DAVID D. BLACKWELL

DO-17

OST1-20

FINAL REPORT
GRACE GEOTHERMAL CORPORATION
BALTAZOR HOT SPRINGS, NEVADA
HOLE NO: 45-14
SWDX JOB NO: 23-82

17

1983 Jan

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

SOUTHWEST DRILLING AND EXPLORATION, INC.
GEOTECHNICAL SERVICES GROUP
14009 MIDLAND ROAD • POWAY, CALIFORNIA 92064 • (714) 486-4286

GRACE GEOTHERMAL CORPORATION

BALTAZOR HOT SPRINGS PROSPECT, NEVADA

SWDX JOB NO. 23-82

INTRODUCTION

During the period from September 21, 1982 to November 1, 1982 one geothermal test well was drilled within the Baltazor Hot Springs KGRA in northwestern Nevada to a total depth of 2,529 feet (Figure 1). Temperature-depth profiles from two temperature surveys run in the open hole are presented in Figure 2. The maximum temperature recorded was 223.77 degrees F at a total survey depth of 2,430 feet. Geothermal gradients from selected intervals in the well ranged from 2.25 degF/100ft to 11.00 degF/100ft. Individual temperature-depth plots, gradient plots, and interval gradient plots are provided in Appendix A. Rock types encountered ranged from unconsolidated alluvium to rhyolitic and basaltic flows, tuffs and flow breccias. A lithologic section for the well is provided in a pocket at the back of the report (Figure 3).

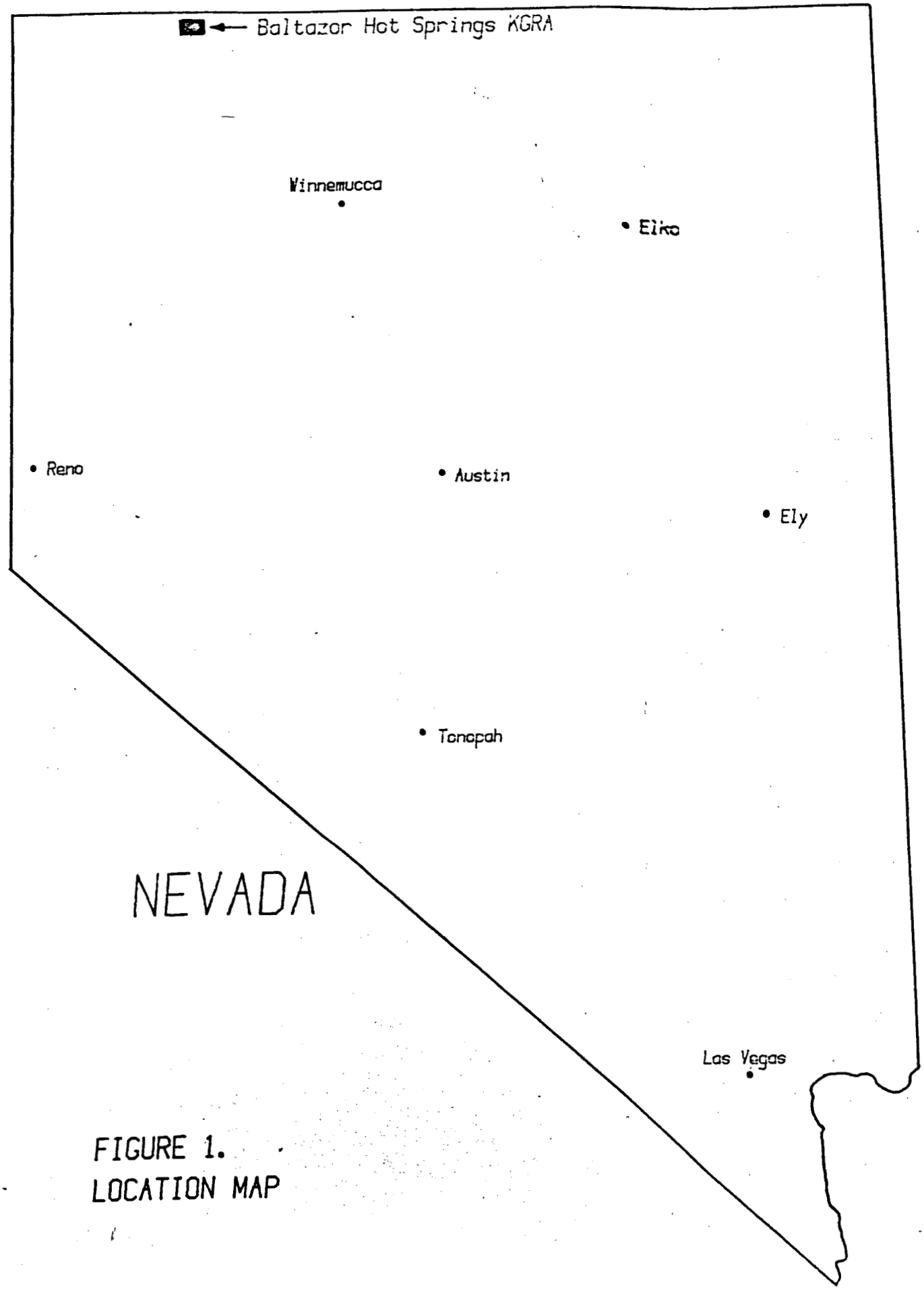


FIGURE 1.
LOCATION MAP

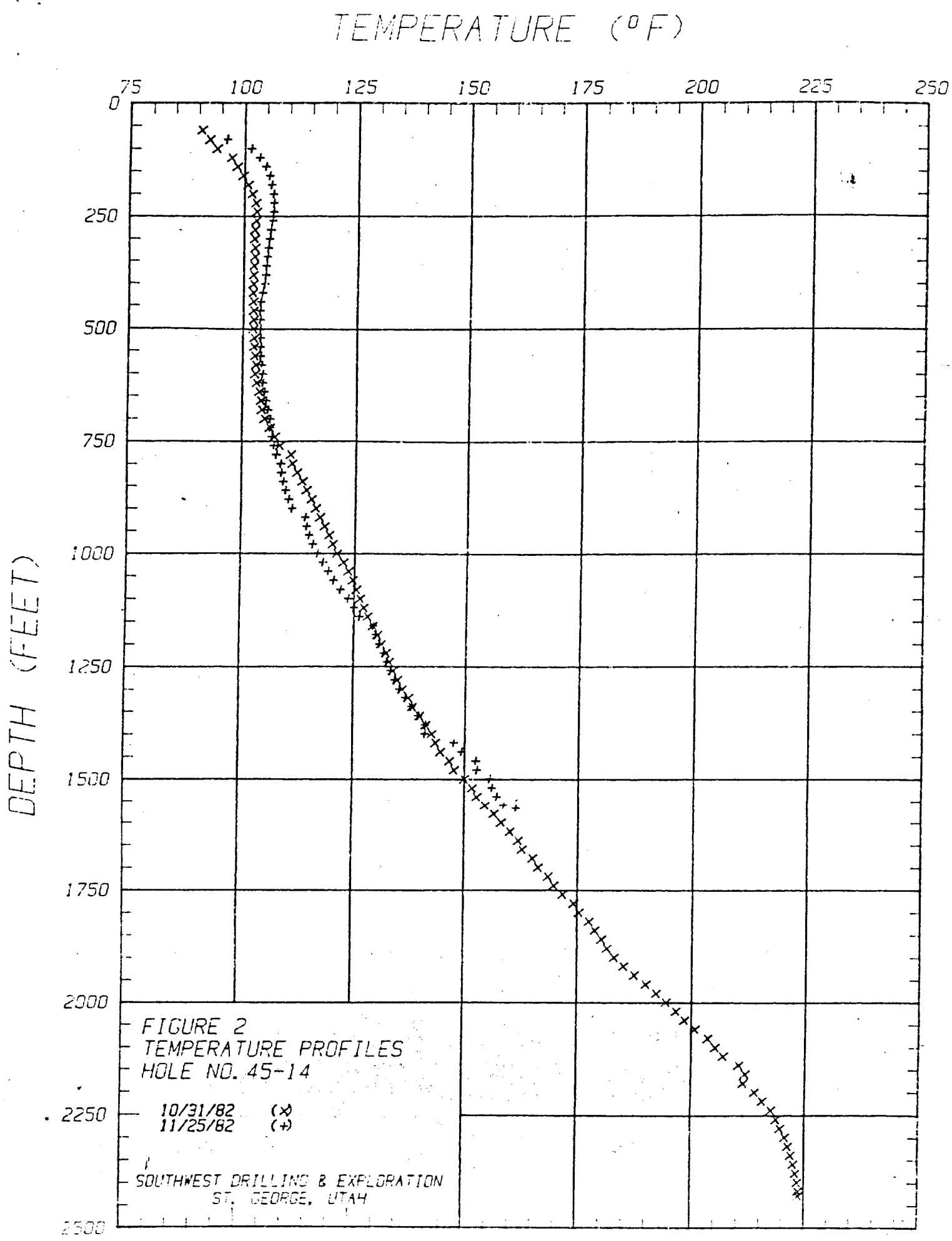


FIGURE 2
TEMPERATURE PROFILES
HOLE NO. 45-14

Thermal conductivity measurements were performed on a total of 26 drill cutting samples that ranged from 2.9 TCU to 5.5 TCU (1 TCU = 1 mcal/cm-sec-degC) and are presented in Appendix B. Selected heat flow data for the well are provided in Table 1.

Well 45-14 was drilled by Southwest Drilling and Exploration, Inc. utilizing a Gardner Denver 2000 rotary drilling machine with a 53 foot mast rated at 100,000 lbs. capacity. Drilling conditions ranged from moderate to difficult with the major problems resulting from the hard and fractured rhyolite sequence in the upper part of the well. Drilling rates below 1,750 feet were greatly reduced as a result of decreasing the weight on the bit to keep the vertical deviation within the required 4 degrees. Fluid losses were contained to a minimum below the rhyolite sequence and did not present a major problem. Selected drilling data and a detailed drilling history are provided in Appendix C.

Earth Power Production Company completed two test holes in the immediate area in June and July 1979. Boreholes BZ 1500-1 and BZ 1500-2 were drilled to depths of 1,543 feet and 1,434 feet respectively. Selected temperature-depth plots from these holes are included in Appendix D.

TABLE 1

HEAT FLOW DATA
BALTAZOR HOT SPRINGS
HOLE NO: 45-14
SWDX JOB NO. 23-82

RUN NUMBER	TOTAL DEPTH (FEET)	BOTTOM HOLE TEMP (DEG F)	GRADIENT A (DEG F/ 100 FT)*	GRADIENT INTERVAL (FEET)	CALC SURF TEMP (DEG F)**	GRADIENT (DEG F/ 100 FT)+	THERMAL CONDUCTIVITY (TCU)++	HEAT FLOW (HFU)}
1	2430	223.77	6.9	800-1280	72.1	4.93	3.6(6)	3.2
				1440-1920	22.6	8.48	3.4(5)	5.3
				1920-2120	-25.7	11.00	3.5(2)	7.0
2	1567	161.41	6.8	600- 900	90.5	2.25	4.0(4)	1.6
				900-1400	56.9	6.08	3.4(5)	3.8
				1420-1567	30.8	8.26	3.1(1)	4.7

* Gradient A = The bottom hole temperature minus an estimated mean annual surface temperature of 55 degF divided by the total depth.

** Extrapolated surface temperature.

\+ Least-squares geothermal gradient calculated over the gradient interval.

++ TCU = mcal/cm-sec-degC. Number of thermal conductivity samples for each interval in parentheses.

} HFU = microcal/sq-cm-sec.

GEOLOGIC SETTING

Baltazor Hot Springs is located along the northwestern margin of the Basin and Range province approximately five miles southwest of Denio, Nevada in northwestern Humbolt County. Well 45-14 was drilled approximately one-half mile west of the hot springs near the base of the Pueblo Mountain Range.

The oldest rocks in the Baltazor Hot Springs area are Permian to Triassic metasedimentary and metavolcanic rocks (Hulen, 1979). These are intruded by Cretaceous diorite and quartz diroite rocks (Edquist, 1981). The metamorphic rocks are unconformably overlain by Miocene basalt and andesitic basalt flows and flow-breccias. Thin horizons of felsic to intermediate flows and ash-flow tuffs are interbedded with the basalts. Dense Miocene rhyolite and rhyolitic flow-breccias lie disconformably on the basalt sequence. This unit is up to 400 feet in thickness, very resistive and typically forms caprock and ridges in the Baltazor area (Hulen, 1979). Miocene felsic ash-flow tuff and tuffaceous sediments lie unconformably on the rhyolite and basalt sequences.

The structure in the Baltazor Hot Springs area is dominated by moderate to high-angle northwest to northeast trending Basin and Range faults (Hulen, 1979).

Water temperatures at Baltazor Hot Springs are up to 200 degrees F. Reservoir temperatures of 329 degrees F and 306 degrees F have been calculated using the silica

and Na-K-Ca geothermometers respectively (Garside and Schilling, 1979). Hydrothermal alteration in the area is characterized by chalcedony bearing calcite veins and argillization of the host rocks (Hulen, 1979).

RESULTS AND DISCUSSION

Two temperature surveys were run in the open hole after completion. The first survey was run 22 hours after the well was reamed to a depth of 796 feet and 134 hours after the hole had been circulated below this depth. This survey was run to a total depth of 2,430 feet. The second survey was run 26 days later to a depth of 1,567 feet where the open well had become bridged with gray-brown clay. Temperature profiles from these surveys are provided in Appendix A.

Thermal conductivity measurements were performed on a total of 26 drill cutting samples from selected intervals using a divided-bar cell apparatus. Porosity values used to calculate in-situ thermal conductivities were estimated considering lithology, penetration rates, and drilling fluid losses. In-situ thermal conductivity values ranged from 2.9 TCU for an ash-tuff sample to 5.5 TCU for an andesitic basalt sample (1 TCU = 1 mcal/cm-sec-degC). The average thermal conductivity for the well is 3.8 TCU. Individual thermal conductivity data are presented in Appendix B.

Temperature-depth profiles from the first temperature survey show three distinct gradient breaks below 800 feet which do not correspond to thermal conductivity contrasts. The upper gradient interval from 800 feet to 1,280 feet has a least-squares geothermal gradient of 4.93 degF/100ft. This is the lowest of the three gradients measured and the character of the profile suggests that there is a significant component of convective heat transfer in the formation through this interval. The gradient interval from 1,440 feet to 1,920 feet appears to be the least disturbed and the calculated geothermal gradient of 8.48 degF/100ft is probably the closest value to the true conductive gradient. Temperature distributions in the lower portion of the well suggest that convective heat transfer within the borehole itself is producing a deceivingly high gradient of 11.00 degF/100ft between 1,920 feet and 2,120 feet.

Data from the second temperature survey confirm the presence of lateral groundwater movement through a warm water aquifer at a depth of approximately 220 feet. Groundwater movement is also evident in the temperature-depth profiles in boreholes BZ-1500-1 and BZ-1500-2 (Ziagos and Blackwell, 1981). The character of the curve below the aquifer suggests that warm groundwater has been present in this zone for less than 1,000 years.

Heat flow values were calculated for the selected gradient intervals and are presented in Table 1.

Calculated heat flow values ranged from 1.6 to 7.0 HFU (1 HFU = 1 μcal/sq-cm-degC). Heat transfer between 1,440 feet and 1,920 feet appears to be predominantly by conduction and the calculated heat flow of 5.3 HFU for this interval is probably the closest value to the true conductive heat flow. Assuming that uniform conductive heat flow exists below 1,440 feet, the theoretical bottom hole temperature can be calculated by extrapolating the gradient between 1,440 feet and 1,920 feet down to the lithologic contact at 2,180 feet, calculating the gradient in the andesitic basalt by dividing the heat flow of 5.3 HFU by an average thermal conductivity of 4.8 TCU and continuing this gradient down to 2,430 feet. The bottom hole temperature calculated in this manner is 222.8 degrees F which is in good agreement with the measured temperature of 223.77 degrees F. This result supports the conclusion that measured temperatures between 1,920 feet and 2,430 feet are disturbed by fluid movement in the hole.

CONCLUSIONS

Thermal data collected from well 45-14 suggest that heat transfer below a depth of 1,440 feet is predominantly by conduction. The conductive heat flow of 5.3 HFU calculated over the interval between 1,440 feet and 1,920 feet represents a minimum value for the total heat flow at this location and is significantly higher than the average background heat flow for the northwestern Basin and Range province of 2. HFU (Sass, et.al.,1976). Heat flow values greater than 4 HFU require either melting within the shallow crust or convective transfer of heat by water or magma. Furthermore, heat flow values greater than 5 HFU are representative of heat flows found over commercial geothermal fields.

REFERENCES

Edquist, R.K., 1981, Geophysical Investigations of the Baltazor Hot Springs Known Geothermal Resource Area, Humbolt County, Nevada: Univ. Utah Rsch. Inst., Earth Science Lab., report ESL-54, 89 pp.

Garside, L.J., J.H. Schilling, 1979, Thermal Waters of Nevada: Nev. Bur. of Mines and Geol., Bull. 91, 163 pp.

Hulen, J.B., 1979, Geology and Alteration of the Baltazor Hot Springs and Painted Hills Thermal Areas, Humbolt County, Nevada: Univ. Utah Rsch. Inst., Earth Science Lab., report ESL-27, 20 pp.

Sass, J.H., W.H. Diment, A.H. Lachenburch, B.V. Marshall, R.J. Munroe, T.J. Moses, T.C. Urban, 1976, A New Heat-Flow Contour Map of the Conterminous United States: U.S. Geol. Surv. Open-File report no. 76-756, 24 pp.

Ziagos, J.P., D.D. Blackwell, 1981, A Model for the Effect of Horizontal Fluid Flow in a Thin Aquifer on Temperature-Depth Profiles: Geothermal Resources Council Trans., vol. 5, 221-223.

Prepared by:

Bart Helms
Staff Geologist

Barry V. Williams
Manager, Geotechnical Services

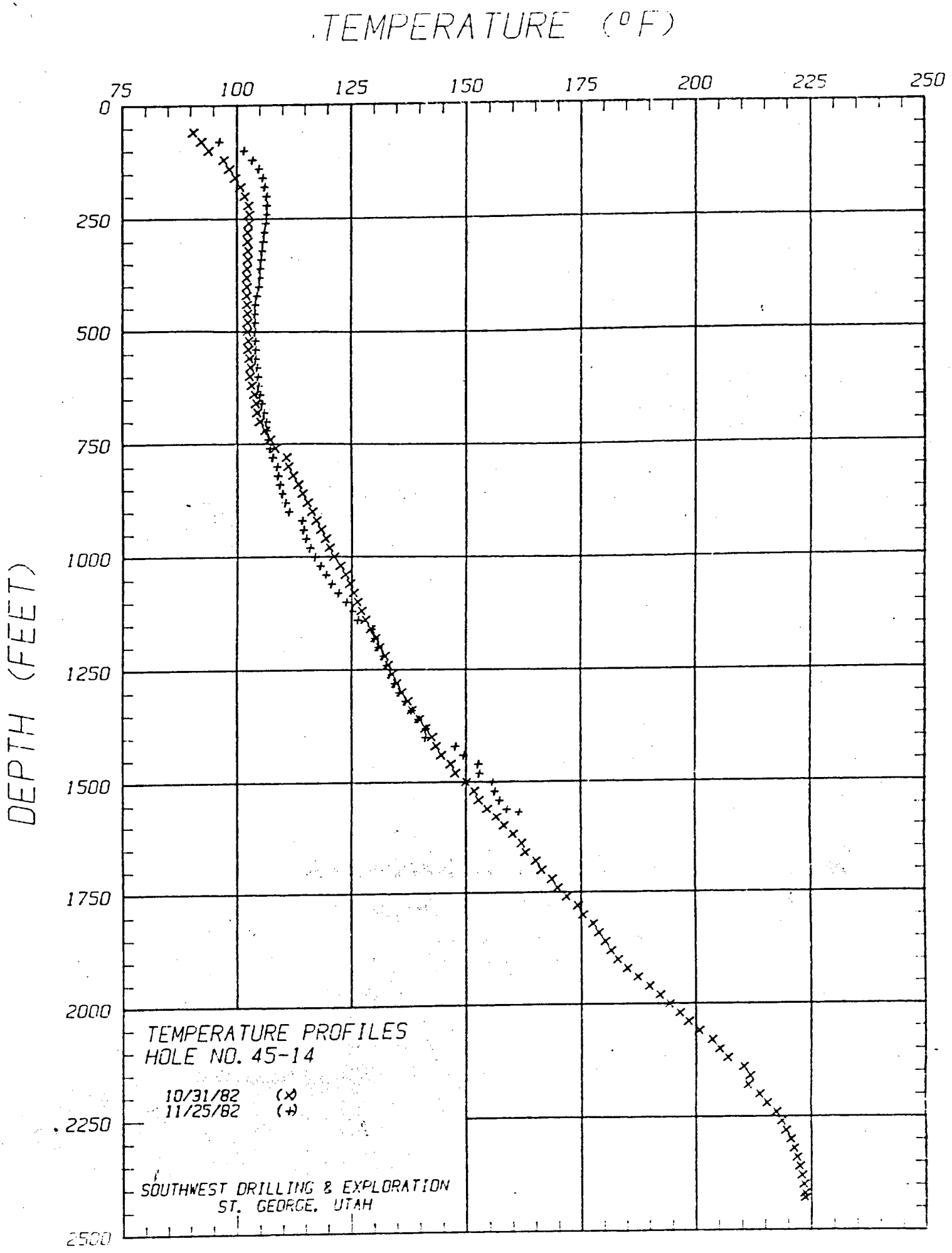
SOUTHWEST DRILLING AND EXPLORATION, INC.
Geotechnical Services Group
14013 Midland Road
Poway, California 92064

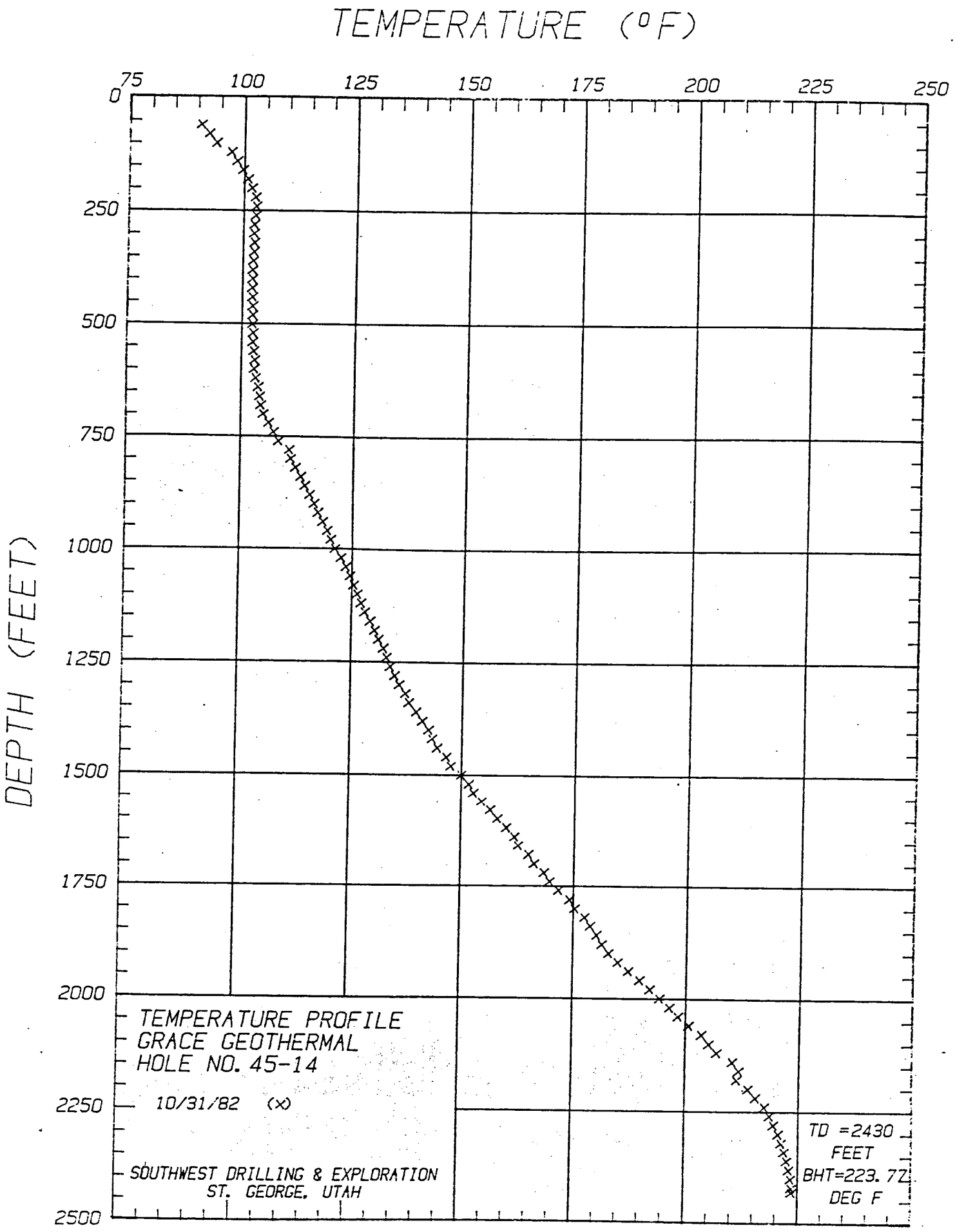
January 1983

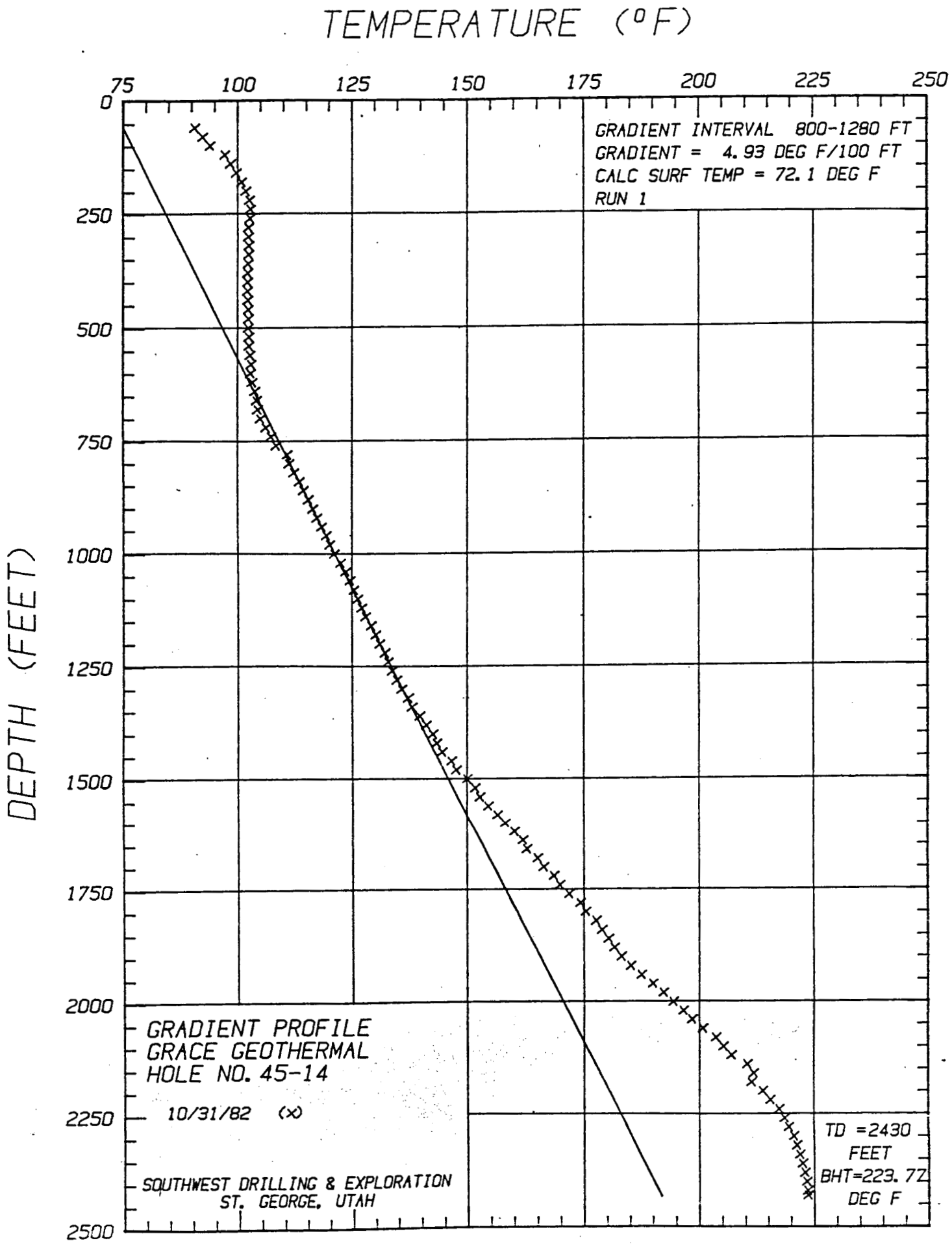
APPENDIX A

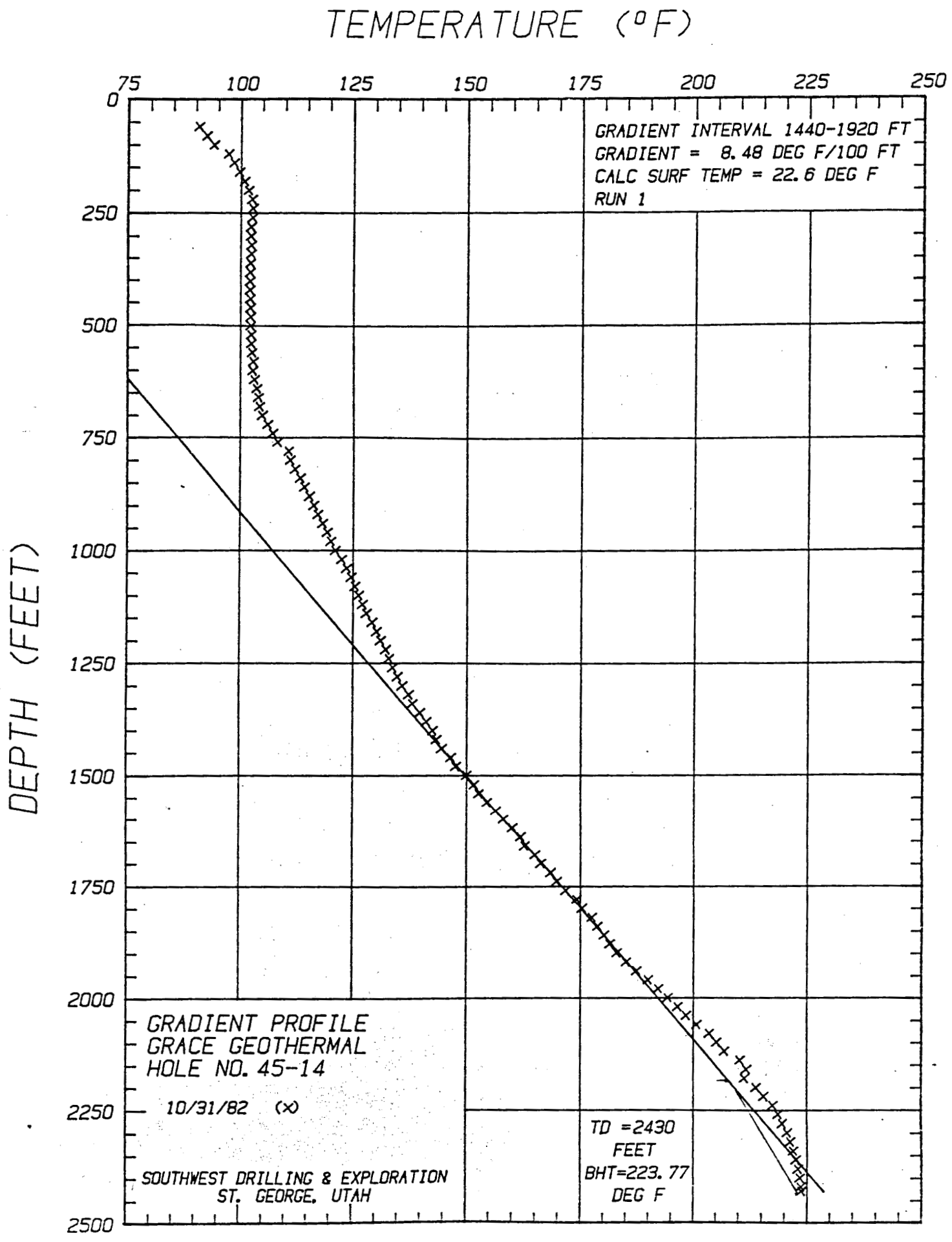
TEMPERATURE, GRADIENT, INTERVAL GRADIENT PLOTS AND TEMPERATURE/DEPTH DATA

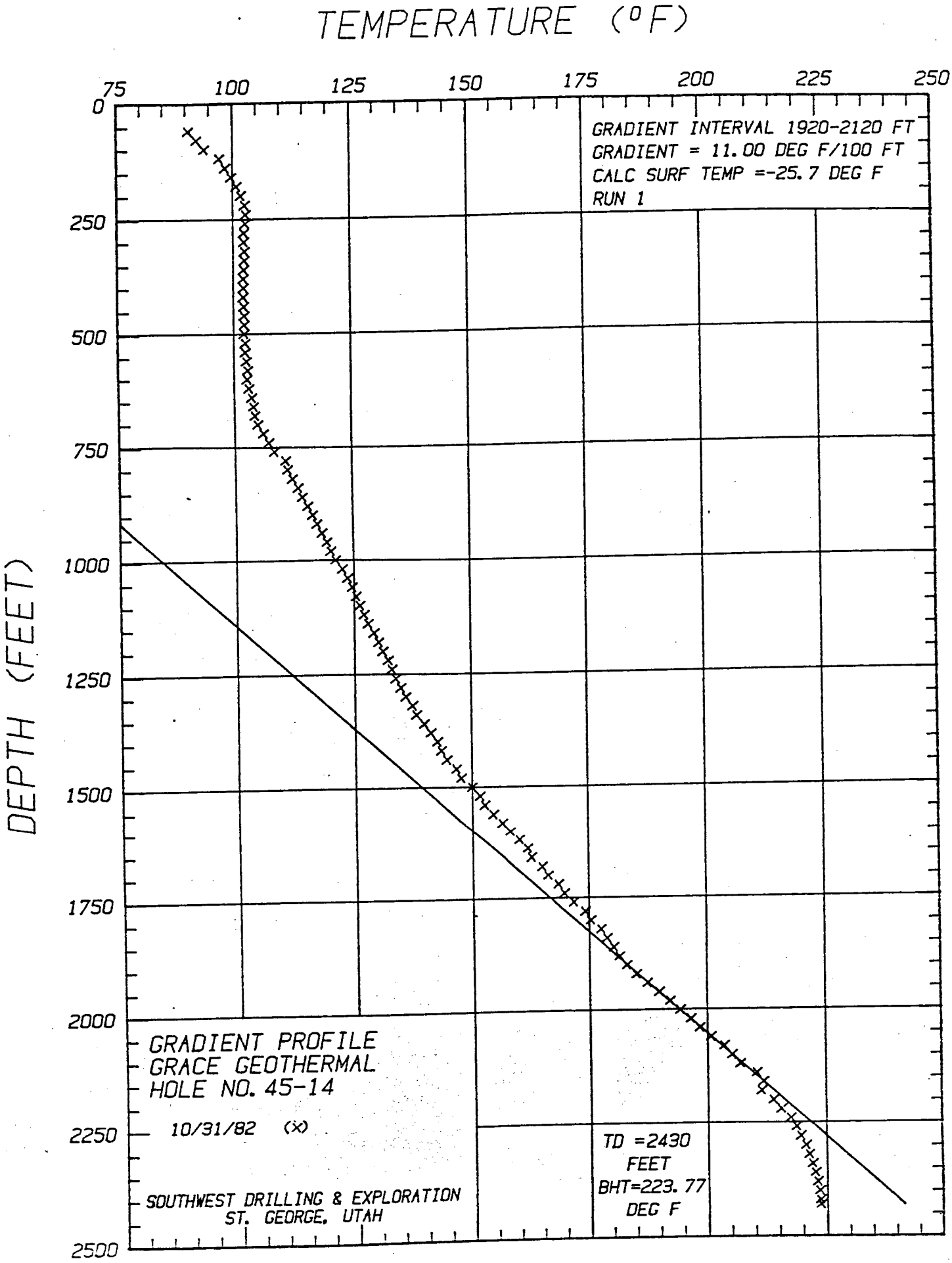
HOLE NO: 45-14


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
TEMPERATURE PROFILES
HOLE NO. 45-14
10/31/82 (x)
11/25/82 (+)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
TEMPERATURE PROFILE
GRACE GEOTHERMAL
HOLE NO. 45-14
10/31/82 (X)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH
TD =2430
FEET
BHT=223.7Z
DEG F


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
GRADIENT INTERVAL 800-1280 FT
GRADIENT = 4.93 DEG F/100 FT
CALC SURF TEMP = 72.1 DEG F
RUN 1
GRADIENT PROFILE
GRACE GEOTHERMAL
HOLE NO. 45-14
10/31/82 (x)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH
TD =2430
FEET
BHT=223.72
DEG F


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
GRADIENT INTERVAL 1440-1920 FT
GRADIENT = 8.48 DEG F/100 FT
CALC SURF TEMP = 22.6 DEG F
RUN 1
GRADIENT PROFILE
GRACE GEOTHERMAL
HOLE NO. 45-14
10/31/82 (X)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH
TD =2430
FEET
BHT=223.77
DEG F


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
GRADIENT INTERVAL 1920-2120 FT
GRADIENT = 11.00 DEG F/100 FT
CALC SURF TEMP =-25.7 DEG F
RUN 1
GRADIENT PROFILE
GRACE GEOTHERMAL
HOLE NO. 45-14
10/31/82 (x)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH
TD =2430
FEET
BHT=223.77
DEG F

TEMPERATURE/DEPTH DATA

HOLE NO: 45-14
SWDX JOB NO: 23-82

RUN 1 RUN DATE: 10/31/82

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)	DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
60	90.62		1060	124.73	4.7
80	92.37	8.7	1080	125.57	4.2
100	94.01	8.2	1100	126.40	4.2
120	97.19	15.9	1120	127.21	4.0
140	98.48	6.5	1140	128.07	4.3
160	99.74	6.3	1160	129.31	6.2
180	100.87	5.7	1180	130.27	4.8
200	101.77	4.5	1200	131.17	4.5
220	102.57	4.0	1220	132.30	5.7
240	102.79	1.1	1240	133.02	3.6
260	102.70	-.5	1260	133.85	4.2
280	102.37	-1.6	1280	134.93	5.4
300	102.37	0.0	1300	135.99	5.3
320	102.47	.5	1320	137.41	7.1
340	102.44	-.1	1340	138.22	4.0
360	102.27	-.9	1360	139.82	8.0
380	102.20	-.3	1380	141.25	7.1
400	102.19	-.0	1400	142.67	7.1
420	102.16	-.1	1420	143.50	4.2
440	102.25	.4	1440	144.66	5.8
460	102.33	.4	1460	146.66	10.0
480	102.35	.1	1480	147.73	5.3
500	102.34	-.1	1500	150.06	11.7
520	102.49	.8	1520	151.79	8.6
540	102.50	.1	1540	152.77	4.9
560	102.72	1.1	1560	154.61	9.2
580	102.97	1.2	1580	156.55	9.7
600	102.86	-.6	1600	158.23	8.4
620	103.22	1.8	1620	160.16	9.7
640	103.77	2.7	1640	162.01	9.2
660	104.15	1.9	1660	162.87	4.3
680	104.41	1.3	1680	165.13	11.3
700	104.97	2.8	1700	166.41	6.4
720	106.16	6.0	1720	168.58	10.8
740	107.31	5.7	1740	169.90	6.6
760	108.41	5.5	1760	171.86	9.8
780	110.82	12.0	1780	174.27	12.1
800	111.21	1.9	1800	175.46	6.0
820	112.28	5.3	1820	177.68	11.1
840	113.48	6.0	1840	178.94	6.3
860	114.37	4.4	1860	180.38	7.2
880	115.46	5.4	1880	181.60	6.1
900	116.48	5.1	1900	183.14	7.7
920	117.36	4.4	1920	185.19	10.3
940	118.42	5.3	1940	187.49	11.5
960	119.47	5.3	1960	190.04	12.7
980	120.24	3.8	1980	192.28	11.2
1000	121.22	4.9	2000	194.41	10.7
1020	122.64	7.1	2020	196.62	11.0
1040	123.79	5.8	2040	198.51	9.4

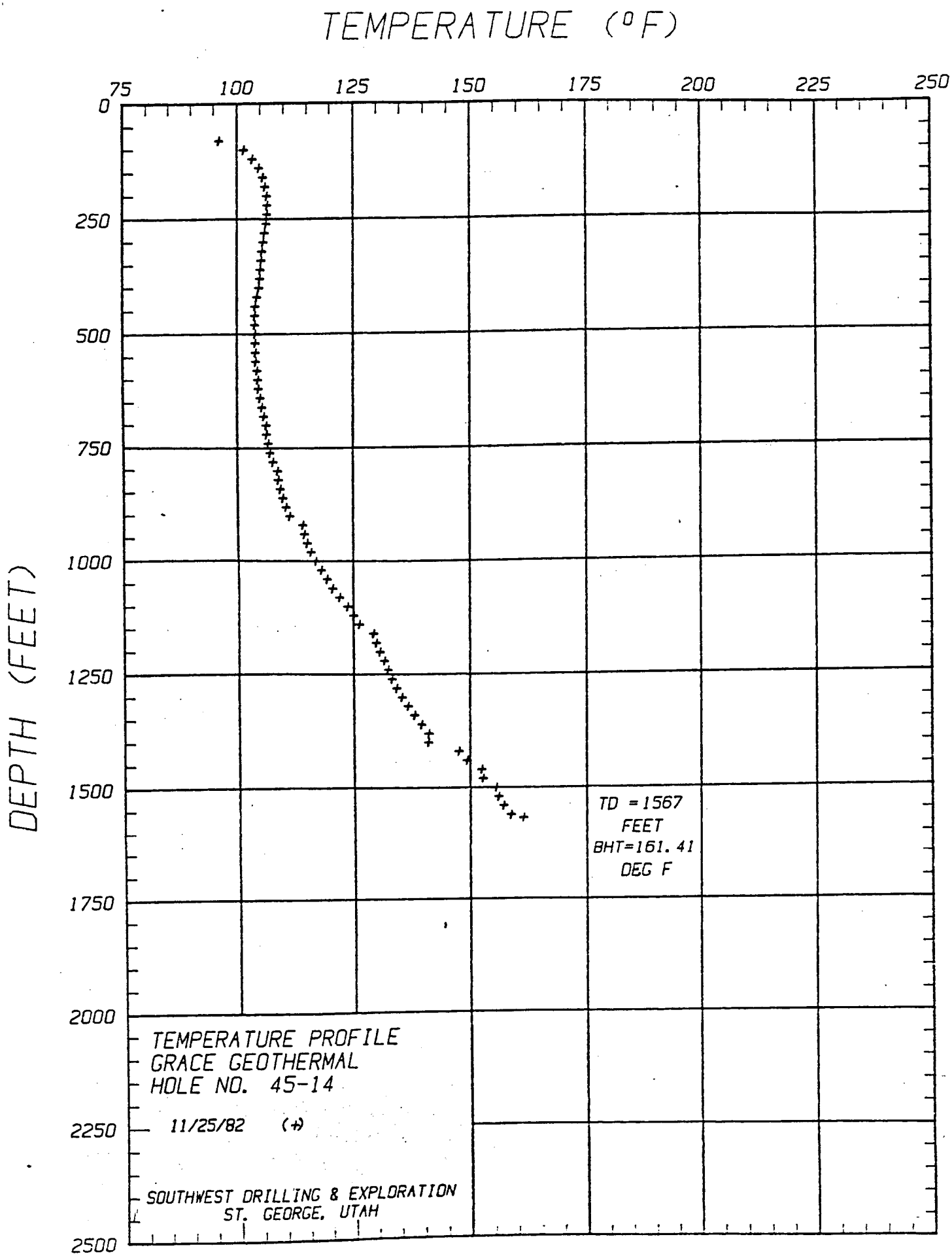
SOUTHWEST DRILLING & EXPLORATION, INC.
ST. GEORGE, UTAH

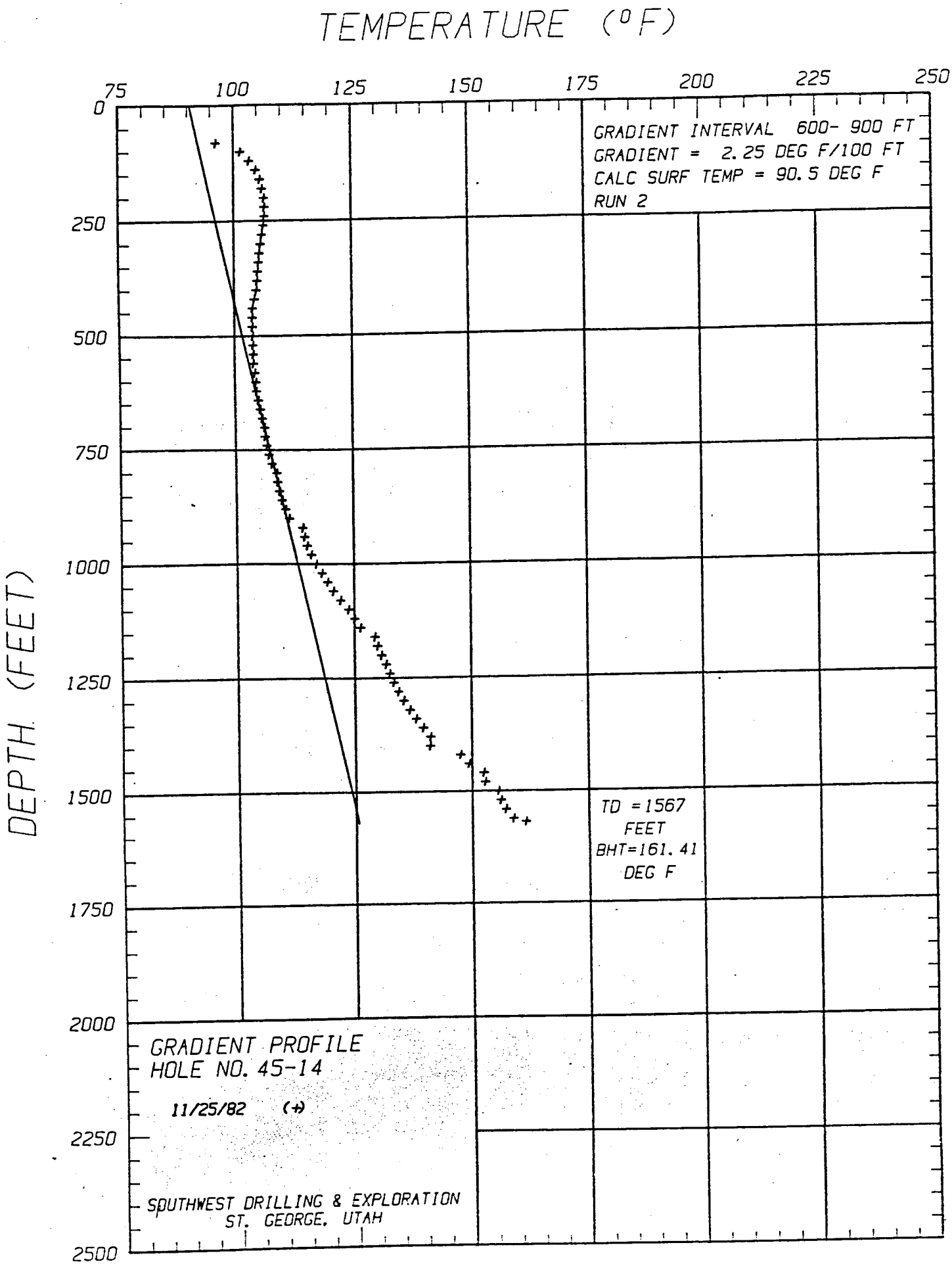
HOLE NO: 45-14
SWDX JOB NO: 23-82

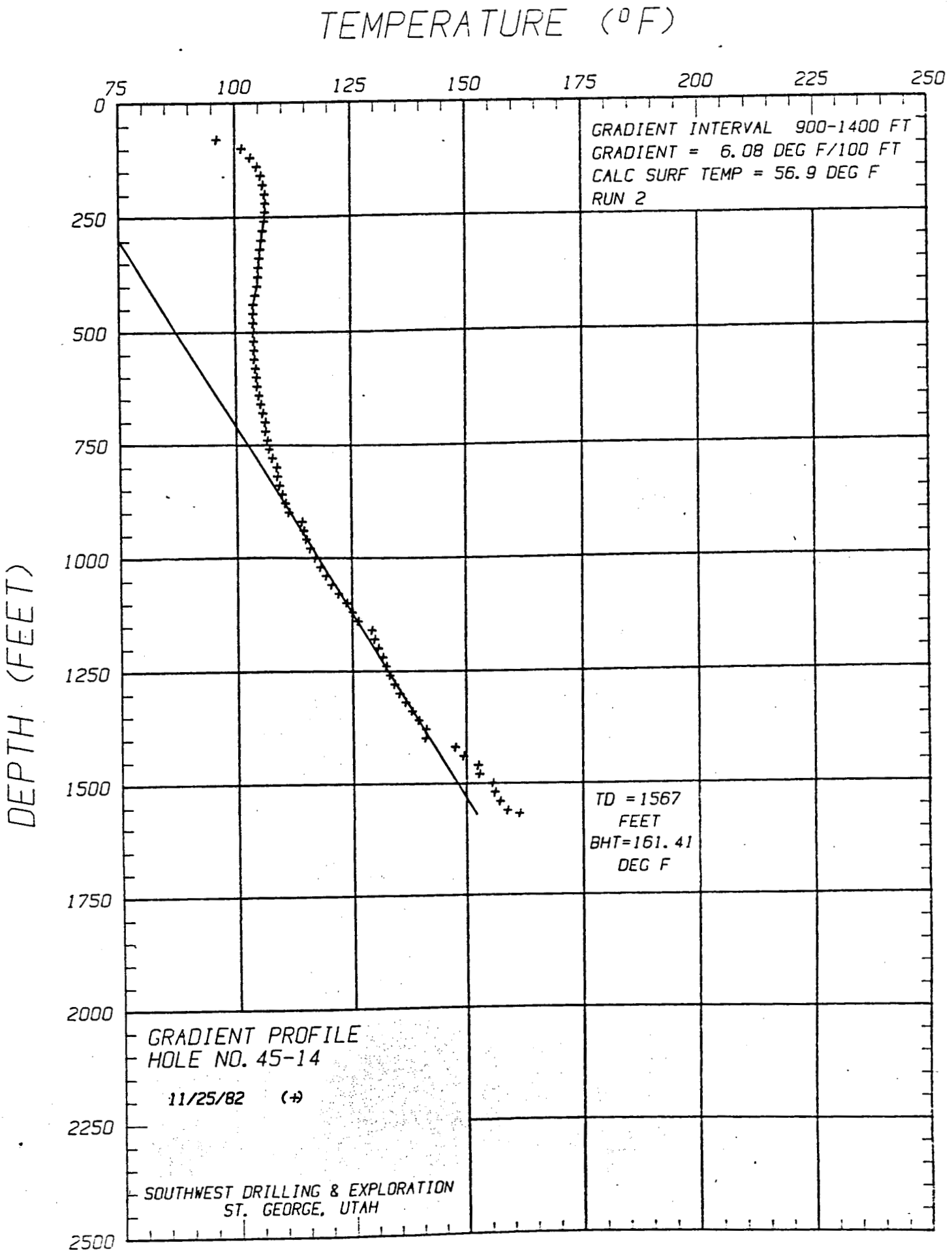
RUN 1 RUN DATE: 10/31/82

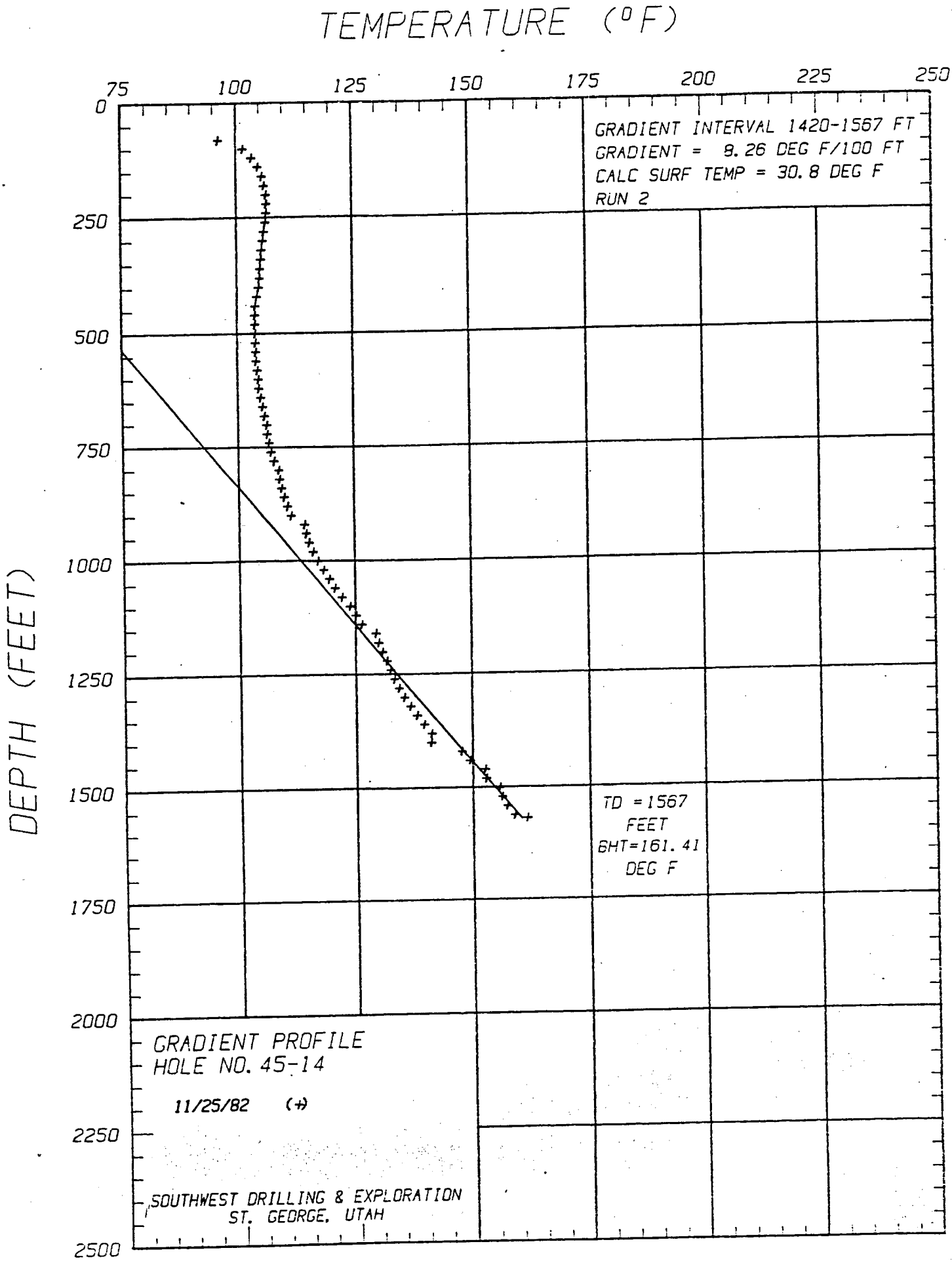
DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
2060	200.84	11.7
2080	203.60	13.8
2100	205.24	8.2
2120	207.00	8.8
2140	210.41	17.1
2160	211.86	7.2
2180	211.40	-2.3
2200	213.91	12.6
2220	215.58	8.3
2240	217.56	9.9
2260	218.74	5.9
2280	219.63	4.4
2300	220.71	5.4
2320	221.39	3.4
2340	222.02	3.2
2360	222.60	2.9
2380	223.08	2.4
2400	223.49	2.1
2420	223.68	.9
2430	223.77	.9

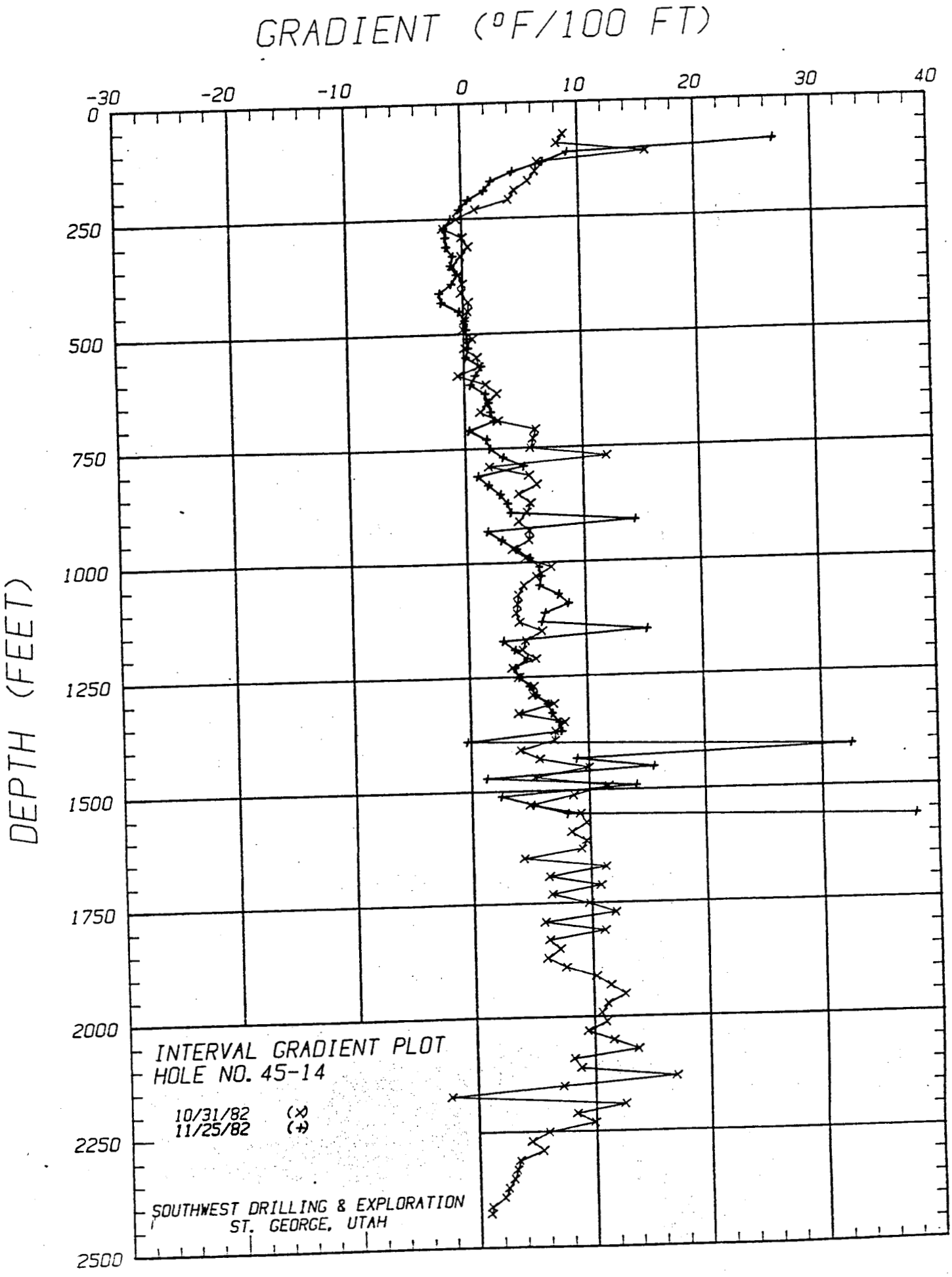
SOUTHWEST DRILLING & EXPLORATION, INC.
ST. GEORGE, UTAH


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
TD = 1567 FEET
BHT=161.41 DEG F
TEMPERATURE PROFILE
GRACE GEOTHERMAL
HOLE NO. 45-14
11/25/82 (+)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
GRADIENT INTERVAL 600- 900 FT
GRADIENT = 2.25 DEG F/100 FT
CALC SURF TEMP = 90.5 DEG F
RUN 2
TD =1567
FEET
BHT=161.41
DEG F
GRADIENT PROFILE
HOLE NO. 45-14
11/25/82 (+)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
GRADIENT INTERVAL 900-1400 FT
GRADIENT = 6.08 DEG F/100 FT
CALC SURF TEMP = 56.9 DEG F
RUN 2
TD = 1567
FEET
BHT=161.41
DEG F
GRADIENT PROFILE
HOLE NO. 45-14
11/25/82 (+)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
DEPTH (FEET)
GRADIENT INTERVAL 1420-1567 FT
GRADIENT = 9.26 DEG F/100 FT
CALC SURF TEMP = 30.8 DEG F
RUN 2
TD = 1567
FEET
BHT=161.41
DEG F
GRADIENT PROFILE
HOLE NO. 45-14
11/25/82 (+)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


GRADIENT (°F/100 FT)
-30
-20
-10
0
10
20
30
40
DEPTH (FEET)
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
INTERVAL GRADIENT PLOT
HOLE NO. 45-14
10/31/82 (×)
11/25/82 (+)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH

TEMPERATURE/DEPTH DATA

HOLE NO: 45-14
SWDX JOB NO: 23-82

RUN 2 RUN DATE: 11/25/82

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
80	96.19	
100	101.54	26.7
120	103.35	9.0
140	104.74	6.9
160	105.60	4.3
180	106.09	2.4
200	106.46	1.9
220	106.56	.5
240	106.51	-.2
260	106.30	-1.0
280	105.98	-1.6
300	105.69	-1.5
320	105.41	-1.4
340	105.24	-.9
360	105.03	-1.0
380	104.92	-.6
400	104.72	-1.0
420	104.31	-2.1
440	103.93	-1.9
460	103.85	-.4
480	103.87	.1
500	103.91	.2
520	103.96	.2
540	104.03	.3
560	104.06	.1
580	104.34	1.4
600	104.52	.9
620	104.62	.5
640	104.96	1.7
660	105.36	2.0
680	105.79	2.2
700	106.28	2.4
720	106.34	.3
740	106.69	1.8
760	107.10	2.0
780	107.73	3.2
800	108.71	4.9
820	108.90	1.0
840	109.27	1.8
860	109.84	2.8
880	110.53	3.5
900	111.28	3.7
920	114.16	14.4
940	114.50	1.7
960	115.08	2.9
980	115.91	4.2
1000	116.96	5.2
1020	118.17	6.0
1040	119.41	6.2
1060	120.62	6.0
1080	122.15	7.6
1100	123.85	8.5
1120	125.14	6.5
1140	126.38	6.2
1160	129.43	15.2
1180	130.00	2.9
1200	130.77	3.9
1220	131.74	4.9
1240	132.50	3.8
1260	133.34	4.2
1280	134.35	5.1
1300	135.46	5.6
1320	136.77	6.5
1340	138.15	6.9
1360	139.65	7.5
1380	141.19	7.7
1400	141.12	-.4
1420	147.63	32.6
1440	149.42	8.9
1460	152.54	15.6
1480	152.79	1.2
1500	155.60	14.1
1520	156.09	2.4
1540	157.13	5.2
1560	158.75	8.1
1567	161.41	38.0

SOUTHWEST DRILLING & EXPLORATION, INC.
ST. GEORGE, UTAH

APPENDIX B

THERMAL CONDUCTIVITY DATA

HOLE NO: 45-14

THERMAL CONDUCTIVITY DATA
BALTAZOR HOT SPRINGS

HOLE NO: 45-14
SWDX JOB NO: 23-82

SAMPLE DEPTH (FEET)	ASSUMED POROSITY (%)	THERMAL CONDUCTIVITY (TCU)*
210- 220	15	4.1
300- 310	15	4.0
430- 440	15	4.1
510- 520	15	2.9
570- 580	15	3.1
610- 620	10	4.0
700- 710	10	4.1
800- 810	10	4.2
880- 890	15	3.7
920- 930	15	3.1
1000-1010	15	3.4
1110-1120	15	3.6
1200-1210	15	3.4
1300-1310	15	3.4
1400-1410	15	3.7
1500-1510	15	3.1
1600-1610	15	3.4
1700-1710	15	3.4
1800-1810	15	3.9
1900-1910	15	3.4

THERMAL CONDUCTIVITY DATA
BALTAZOR HOT SPRINGS

HOLE NO: 45-14
SWDX JOB NO: 23-82

SAMPLE DEPTH (FEET)	ASSUMED POROSITY (%)	THERMAL CONDUCTIVITY (TCU)*
2000-2010	15	3.6
2100-2110	15	3.4
2200-2210	15	4.8
2300-2310	15	4.9
2400-2410	15	4.8
2500-2510	15	5.5

* - TCU = 1 mcal/cm-sec-deg C

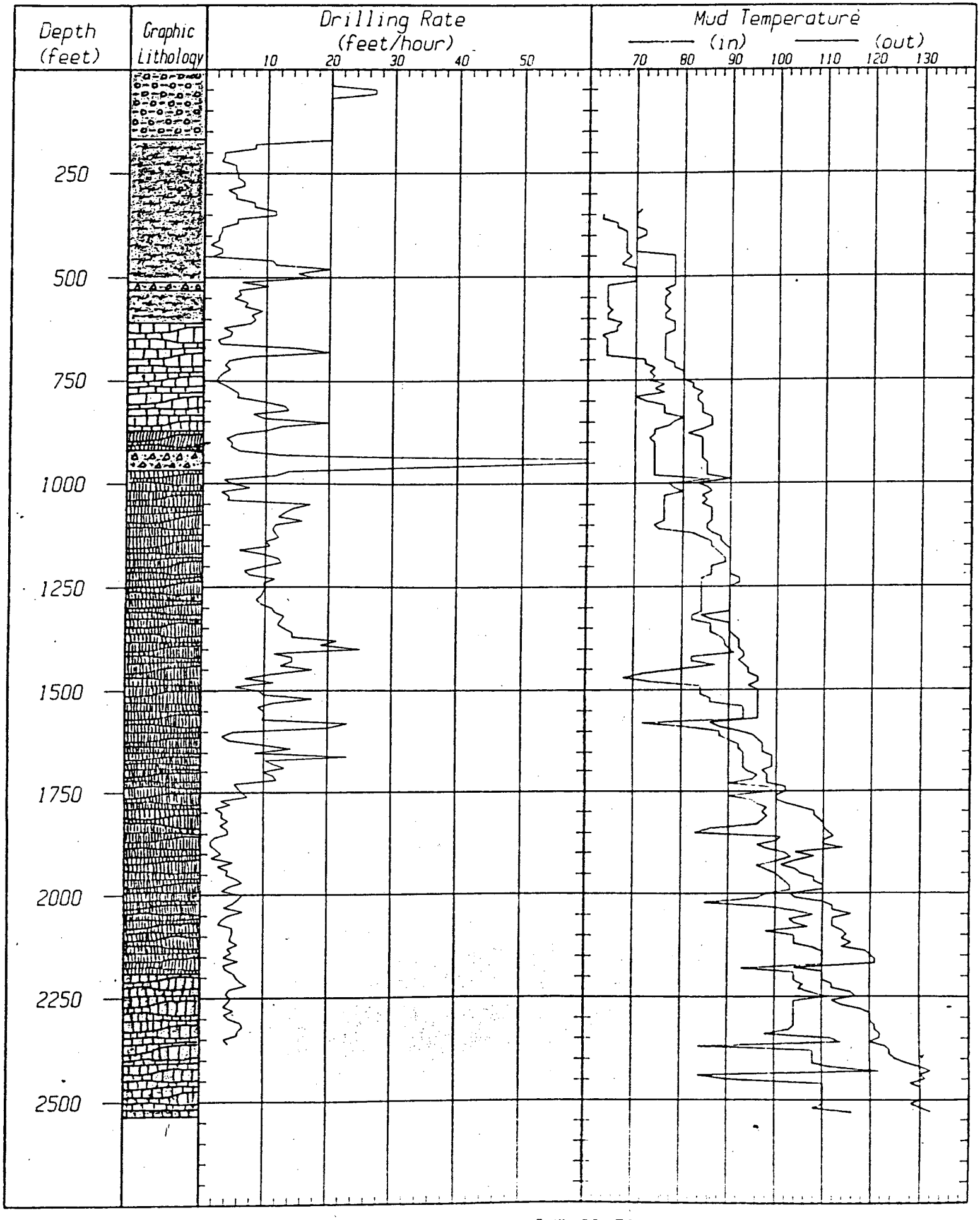
APPENDIX C

DRILLING HISTORY AND DRILLING DATA PLOT

HOLE NO: 45-14

DRILLING DATA

HOLE NO: 45-14



SOUTHWEST DRILLING & EXPLORATION, INC.

DRILLING HISTORY

HOLE NO: 45-14
SWDX JOB NO: 23-82

DATE	DEPTH	SUMMARY OF OPERATIONS
9/21/82	0- 0	Move rig to site. Build road and pad. Dig one mud pit and rig up.
9/22/82	0- 0	Continue to rig up and dig second mud pit.
9/23/82	0- 0	Finish digging mud pits. Haul water and mix mud. Send flat bed truck to pick up casing.
9/24/82	0- 36	Stir up mud pits. Spud hole at 7:30 am with 17 1/2" bit and drill to 36' in alluvial fan deposits. Set 12 1/4" surface casing to 36'. Mix cement and pump down outside of casing. Build and install flowline.
9/25/82	36- 190	Make up 8 3/4" bottom hole assembly and drill to 147'. Trip to check bit. Run in hole with 9 7/8" bit and ream from 36' to 147'. Drill to 190' with 9 7/8" bit. Drilling in alluvial fan deposits to 180', rhyolite to 190'.
9/26/82	190- 280	Drill to 200'. Trip to check bit and adjust rotary table clutch linkage. Drill to 207'. Trip to lay down stabilizer and drill to 280' in rhyolite with 9 7/8" bit.
9/27/82	280- 394	Drill to 312' and encounter lost circulation zone. Loose 1/2 pit of mud. Mix mud and LCM. Regain circulation. Drill to 394' in rhyolite.
9/28/82	394- 407	Mix mud. Drill to 407' in rhyolite. Trip out of hole and make up 12 1/4" hole opener. Ream hole from 36'.
9/29/82	407- 421	Continue to ream hole with 12 1/4" hole opener to 407'. Trip out to lay down hole opener. Clean mud pits and mix mud. Run in hole with 9 7/8" bit and drill to 417'. Trip to lay down stablizer. Run in hole and drill to 421' in rhyolite.
9/30/82	421- 442	Drill to 442' in rhyolite. Trip out of hole. Make up hole opener. Run in hole and ream hole with 12 1/4" opener from 407'.

DATE	DEPTH	SUMMARY OF OPERATIONS
10/01/82	442- 442	Continue to ream hole with 12 1/4" hole opener to 418'. Pull out of hole. Gearhart logging hole. Run 9 5/8" casing. Unable to get casing past 320'. Pull casing out of hole.
10/02/82	442- 442	Continue to pull casing out of hole. Make up stacked hole opener. Run in hole with 12 1/4" stacked hole opener. Ream to straighten hole from about 280'.
10/03/82	442- 442	Continue to ream hole to straighten down to 403'. Pull out of hole and lay down pipe. Run 9 5/8" casing to 402'. Cement casing; good returns. Wait on cement.
10/04/82	442- 442	Wait on cement. Dig cellar for BOPE. Cut off casing, weld on well head and install BOPE. Test BOPE; passes test. Clean mud pits. Make up 8 3/4" down hole assembly.
10/05/82	442- 525	Run in hole with 8 3/4" bit. Tagged cement at 369'. Condition mud. Drill to formation 428'. Trip to change to 6 3/4" bit and stablizer. Drill in altered rhyolite to 525'. 500' to 520' is vesicular rhyolite and ash tuff.
10/06/82	525- 649	Drill with 6 3/4" bit to 649'. Drilling in vesicular rhyolite to 570', and rhyolite to 610'. Lithology change at 610' to andesite where drilling slows.
10/07/82	649- 736	Drill with 6 3/4" bit to 660'. Trip to change bit and drill to 736' in andesite.
10/08/82	736- 750	Drill to 750'. Pull out of hole to switch from mud to air. Run in hole. Encounter too much water (~200 GPM). Pull out of hole. Switch to mud and ream hole.
10/09/82	750- 881	Continue to ream hole with 6 3/4" bit to 750'. Trip to change bit. Drill to 881'. Lithology change at 870' to basalt.
10/10/82	881-1018	Drill to 940' in basalt, to 970' in ash flow tuff, to 990' in basalt, to 1018' in basalt/clay. Trip out of hole at 990' to clean 6 3/4" bit and put in jets.
10/11/82	1018-1228	Continue to drill with 6 3/4" bit from 1018' to 1228' in basalt.

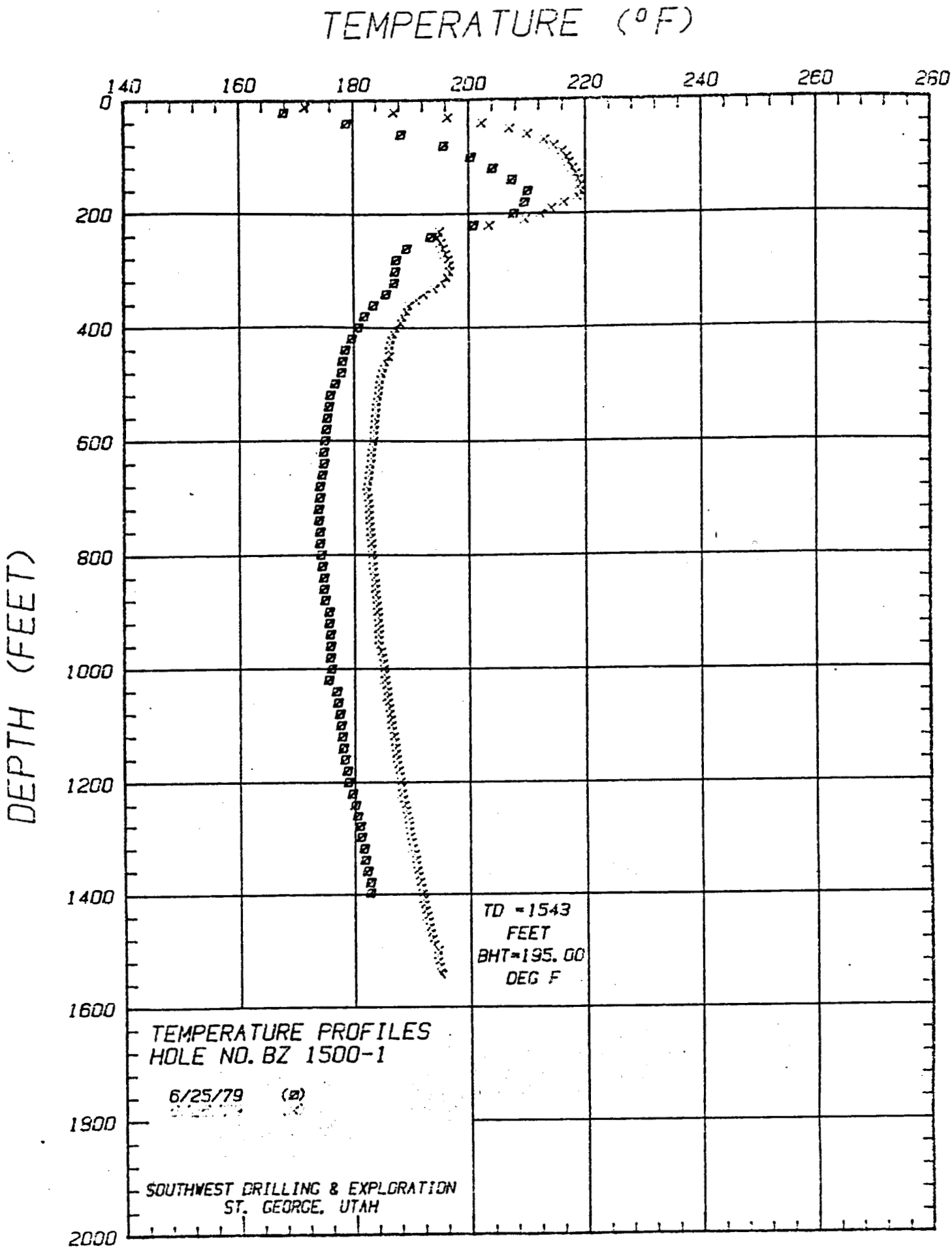
DATE	DEPTH	SUMMARY OF OPERATIONS
10/12/82	1228-1483	Drill from 1228' to 1483' with 6 3/4" bit. Drilling in basalt with blue clay.
10/13/82	1483-1612	Drill with 6 3/4" bit to 1490' (still in basalt with blue clay). Thin mud and drill to 1570' in basalt. Trip out of hole to check bit. Clean mud pits and run maintainence on rig. Mix mud and run in hole with 6 3/4" bit. Drill to 1612' in basalt.
10/14/82	1612-1750	Drill with 6 3/4" bit to 1750' in basalt. Circulate to clean hole and drop drift tool (bad run). Run in hole and mix mud.
10/15/82	1750-1804	Drop drift tool again (6 deg off). Trip out of hole. Maintainence. Mix mud and run in hole with 6 3/4" bit, drill in basalt to 1804'. Drilling with reduced weight on bit to straighten hole.
10/16/82	1804-1872	Drill with 6 3/4" bit from 1804' to 1872' in basalt with ash/tuff.
10/17/82	1872-1913	Drill with 6 3/4" bit to 1895'. Mix mud and continue down to 1913' in basalt. Drop drift tool (3.25 deg off). Pull out of hole. Run maintainence on rig.
10/18/82	1913-1954	Rig maintainence. Run in hole with new 6 1/2" bit. Drill to 1920'. Mix mud and continue to 1954' in basalt.
10/19/82	1954-2038	Drill to 1994' with 6 1/2" bit. Circulate and drop drift tool (5.75 deg off). Pull out of hole, maintainence, run in hole. Drill ahead to 2038' with 6 1/2" bit in basalt.
10/20/82	2038-2132	Drill ahead to 2132' in basalt with 6 1/2" bit. At 2064' added water to pit to reduce viscosity of mud. Rig maintainence at 2114'.
10/21/82	2132-2184	Drill ahead to 2184' in basalt with 6 1/2" bit. Open 3rd mud pit and mix mud. Pull out of hole - 10 buttons missing from bit. Install new 6 1/2" journel button bit, mix mud and run in hole. Circulate and run wireline deviation survey (3.75 deg off). Pull out of hole - plugged float. Clean mud pump and lines.
10/22/82	2184-2268	Run in hole. Mix and condition mud. Drill with 6 1/2" bit to 2268' in basalt to 2190', to 2268' in andesitic basalt. Water added to mud pits at 2194',2206', and 2254'.

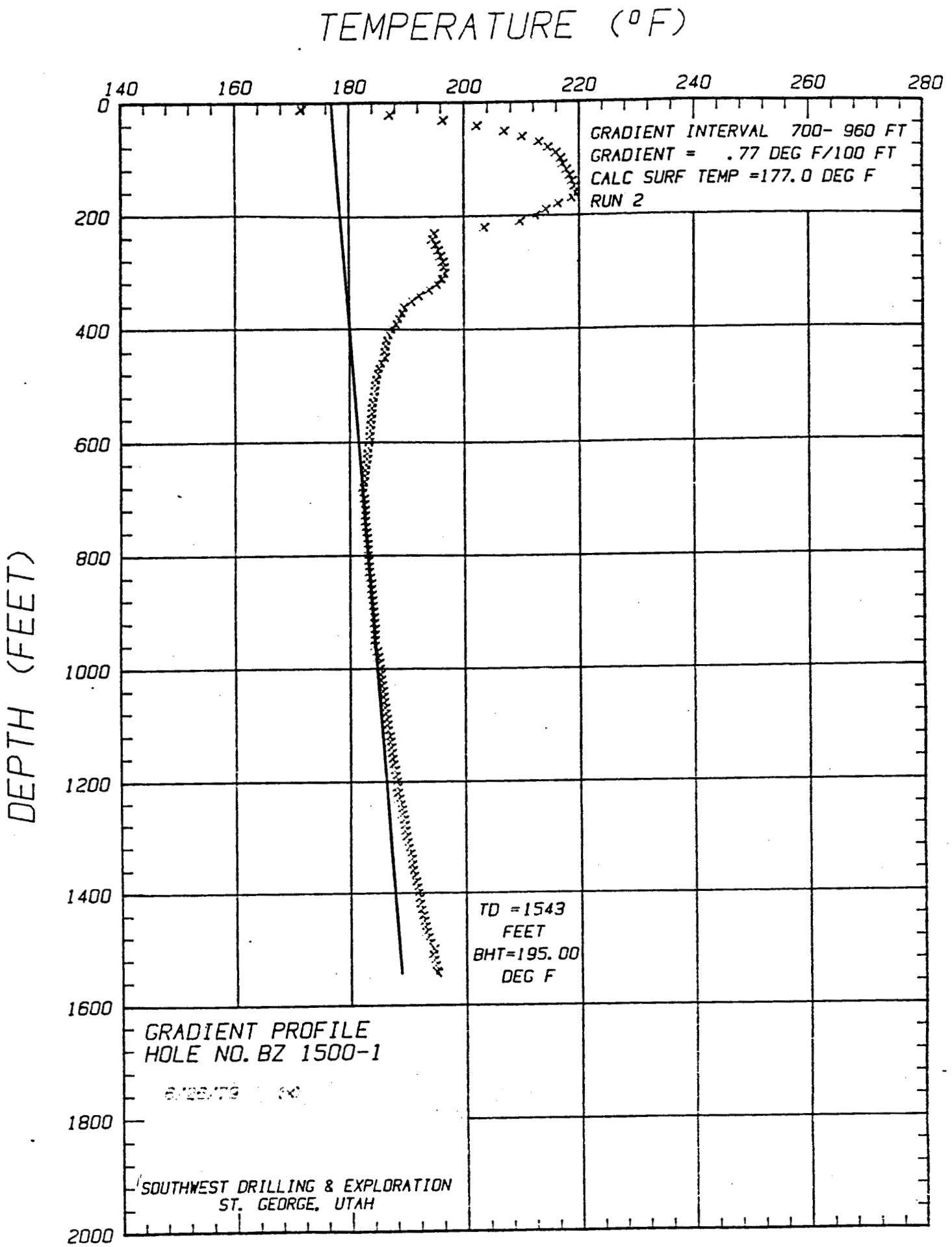
DATE	DEPTH	SUMMARY OF OPERATIONS
10/23/82	2268-2375	Drill ahead with 6 1/2" bit to 2300' mixing mud at 2294'. Run wireline deviation survey at 2300' (2.25 deg off). Drill ahead to 2375' mixing mud at 2354'. Drilling in andesitic basalt 2268' to 2375'.
10/24/82	2375-2462	Maintainence (repair pump clutch yoke). Drill ahead to 2400'. Circulate and run wireline deviation survey (2.00 deg off). Drill ahead to 2434'. Maintainence (change hoisting line). Drill ahead to 2462', mixing mud at 2454'. Andesitic basalt 2375' to 2462'.
10/25/82	2462-2529	Drill ahead to 2500' with 6 1/2" bit. Circulate and run wireline deviation survey (bad run). Drill ahead to 2513', circulate, and run survey again (5.00 deg off). Drill to 2529' in andesitic basalt. Pull out of hole.
10/26/82	2529-2529	Maintainence (clean and re-install hoist line clutch). Clean mud pits and mix mud. Maintainence (change battery on rig, air line on draw works, and check gear boxes). Run in hole and mix mud. Problems with hoisting line clutch, will not pull pipe. Pull out of hole.
10/27/82	2529-2529	Maintainence on hoisting line clutch.
10/28/82	2529-2529	Make up 8 5/8" hole opener. Run in hole to 475'. Stir mud pits and mix mud. Ream hole from 475' to 758'.
10/29/82	2529-2529	Ream hole with 8 5/8" hole opener from 758' to 796'.
10/30/82	2529-2529	Pull out of hole and lay down pipe. Pick up and load equipment.
10/31/82	2529-2529	Run temperature survey on hole. TD = 2430'.
11/01/82	2529-2529	Rig down. Move rig to Denio Junction. Remove mud from pits.

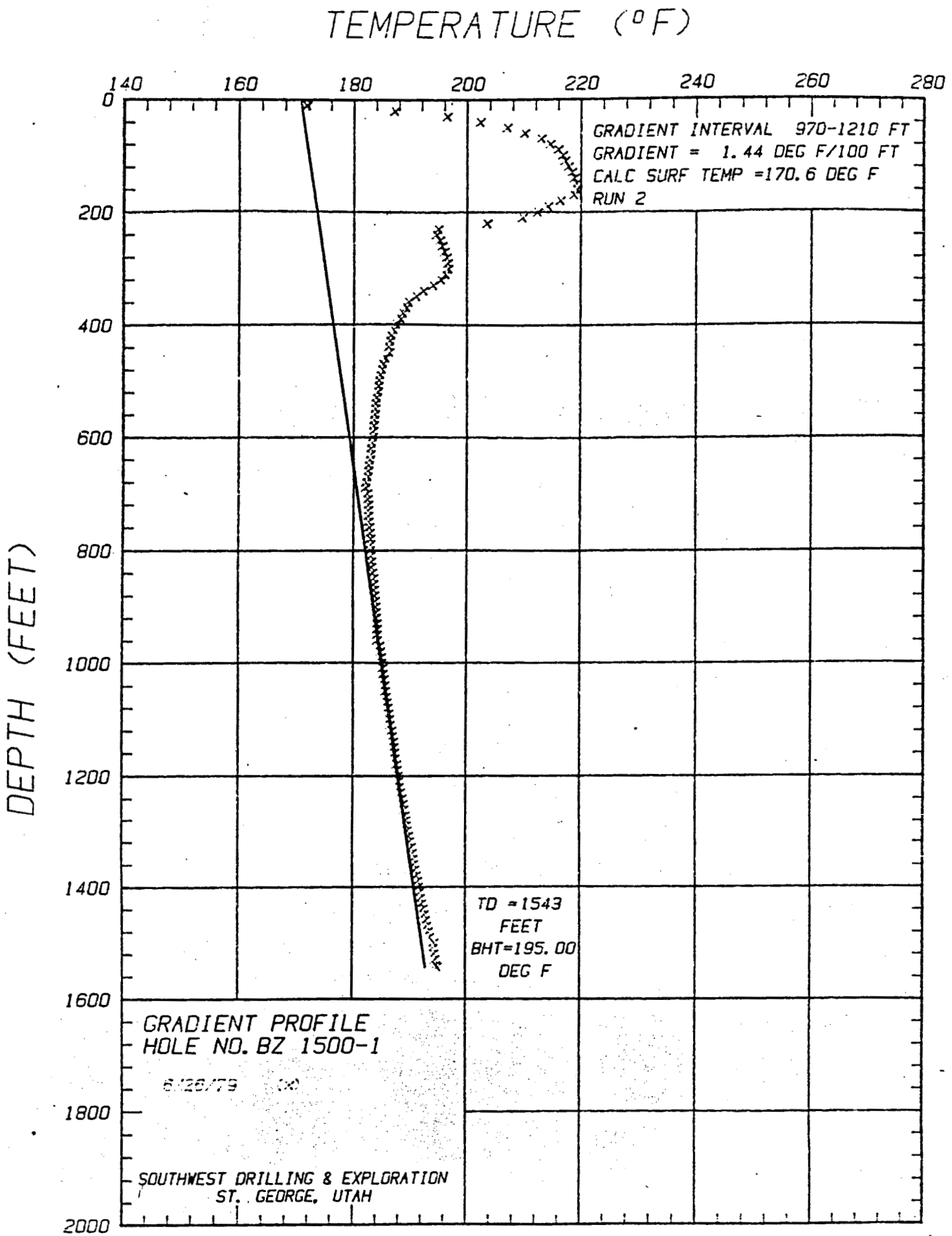
APPENDIX D

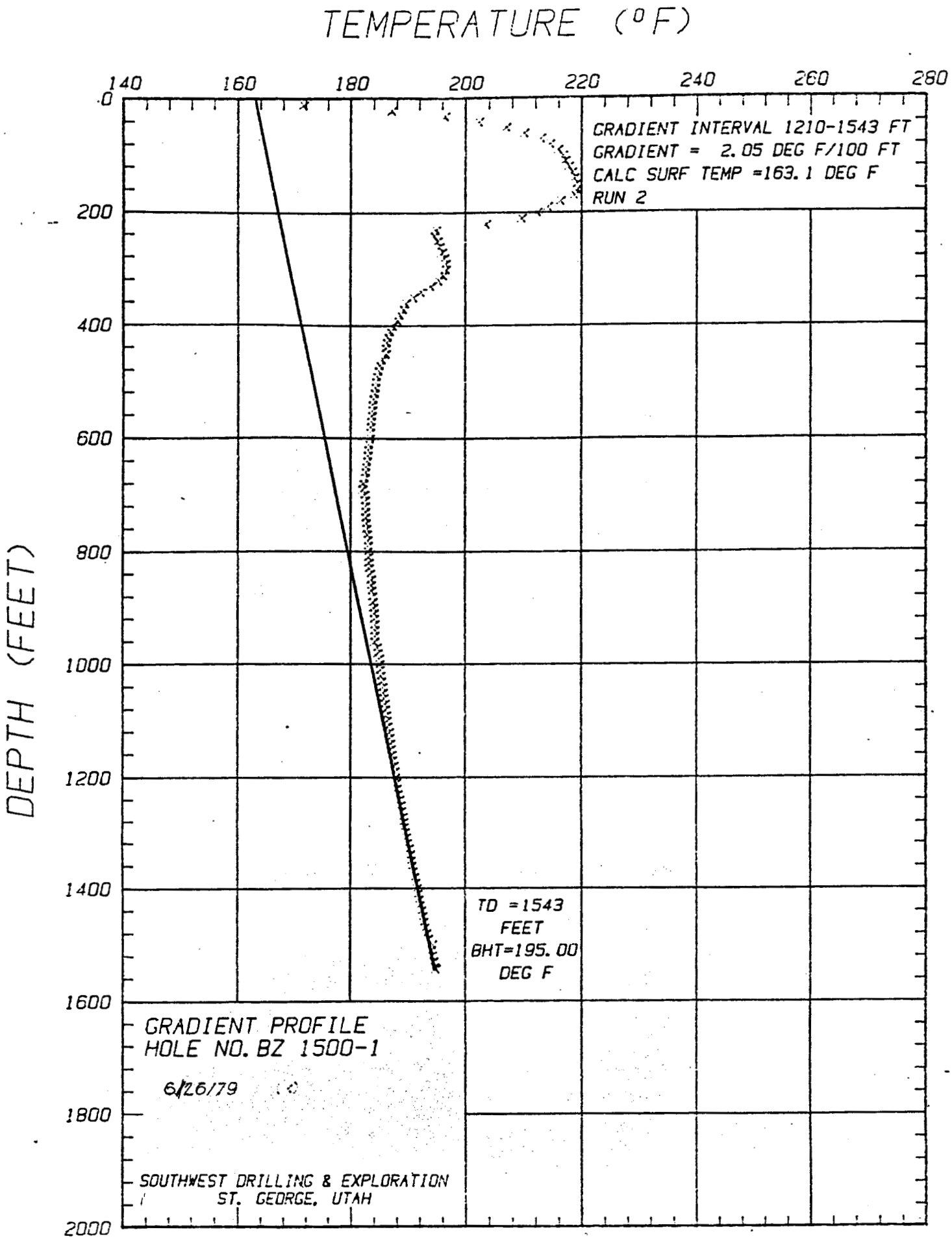
TEMPERATURE, GRADIENT, INTERVAL GRADIENT PLOTS AND TEMPERATURE/DEPTH DATA

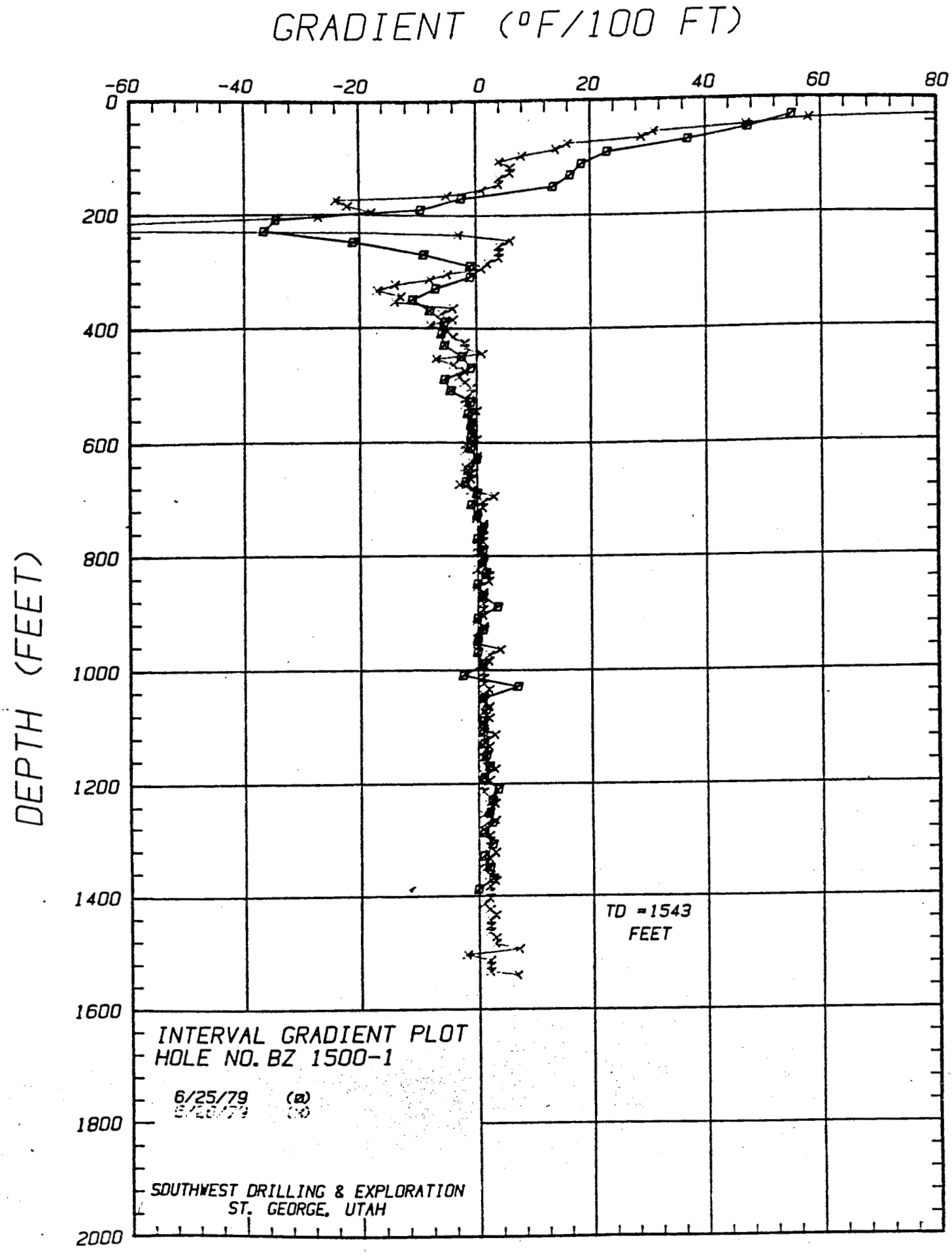
HOLE NOS: BZ 1500-1 & BZ 1500-2


TEMPERATURE (°F)
140
160
180
200
220
240
260
280
DEPTH (FEET)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
TD =1543
FEET
BHT=195.00
DEG F
TEMPERATURE PROFILES
HOLE NO. BZ 1500-1
6/25/79
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
140
160
180
200
220
240
260
280
DEPTH (FEET)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
GRADIENT INTERVAL 700- 960 FT
GRADIENT = .77 DEG F/100 FT
CALC SURF TEMP =177.0 DEG F
RUN 2
TD =1543
FEET
BHT=195.00
DEG F
GRADIENT PROFILE
HOLE NO. BZ 1500-1
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
140
160
180
200
220
240
260
280
DEPTH (FEET)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
GRADIENT INTERVAL 970-1210 FT
GRADIENT = 1.44 DEG F/100 FT
CALC SURF TEMP =170.6 DEG F
RUN 2
TD =1543
FEET
BHT=195.00
DEG F
GRADIENT PROFILE
HOLE NO. BZ 1500-1
6/26/79
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
140
160
180
200
220
240
260
280
DEPTH (FEET)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
GRADIENT INTERVAL 1210-1543 FT
GRADIENT = 2.05 DEG F/100 FT
CALC SURF TEMP =163.1 DEG F
RUN 2
TD =1543
FEET
BHT=195.00
DEG F
GRADIENT PROFILE
HOLE NO. BZ 1500-1
6/26/79
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


GRADIENT (°F/100 FT)
-60
-40
-20
0
20
40
60
80
DEPTH (FEET)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
TD =1543
FEET
INTERVAL GRADIENT PLOT
HOLE NO. BZ 1500-1
6/25/79
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH

TEMPERATURE/DEPTH DATA

HOLE NO: BZ 1500-1
SWDX JOB NO: 21-82

RUN 1 RUN DATE: 6/25/79

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
20	167.90	
40	178.90	55.0
60	188.40	47.5
80	195.80	37.0
100	200.40	23.0
120	204.10	18.5
140	207.40	16.5
160	210.10	13.5
180	209.60	-2.5
200	207.70	-9.5
220	200.80	-34.5
240	193.50	-36.5
260	189.30	-21.0
280	187.50	-9.0
300	187.30	-1.0
320	187.10	-1.0
340	185.70	-7.0
360	183.50	-11.0
380	181.90	-8.0
400	180.80	-5.5
420	179.60	-6.0
440	178.50	-5.5
460	178.00	-2.5
480	177.80	-1.0
500	176.70	-5.5
520	175.80	-4.5
540	175.60	-1.0
560	175.30	-1.5
580	175.10	-1.0
600	174.90	-1.0
620	174.70	-1.0
640	174.70	0.0
660	174.40	-1.5
680	174.00	-2.0
700	174.00	0.0
720	173.80	-1.0
740	173.80	0.0
760	174.00	1.0
780	174.00	0.0
800	174.20	1.0
820	174.40	1.0
840	174.70	1.5
860	174.70	0.0
880	174.90	1.0
900	175.60	3.5
920	175.60	0.0
940	175.80	1.0
960	175.80	0.0
980	175.80	0.0
1000	176.00	1.0
1020	175.50	-2.5
1040	176.90	7.0
1060	177.10	1.0
1080	177.40	1.5
1100	177.60	1.0
1120	177.80	1.0
1140	178.00	1.0
1160	178.30	1.5
1180	178.70	2.0
1200	178.90	1.0
1220	179.60	3.5
1240	180.10	2.5
1260	180.50	2.0
1280	181.00	2.5
1300	181.20	1.0
1320	181.70	2.5
1340	181.90	1.0
1360	182.30	2.0
1380	182.80	2.5
1398	182.80	0.0

SOUTHWEST DRILLING & EXPLORATION, INC.
ST. GEORGE, UTAH

TEMPERATURE/DEPTH DATA

HOLE NO: BZ 1500-1
SWDX JOB NO: 21-82

RUN 2 RUN DATE: 6/26/79

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)	DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
10	171.70		510	184.30	-1.0
20	187.20	155.0	520	184.20	-1.0
30	196.50	93.0	530	184.00	-2.0
40	202.30	58.0	540	183.80	-2.0
50	207.00	47.0	550	183.80	0.0
60	210.10	31.0	560	183.70	-1.0
70	213.00	29.0	570	183.60	-1.0
80	214.60	16.0	580	183.50	-1.0
90	216.00	14.0	590	183.40	-1.0
100	216.80	8.0	600	183.40	0.0
110	217.20	4.0	610	183.20	-2.0
120	217.80	6.0	620	183.00	-2.0
130	218.40	6.0	630	183.00	0.0
140	218.80	4.0	640	182.90	-1.0
150	219.20	4.0	650	182.70	-2.0
160	219.30	1.0	660	182.60	-1.0
170	218.80	-5.0	670	182.50	-1.0
180	216.40	-24.0	680	182.20	-3.0
190	214.20	-22.0	690	182.10	-1.0
200	212.40	-18.0	700	182.40	3.0
210	209.70	-27.0	710	182.50	1.0
220	203.50	-62.0	720	182.60	1.0
230	194.90	-86.0	730	182.60	0.0
240	194.60	-3.0	740	182.60	0.0
250	195.20	6.0	750	182.70	1.0
260	195.60	4.0	760	182.80	1.0
270	196.00	4.0	770	182.90	1.0
280	196.40	4.0	780	183.00	1.0
290	196.60	2.0	790	183.00	0.0
300	196.70	1.0	800	183.00	0.0
310	196.20	-5.0	810	183.10	1.0
320	195.40	-8.0	820	183.20	1.0
330	194.00	-14.0	830	183.20	0.0
340	192.30	-17.0	840	183.40	2.0
350	191.00	-13.0	850	183.60	2.0
360	189.60	-14.0	860	183.60	0.0
370	189.20	-4.0	870	183.70	1.0
380	188.60	-6.0	880	183.80	1.0
390	188.20	-4.0	890	183.90	1.0
400	187.40	-8.0	900	184.00	1.0
410	186.90	-5.0	910	184.10	1.0
420	186.50	-4.0	920	184.10	0.0
430	186.30	-2.0	930	184.20	1.0
440	186.10	-2.0	940	184.20	0.0
450	186.20	1.0	950	184.20	0.0
460	185.50	-7.0	960	184.20	0.0
470	185.10	-4.0	970	184.60	4.0
480	184.90	-2.0	980	184.80	2.0
490	184.60	-3.0	990	185.00	2.0
500	184.40	-2.0	1000	185.10	1.0

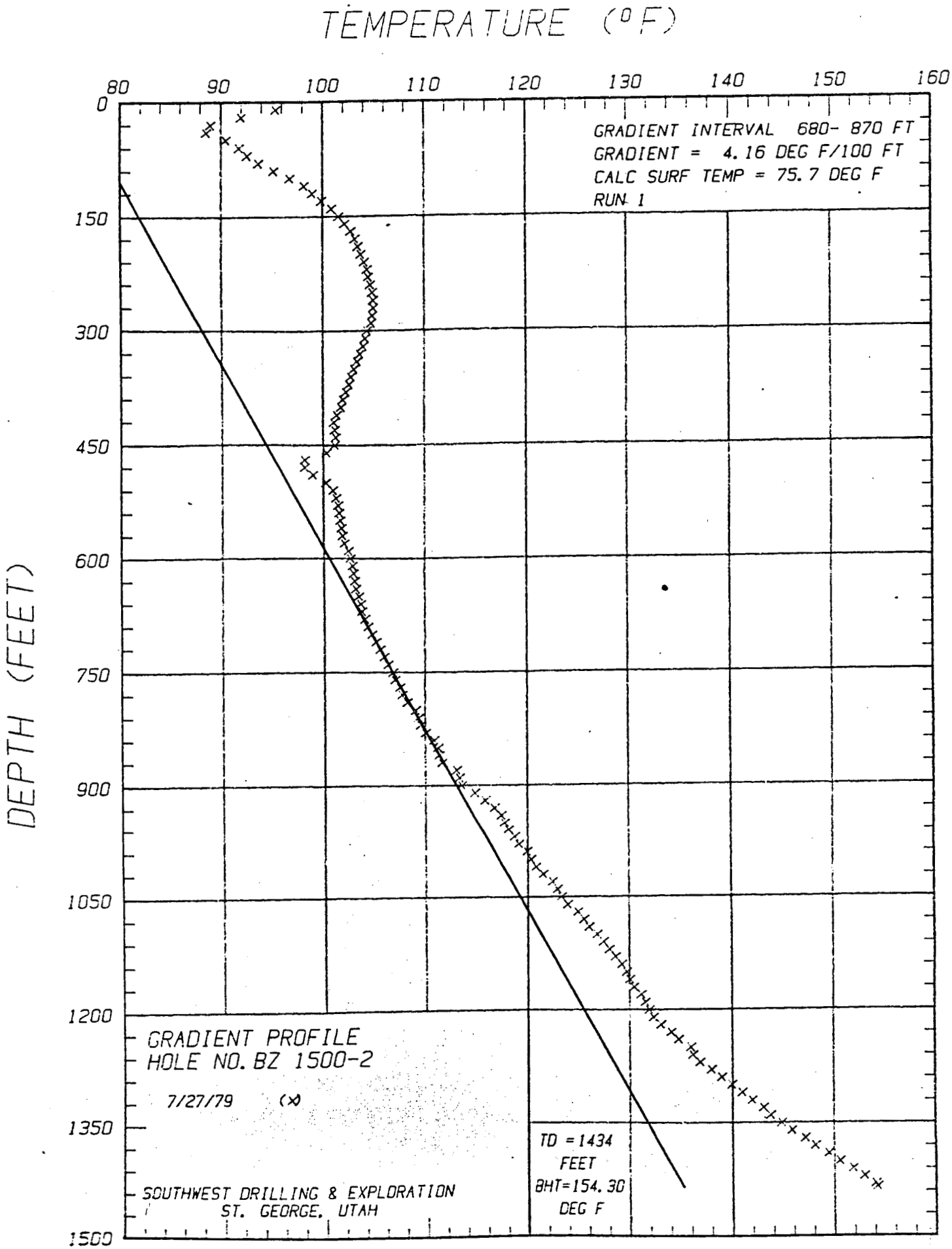
SOUTHWEST DRILLING & EXPLORATION, INC.
ST. GEORGE, UTAH

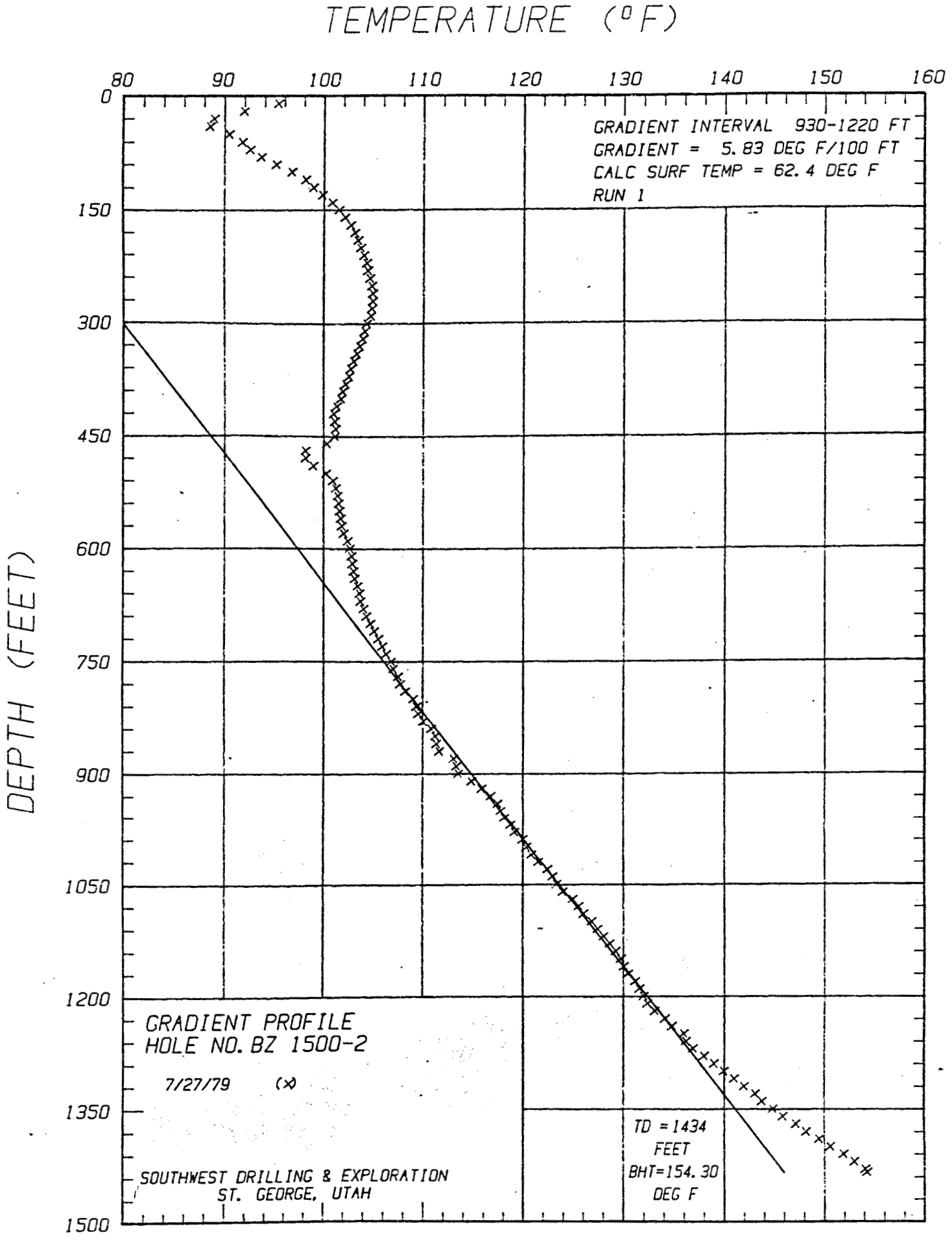
HOLE NO: BZ 1500-1
SWDX JOB NO: 21-82

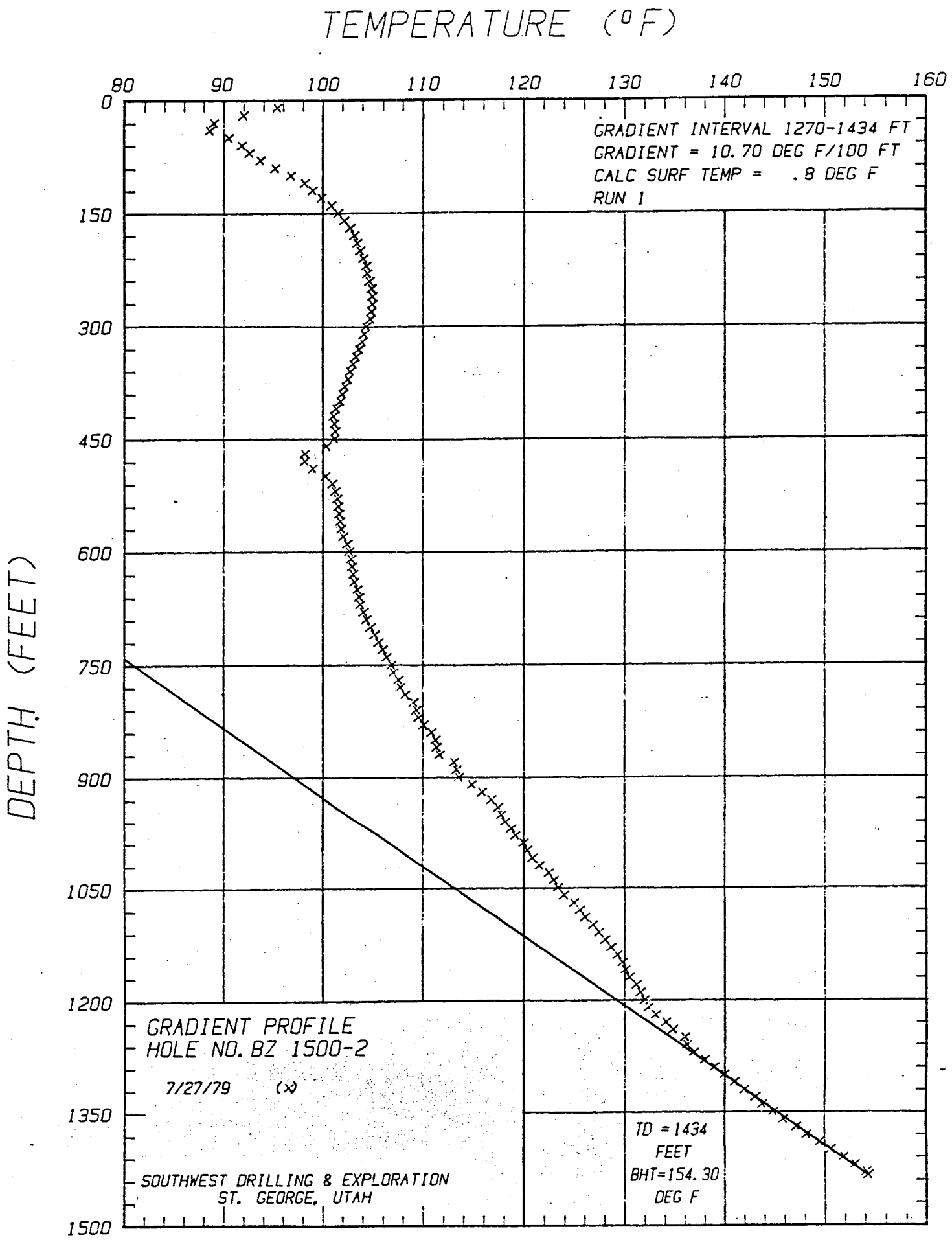
RUN 2 RUN DATE: 6/26/79

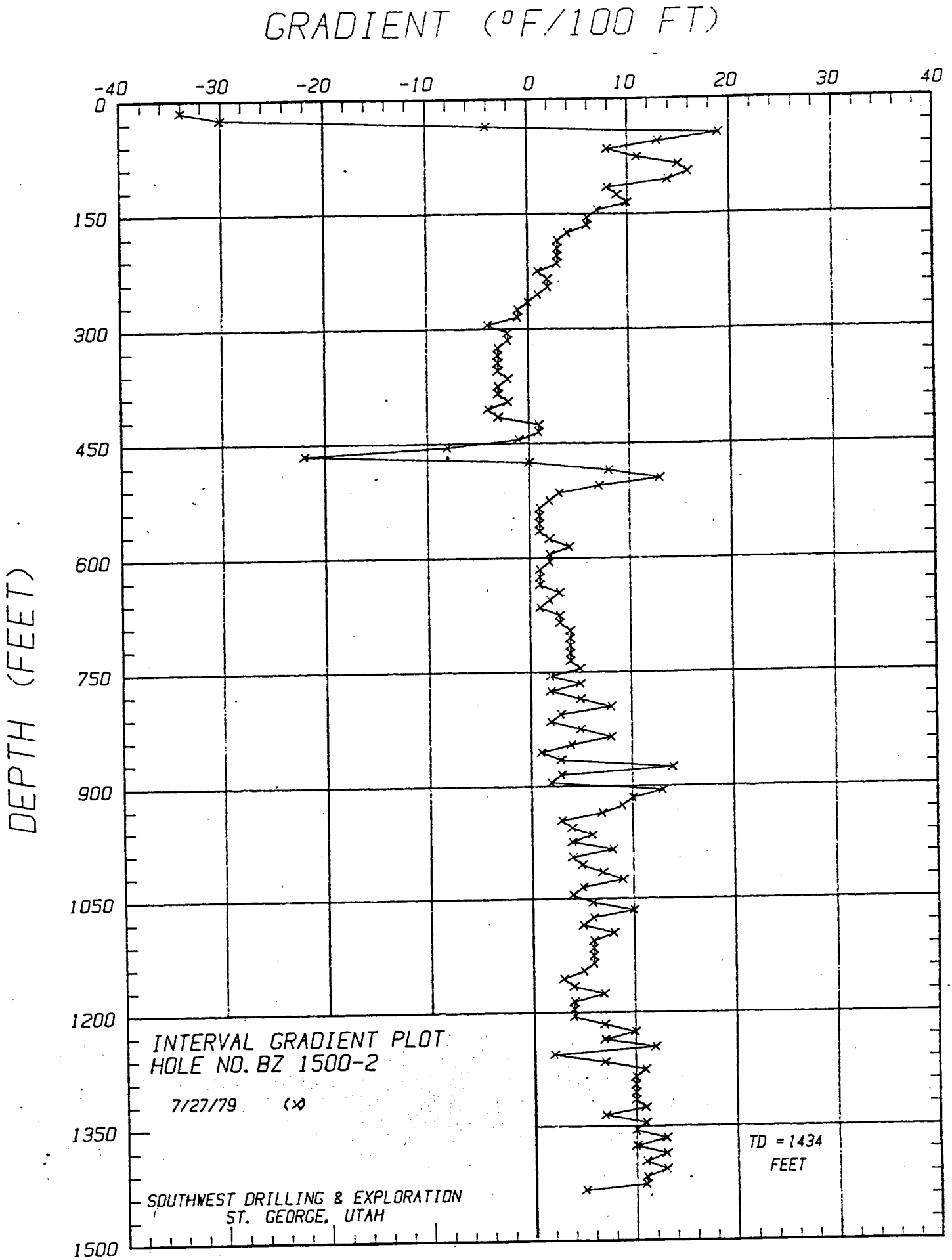
DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
1010	185.20	1.0
1020	185.30	1.0
1030	185.40	1.0
1040	185.60	2.0
1050	185.70	1.0
1060	185.80	1.0
1070	186.00	2.0
1080	186.10	1.0
1090	186.30	2.0
1100	186.40	1.0
1110	186.50	1.0
1120	186.80	3.0
1130	186.90	1.0
1140	187.10	2.0
1150	187.20	1.0
1160	187.30	1.0
1170	187.40	1.0
1180	187.70	3.0
1190	187.80	1.0
1200	188.00	2.0
1210	188.10	1.0
1220	188.20	1.0
1230	188.40	2.0
1240	188.70	3.0
1250	188.90	2.0
1260	189.00	1.0
1270	189.30	3.0
1280	189.40	1.0
1290	189.50	1.0
1300	189.70	2.0
1310	189.90	2.0
1320	190.10	2.0
1330	190.40	3.0
1340	190.60	2.0
1350	190.70	1.0
1360	190.80	1.0
1370	191.00	2.0
1380	191.30	3.0
1390	191.50	2.0
1400	191.70	2.0
1410	191.90	2.0
1420	192.00	1.0
1430	192.20	2.0
1440	192.50	3.0
1450	192.70	2.0
1460	192.90	2.0
1470	193.10	2.0
1480	193.40	3.0
1490	193.70	3.0
1500	194.40	7.0
1510	194.20	-2.0
1520	194.40	2.0
1530	194.60	2.0
1540	194.80	2.0
1543	195.00	6.7

SOUTHWEST DRILLING & EXPLORATION, INC.
ST. GEORGE, UTAH


TEMPERATURE (°F)
80
90
100
110
120
130
140
150
160
0
150
300
450
600
750
900
1050
1200
1350
1500
DEPTH (FEET)
GRADIENT INTERVAL 680- 870 FT
GRADIENT = 4.16 DEG F/100 FT
CALC SURF TEMP = 75.7 DEG F
RUN 1
GRADIENT PROFILE
HOLE NO. BZ 1500-2
7/27/79
TD = 1434
FEET
BHT=154.30
DEG F
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
80
90
100
110
120
130
140
150
160
0
150
300
450
600
750
900
1050
1200
1350
1500
DEPTH (FEET)
GRADIENT INTERVAL 930-1220 FT
GRADIENT = 5.83 DEG F/100 FT
CALC SURF TEMP = 62.4 DEG F
RUN 1
GRADIENT PROFILE
HOLE NO. BZ 1500-2
7/27/79
TD = 1434
FEET
BHT=154.30
DEG F
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH


TEMPERATURE (°F)
80
90
100
110
120
130
140
150
160
0
150
300
450
600
750
900
1050
1200
1350
1500
DEPTH (FEET)
GRADIENT INTERVAL 1270-1434 FT
GRADIENT = 10.70 DEG F/100 FT
CALC SURF TEMP = .8 DEG F
RUN 1
GRADIENT PROFILE
HOLE NO. BZ 1500-2
7/27/79 (X)
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH
TD = 1434
FEET
BHT=154.30
DEG F


GRADIENT (°F/100 FT)
-40
-30
-20
-10
0
10
20
30
40
DEPTH (FEET)
0
150
300
450
600
750
900
1050
1200
1350
1500
INTERVAL GRADIENT PLOT
HOLE NO. BZ 1500-2
7/27/79
TD = 1434
FEET
SOUTHWEST DRILLING & EXPLORATION
ST. GEORGE, UTAH

TEMPERATURE/DEPTH DATA

HOLE NO: BZ 1500-2
SWDX JOB NO: 21-82

RUN 1 RUN DATE: 7/27/79

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)	DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
10	95.40		510	101.00	7.0
20	92.00	-34.0	520	101.30	3.0
30	89.00	-30.0	530	101.50	2.0
40	88.60	-4.0	540	101.60	1.0
50	90.50	19.0	550	101.70	1.0
60	91.80	13.0	560	101.80	1.0
70	92.60	8.0	570	101.90	1.0
80	93.70	11.0	580	102.10	2.0
90	95.20	15.0	590	102.50	4.0
100	96.80	16.0	600	102.70	2.0
110	98.20	14.0	610	102.90	2.0
120	99.00	8.0	620	103.00	1.0
130	99.90	9.0	630	103.10	1.0
140	100.90	10.0	640	103.20	1.0
150	101.60	7.0	650	103.50	3.0
160	102.20	6.0	660	103.70	2.0
170	102.80	6.0	670	103.80	1.0
180	103.20	4.0	680	104.10	3.0
190	103.50	3.0	690	104.40	3.0
200	103.80	3.0	700	104.80	4.0
210	104.10	3.0	710	105.20	4.0
220	104.40	3.0	720	105.60	4.0
230	104.50	1.0	730	106.00	4.0
240	104.70	2.0	740	106.40	4.0
250	104.90	2.0	750	106.90	5.0
260	105.00	1.0	760	107.10	2.0
270	105.00	0.0	770	107.60	5.0
280	104.90	-1.0	780	107.80	2.0
290	104.80	-1.0	790	108.30	5.0
300	104.40	-4.0	800	109.10	8.0
310	104.20	-2.0	810	109.40	3.0
320	104.00	-2.0	820	109.60	2.0
330	103.70	-3.0	830	110.10	5.0
340	103.40	-3.0	840	110.90	8.0
350	103.10	-3.0	850	111.30	4.0
360	102.80	-3.0	860	111.40	1.0
370	102.60	-2.0	870	111.70	3.0
380	102.30	-3.0	880	113.10	14.0
390	102.00	-3.0	890	113.40	3.0
400	101.80	-2.0	900	113.60	2.0
410	101.40	-4.0	910	114.90	13.0
420	101.10	-3.0	920	115.90	10.0
430	101.20	1.0	930	116.80	9.0
440	101.30	1.0	940	117.50	7.0
450	101.20	-1.0	950	117.80	3.0
460	100.40	-8.0	960	118.20	4.0
470	98.20	-22.0	970	118.80	6.0
480	98.20	0.0	980	119.20	4.0
490	99.00	8.0	990	120.00	8.0
500	100.30	13.0	1000	120.40	4.0

SOUTHWEST DRILLING & EXPLORATION, INC.
ST. GEORGE, UTAH

HOLE NO: BZ 1500-2
SWDX JOB NO: 21-82

RUN 1 RUN DATE: 7/27/79

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
1010	120.90	5.0
1020	121.60	7.0
1030	122.50	9.0
1040	123.00	5.0
1050	123.40	4.0
1060	124.00	6.0
1070	125.00	10.0
1080	125.60	6.0
1090	126.10	5.0
1100	126.90	8.0
1110	127.50	6.0
1120	128.10	6.0
1130	128.70	6.0
1140	129.30	6.0
1150	129.80	5.0
1160	130.10	3.0
1170	130.50	4.0
1180	131.20	7.0
1190	131.60	4.0
1200	132.00	4.0
1210	132.40	4.0
1220	133.10	7.0
1230	134.10	10.0
1240	134.80	7.0
1250	136.00	12.0
1260	136.20	2.0
1270	136.90	7.0
1280	138.00	11.0
1290	139.00	10.0
1300	140.00	10.0
1310	141.00	10.0
1320	142.00	10.0
1330	143.10	11.0
1340	143.80	7.0
1350	144.90	11.0
1360	145.90	10.0
1370	147.20	13.0
1380	148.20	10.0
1390	149.50	13.0
1400	150.60	11.0
1410	151.90	13.0
1420	153.00	11.0
1430	154.10	11.0
1434	154.30	5.0

SOUTHWEST DRILLING & EXPLORATION, INC.
ST. GEORGE, UTAH