER HALF INCH BOTH WAYS
L. L. RIDGWAY COMPANY, INC.
PRINTED IN U.S.A.

Figure 6

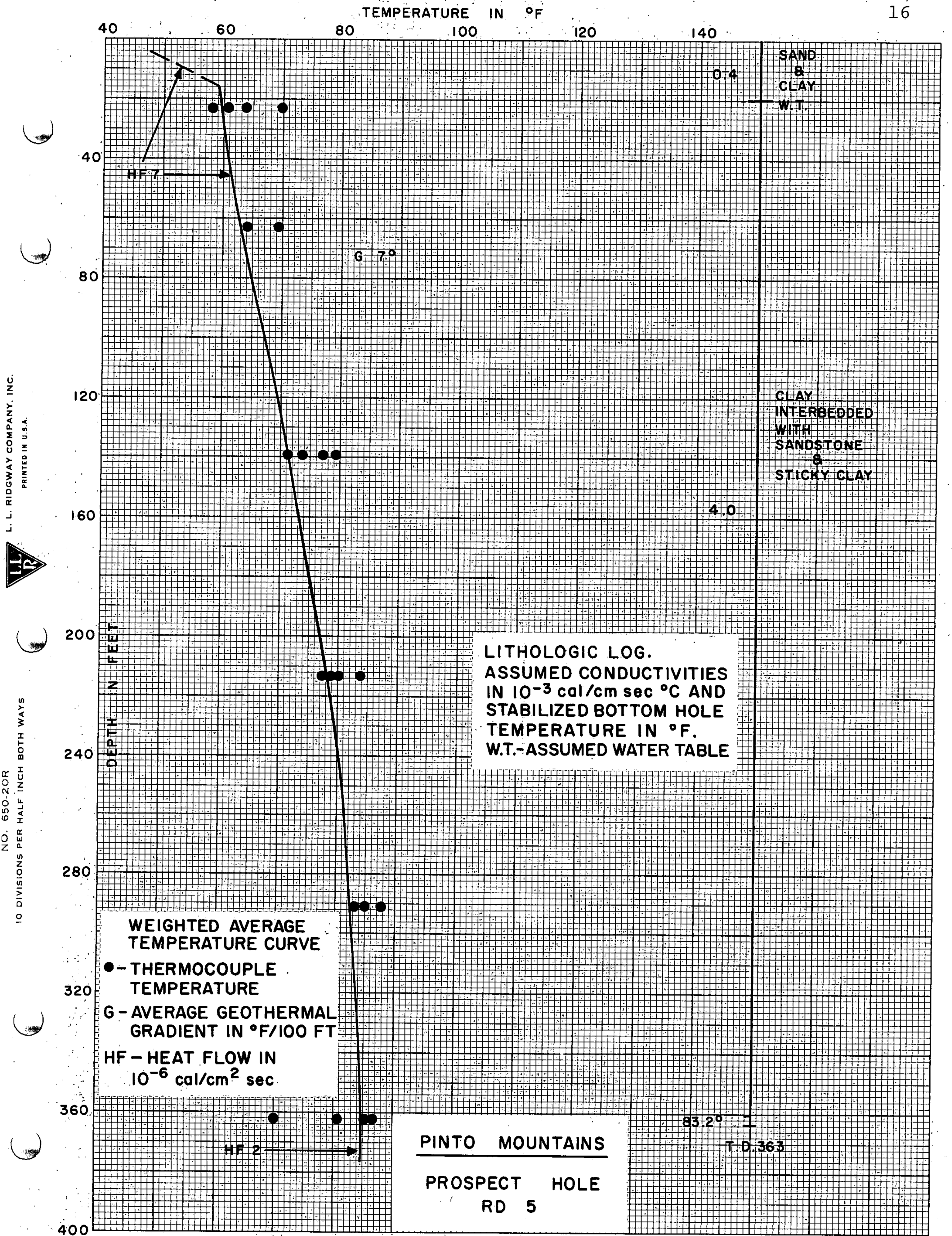

TEMPERATURE IN °F
40
60
80
100
120
140
SAND & CLAY
0.4
W.T.
HF 7
G 7°
CLAY INTERBEDDED WITH SANDSTONE & STICKY CLAY
4.0
DEPTH IN FEET
40
80
120
160
200
240
280
320
360
400
LITHOLOGIC LOG.
ASSUMED CONDUCTIVITIES IN 10^{-3} cal/cm sec °C AND STABILIZED BOTTOM HOLE TEMPERATURE IN °F.
W.T.-ASSUMED WATER TABLE
WEIGHTED AVERAGE TEMPERATURE CURVE
●- THERMOCOUPLE TEMPERATURE
G - AVERAGE GEOTHERMAL GRADIENT IN °F/100 FT
HF - HEAT FLOW IN 10^{-6} cal/cm^2 sec
83.2°
T.D.363
HF 2
PINTO MOUNTAINS
PROSPECT HOLE RD 5
NO. 650-20R
10 DIVISIONS PER HALF INCH BOTH WAYS
L. L. RIDGWAY COMPANY, INC.
PRINTED IN U.S.A.

Figure 7

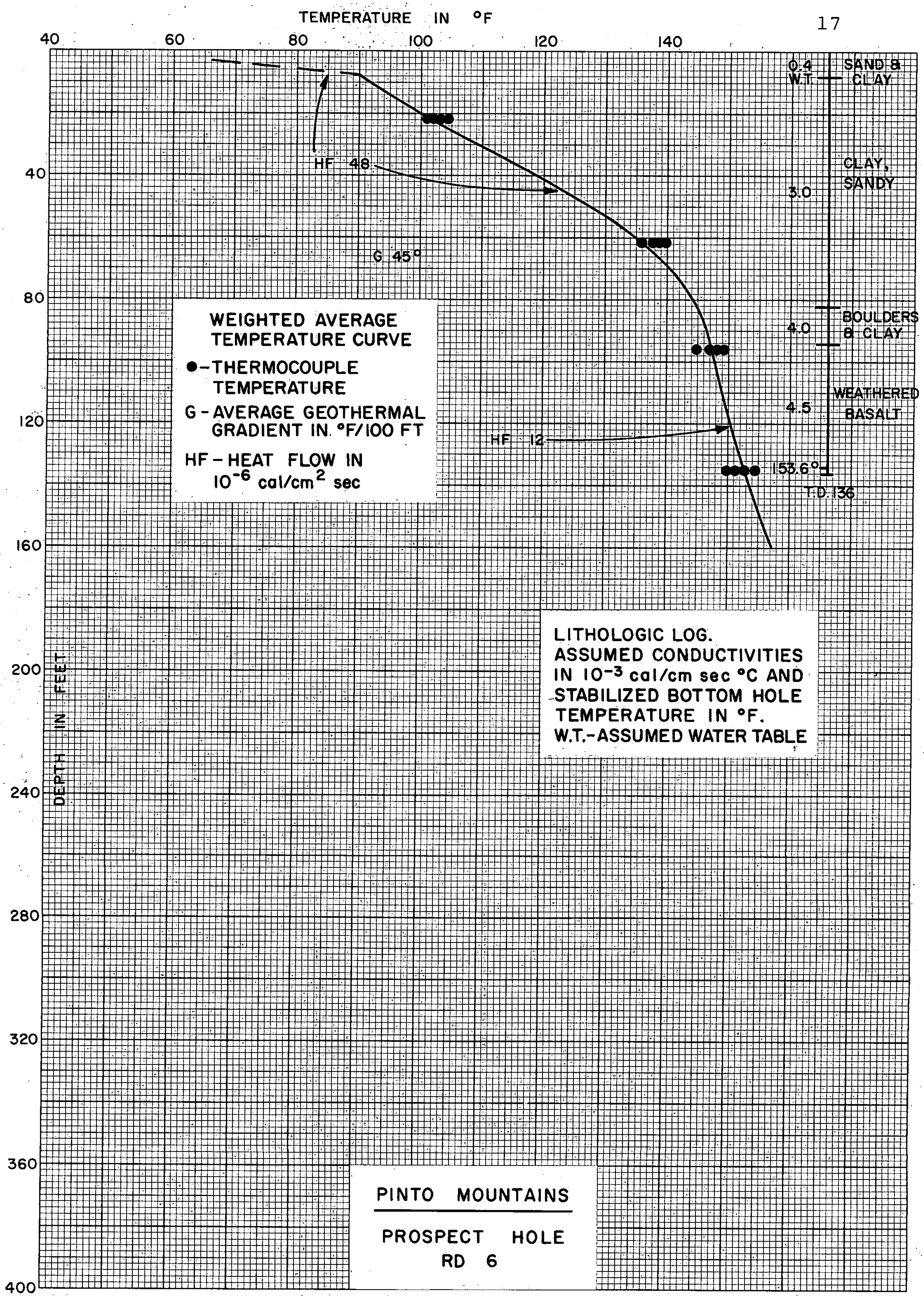
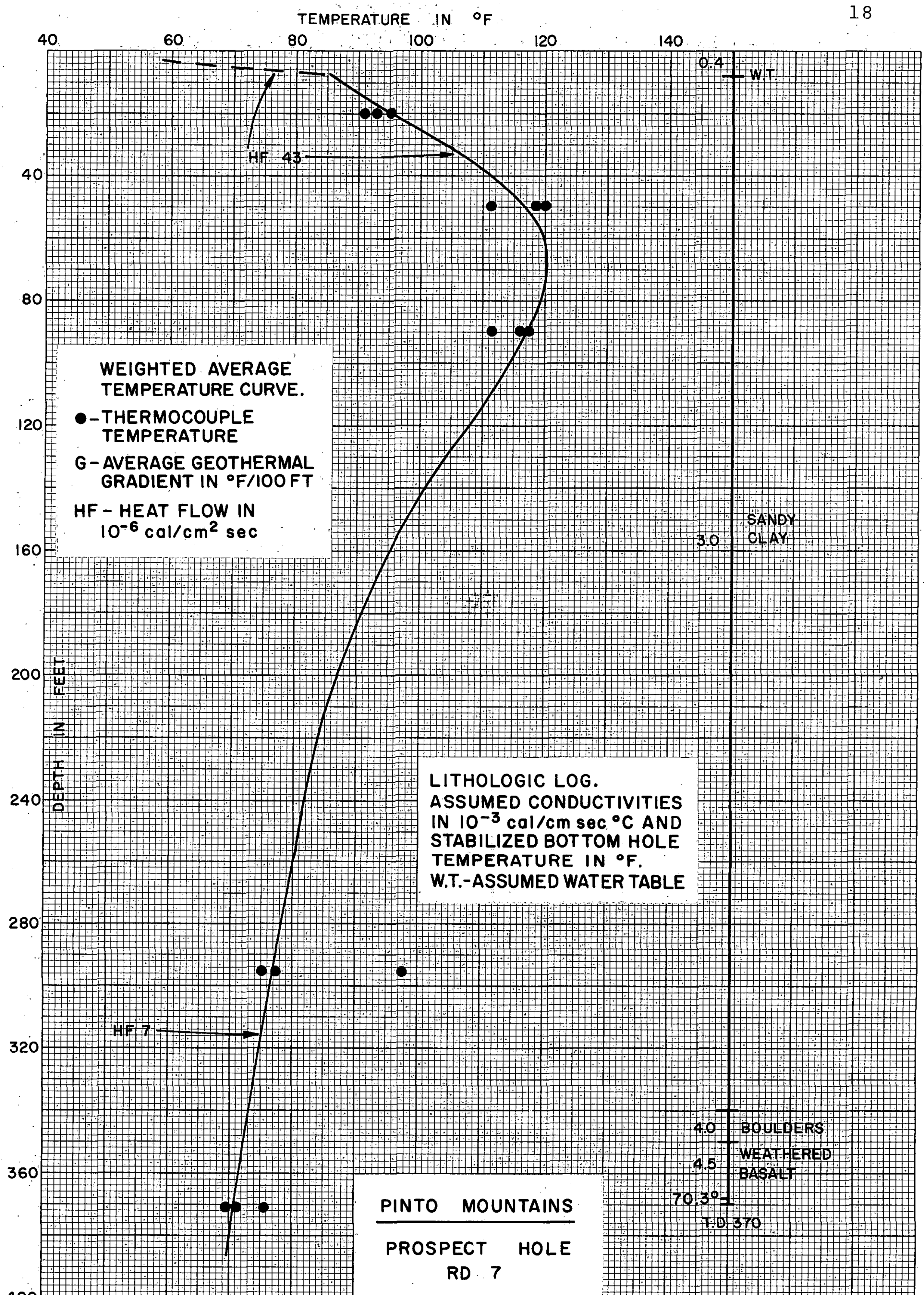

TEMPERATURE IN °F
40
60
80
100
120
140
DEPTH IN FEET
40
80
120
160
200
240
280
320
360
400
HF 48
G 45°
HF 12
0.4
W.T.
SAND & CLAY
CLAY, SANDY
3.0
BOULDERS & CLAY
4.0
WEATHERED BASALT
4.5
153.6°
T.D. 136
WEIGHTED AVERAGE TEMPERATURE CURVE
●-THERMOCOUPLE TEMPERATURE
G-AVERAGE GEOTHERMAL GRADIENT IN °F/100 FT
HF-HEAT FLOW IN 10^{-6} cal/cm^2 sec
LITHOLOGIC LOG. ASSUMED CONDUCTIVITIES IN 10^{-3} cal/cm sec °C AND STABILIZED BOTTOM HOLE TEMPERATURE IN °F.
W.T.-ASSUMED WATER TABLE
PINTO MOUNTAINS
PROSPECT HOLE
RD 6

Figure 8



TEMPERATURE IN °F
40
60
80
100
120
140
DEPTH IN FEET
40
80
120
160
200
240
280
320
360
400
HF 43
HF 7
0.4
W.T.
SANDY CLAY
3.0
4.0
BOULDERS
4.5
WEATHERED BASALT
70.3°
T.D. 370
WEIGHTED AVERAGE TEMPERATURE CURVE.
●-THERMOCOUPLE TEMPERATURE
G-AVERAGE GEOTHERMAL GRADIENT IN °F/100 FT
HF-HEAT FLOW IN 10^{-6} cal/cm² sec
LITHOLOGIC LOG.
ASSUMED CONDUCTIVITIES IN 10^{-3} cal/cm sec °C AND STABILIZED BOTTOM HOLE TEMPERATURE IN °F.
W.T.-ASSUMED WATER TABLE
PINTO MOUNTAINS
PROSPECT HOLE
RD 7

Figure 9

Mountains prospect holes RD 1-6 have gradients 7°F to 47°F/100 ft, 6 to 42 times higher than "normal."

The current estimate of global average heat flow is 1.5×10^{-6} cal/cm^{2}sec, and for geothermal considerations heat flow in the range of $0.8 - 2.0 \times 10^{-6}$ cal/cm^{2}sec should be considered in the "normal" range (White, 1965, p. 14). Values for the vertical component of heat flux in the Pinto Mountains prospect holes are 2 to 48×10^{-6} cal/cm^{2}sec, as much as 32 times "normal."

We have geologic explanations for some of the variations in heat flux. Although RD 5 is anomalously warm, it is the coolest hole in the area. Location is on the ridge between West and East Springs in Tertiary "volcanics," whereas all the other six holes are topographically lower, in and near the hot spring areas, and in and near the major normal fault zones bounding the Pinto Mountains structural block, or blocks.

The highest vertical components of heat flux are in RD 1, 6, and 7, West Spring area. RD 1 is located on the surface trace of a normal fault dipping west about 70°, and RD 6 and 7 are topographically and structurally lower, in the alluvial gravels west of the fault trace. The decrease in heat flux below 50 ft in RD 6 and 7 probably indicates a flow, or at least the existence, of hot water at depths of 50 to 80 ft. We cannot now rule out error in placement of thermocouples in RD 7.

Prospect holes RD 3 and 4 are located west of the east-dipping normal fault at East Springs, in "volcanics" of the upthrown block. Although thermally anomalous, the heat flux is not as high as in holes basinward of the West Spring.

The thermal data clearly support the thesis that mountain front normal faults are the conduits for the hot ascending waters of the Great Basin thermal areas.

At Soldier Meadows 30 temperature holes were drilled, one to 100 ft and the others to 20 ft or less. Although anomalous temperatures are indicated, data from these shallow holes with only bottom-hole thermocouples are of very limited use in thermal calculations. We cannot now make meaningful deductions from them.

The curves of Figures 3-9 show temperatures at the water table about 20°F higher in areas of high than in areas of low vertical flux. Such temperature anomalies will not of course persist undiminished to the surface, because regions of high vertical flux must also have a high vertical component of the geothermal gradient. Nevertheless, we believe the possibility that these temperature anomalies are manifest at the surface to a degree detectable by means of infrared radiometers, above noise of emissivity effects and variations in depth to water table, is worth further investigation.

A plan for this surveying is under discussion with Geophoto Services (Texas Instruments). The tentative schedule is to have a ground survey at Soldier Meadows made by a Geophoto expert and G. W. Berry during about a month of the fall of 1967, using thermistors at the surface and depths of a few inches, and a hand-held infrared radiometer. This fieldwork is prerequisite for airborne infrared sensing which has been under discussion with Geophoto and the parent Texas Instruments for the past three years.

<u>Selected References</u>:

Berry, G. W., and Downs, G. R., 1966a, Fly Ranch hot springs: Sun Oil Co. Map, Aug. 25, 1966. With separate spring data tabulations.

Berry, G. W., and Downs, G. R., 1966b, Gerlach hot springs: Sun Oil Co. Map, Aug. 25, 1966. With separate spring data tabulations.

Berry, G. W., and Downs, G. R., 1966c, Pinto Mountains hot springs area: Sun Oil Co. Map, Aug. 25, 1966. With separate spring and prospect hole data tabulations.

Berry, G. W., and Downs, G. R., 1966d, Soldier Meadows area: Sun Oil Co. Map, Aug. 25, 1966. With separate spring and temperature hole data tabulations.

Clark, S. P., Jr., 1966, Thermal conductivity, <u>in</u> Clark, S. P., Jr., ed., Handbook of physical constants, rev. ed.: Geol. Soc. American Mem. 97, p. 459-482.

Downs, G. R., and Berry, G. W., 1966, Northwest Nevada temperatures: Sun Oil Co. Rept., Mar. 1, 1966, 2 p.

Elder, J. W., 1965, Physical processes in geothermal areas, in W. H. K. Lee, ed., Terrestrial heat flow: Am. Geophys. Union Geophys. Mon. Ser. No. 8, p. 211-239.

Gilbert, J. E., and Berry, G. W., 1964, Geothermal project progress report: Cordero Mining Co. Rept., Palo Alto, April 10, 1964, 13 p.

Grindley, G. W., 1965, The geology, structure, and exploitation of the Wairakei geothermal field, Taupo, New Zealand: New Zealand Geol. Survey Bull. n.s. 75, 131 p.

Keller, G. V., and Pritchard, J. I., 1966, Report on electrical geophysical investigations of hot-springs areas (Fly Ranch and Gerlach, Nev.): Sun Oil Co. Rept., Denver, Oct. 17, 1966, 15 p., app. A-C.

McNitt, J. R., 1963, Exploration and development of geothermal power in California: California Div. Mines and Geology Spec. Rept. 75, 45 p.

Thompson, G. A., and White, D. E., 1964, Regional geology of the Steamboat Springs area, Washoe County, Nevada: U. S. Geol. Survey Prof. Paper 458-A, 52 p.

White, D. E., 1957, Thermal waters of volcanic origin: Geol. Soc. America Bull., v. 68, p. 1637-1658.

White, D. E., 1964, Preliminary evaluation of geothermal areas by geochemistry, geology, and shallow drilling: United Nations Conf. New Sources of Energy, Rome 1961, Proc., v. 2, Geothermal Energy I: p. 402-408.

White, D. E., 1965, Geothermal energy: U. S. Geol. Survey Circ. 519, 17 p.

Zemansky, M. W., 1957, Heat and thermodynamics, 4th ed.: New York, McGraw-Hill, 484 p.

PINTO MOUNTAINS

PROSPECT HOLES

	*ELEV.	TOTAL DEPTH FEET	COMP. DATE 1966	LITHOLOGY		THERMO-COUPLE FEET	DATE 1966	TC°F	DATE 1966	TC°F	DATE 1966	TC°F	DATE 1966	TC°F	DATE 1966	TC°F
RD1	4103	55	6-3	0-55 sand & clay	Drilled with air, stopped by water (40)	12.5	6-11	74.0	6-15	77.0	7-1	80.0	7-21	76.0		
	12509	16.73				30	6-11	93.0	6-15	91.7	7-1	94.0	7-21	87.3		
						53	6-11	101.5	6-15	101.0	7-1	100.0	7-21	95.0		
RD2	4118	211	6-9	0-190 sand & clay 190-200 grano-diorite, weathered 200-211 grano-diorite	Drilled with mud	17	6-10	71.0	6-11	63.0	6-15	73.0	7-1	65.0	7-21	66.0
	1255.5	64.3				61	6-10	87.5	6-11	76.0	6-15	86.5	7-1	79.0	7-21	82.0
						111	6-10	95.0	6-11	92.0	6-15	102.5	7-1	92.0	7-21	92.0
						161	6-10	104.5	6-11	100.0	6-15	108.5	7-1	104.0	7-21	99.3
						209	6-10	112.0	6-11	107.0	6-15	115.0	7-1	108.0	7-21	103.5
RD3	4143	100	6-11	0-100 sand & clay	Drilled with mud, lost circ. 98, water stood at 4135	22	6-16	72.5	6-18	72.5	7-1	73.0	7-21	?		
	1263.1	30.5				60	6-16	94.0	6-18	95.0	7-1	87.5	7-21	76.1		
						97	6-16	102.0	6-18	102.0	7-1	86.0	7-21	?		
RD4	4139	210	6-15	0-200 sand & clay 200-210 grano-diorite	Drilled with mud	22	6-16	72.0	6-18	68.0	7-1	65.0	7-21	64.0		
	1261.9	44.0				55	6-16	81.0	6-18	77.0	7-1	74.5	7-21	72.1		
						105	6-16	90.0	6-18	86.0	7-1	86.0	7-21	78.3		
						155	6-16	93.5	6-18	94.0	7-1	93.4	7-21	95.0		
						203	6-16	104.5	6-18	104.0	7-1	102.5	7-21	103.5		
RD5	4284	363	6-21	0-20 coarse grit, sand-stone, & clay 20-363 clay, sticky, inter-bedded with sandstone & silty clay	Drilled with mud	23	6-22	69.0	6-25	63,5	7-1	60.0	7-21	58.0		
	1306.1	110.7				63	6-22	69.0	6-25	64.0	7-1	64.0	7-21	64.1		
						139	6-22	78.0	6-25	76.0	7-1	70.5	7-21	73.0		
						213	6-22	78.0	6-25	82.5	7-1	78.5	7-21	77.5		
						288	6-22	86.0	6-25	83.5	7-1	74.5	7-21	82.0		
						361	6-22	79.5	6-25	69.0	7-1	85.5	7-21	83.2		
RD6	4068	136	6-22	0-10 sand & clay 10-82 clay, sandy 82-84 basalt boulder 84-85 grano-diorite boulder 85-95 basalt boulders & white clay 95-136 basalt, weathered	Drilled with mud	22	6-24	103.2	6-25	101.5	7-1	100.5	7-21	103.0		
	1240.2	41.5				60	6-24	135.0	6-26	137.0	7-1	138.0	7-21	136.4		
						95	6-24	146.5	6-26	146.5	7-1	143.5	7-21	147.0		
						134	6-24	149.5	6-26	150.0	7-1	150.5	7-21	153.6		

*Elevations in Pinto Mountains area, based on assumed 4100.00 at station east of west spring, subject to correction

PINTO MOUNTAINS

PROSPECT HOLES

	ELEV.	TOTAL DEPTH FEET	COMP. DATE 1966	LITHOLOGY		THERMO-COUPLE FEET	DATE 1966	TC°F	DATE 1966	TC°F	DATE 1966	TC°F	DATE 1966	TC°F	DATE 1966	TC°F
RD7	4064	370	6-25	0-340 clay, sandy & gritty	Drilled with mud	20	6-26	91.0	7-1	93.0	7-21	95.0				
						50	6-26	111.0	7-1	118.5	7-21	119.3				
	1239.0	112.0				90	6-26	111.0	7-1	117.0	7-21	116.0				
				340-350 boulders		293	6-26	77.0	7-1	97.0	7-21	75.3				
						368	6-26	71.0	7-1	75.5	7-21	70.3				
				350-370 basalt, weathered												