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STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building
Portland, Oregon 97201

OPEN-FILE REPORT O-80-14

PROGRESS REPORT ON ACTIVITIES OF THE LOW-TEMPERATURE RESOURCE ASSESSMENT PROGRAM 1979-1980

Principal Investigator:

Donald A. Hull

Prepared for
U.S. Department of Energy
Under State Cooperative Agreement No.
DE-FC07-79ET-7220

1980

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November 17, 1980

Dr. Leland L. Mink
Energy and Technology Division
Idaho Operations Office
Department of Energy
550 Second Street
Idaho Falls, Idaho 83401

Dear Dr. Mink:

Subject: Cooperative Agreement No. DE-FC07-79ET-7220; Annual Report

Submitted herewith is a brief summary report on the activities of the low-temperature resource assessment of the nine site-specific areas designated in the above-referenced agreement for the year 1979-1980. The title and areal definition of each area is shown on Figure I. Included with this brief report are a summary of activities and findings, a list of materials to be included in the final report, and a copy of a representative geologic bibliography.

The final report for each of the nine study areas will be in the form of an open-file report to be released by DOGAMI during January, 1981. They will include all the material referenced in this report placed in a single packet with a brief text discussing geology, geophysics, and geochemistry, and their direct relation to the recognized geothermal systems.

Sincerely,

Donald A. Hull
Principal Investigator

DAH/bh

BELKNAP-FOLEY

The Belknap-Foley area is in the west-central portion of Oregon immediately west of McKenzie Pass in the Cascade Mountain Range. The material in the open-file report to be made available December 1, 1980, is summarized in Table 1. These data include an aeromagnetic, gravity, and lineament study map at a scale of 1:250,000 and a geologic map and geologic cross sections at a scale of 1:62,500. Pertinent rock chemistry and potassium-argon age-date results together with geothermal gradient data will be presented in the form of overlays on the geologic map. Summarized in individual tables in this annual report are available water-chemistry data and geothermal-gradient data. These data will also be included in the open-file report.

In general, the aeromagnetic data seem to be primarily related to topography, in large part because the Pliocene units capping the ridges have a higher proportion of magnetically susceptible lavas than the older Miocene and Oligocene rocks. Thus, as a result, there is a relatively good correlation between the aeromagnetic data and the topography.

The gravity data indicate a generally decreasing complete Bouguer anomaly value from west to east, primarily related to a regional change across the Cascade Range. This regional change has been discussed in detail in various publications (Blackwell and others, 1978; Pitts, 1979). The gravity data can be interpreted in terms of a residual anomaly associated either with the whole Cascade Range or locally with the transition between the High Cascade Range and the Western Cascade Range provinces. This gravity gradient or gravity anomaly passes directly through the area of study and appears to be related to local or regional control of the geothermal systems.

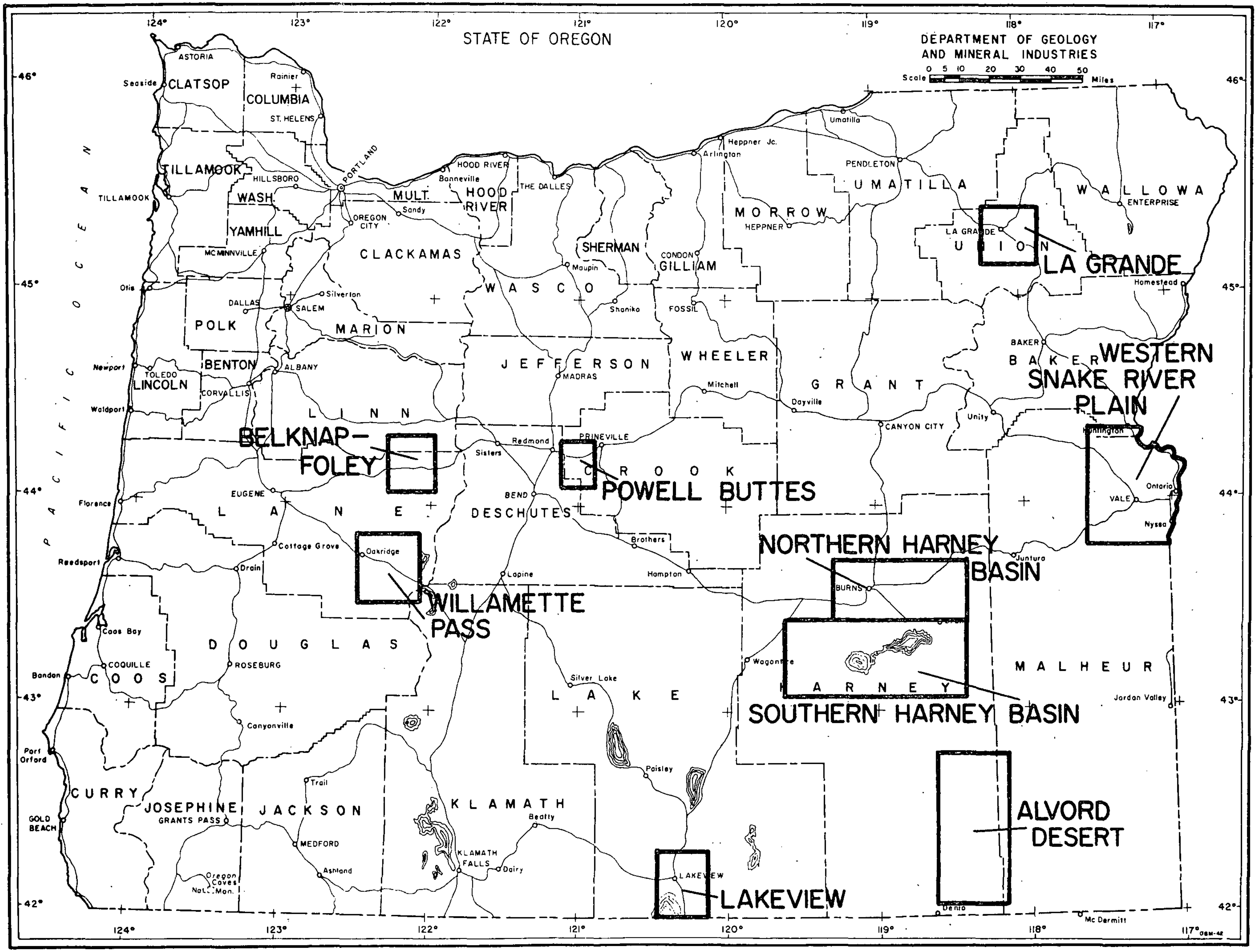

Figure 1: Map showing location of study area.

Table 1

Contents of open-file release
on Belknap-Foley low-temperature geothermal resource area

Item	Scale	Comments
Aeromagnetic map	1:250,000	
Gravity map	1:250,000	
Lineament map	1:250,000	
Geologic map	1:62,500	122°00'00" to 122°30'00" 44°00'00" to 44°30'00"
Geologic Cross Sections	1:62,500	
Rock Chemistry, Age Data, Gradient Data, Water Chemistry	1:62,500	Overlays on geologic map
Well and Spring Chemistry	--	Table
Geothermal-Gradient/ heat-flow data	--	Table
Brief Text	--	
Bibliography	--	

NOTE -

Water-Chemistry tables are currently being revised and are not available to be included with this report. They will, however, be included with the DOGAMI Open-File Reports.

The lineament study indicates a predominately north-northwest fabric superimposed on a weak, older east-west trend. The geologic map has been compiled at a scale of 1:62,500 to include all or part of three 15-minute quadrangles. The most significant results of the mapping are that several major structures which appear to be related to the geothermal systems have been identified. In particular, along the North Fork of the McKenzie River, a major fault system occurs in which the Pliocene rocks are downdropped approximately 900 m to the east along a series of en echelon step faults. This zone appears to represent the western boundary of the Cascade graben proposed by Allen (1966), Taylor (1980), and others. Three of the hot springs in the area appear to be localized along this zone of faulting. In addition, a major north-south fault through Cougar Reservoir has been identified as a normal fault with minor oblique motion in which the east side has been downdropped on the order of 200 m. This structure appears to localize two hot springs observed near the reservoir.

The spring chemistry data from the Geotherm file and other sources are included in Table 2. In general, unmixed models based on the data do not indicate reservoir temperatures in excess of 150^{o}C. For the open-file report, sodium-potassium-calcium, silica, and mixing temperatures will be calculated using the data. Results of the geothermal-gradient studies are shown in Table 3. As yet, no holes have been drilled specifically for this project in this area; a few holes, however, are available from regional studies. These holes document the major west-to-east increase in heat flow observed along the Cascade Range. The boundary coincides with the western border of the north-south gravity gradient mentioned above. Background gradients west of the boundary are on the order of 50-70^{o}C/km. All detailed temperature-depth data are on file in the DOGAMI office.

TABLE 3. Locations and geothermal gradients for the Belknap-Foley low-temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files.

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	CORR. GRAD. °C/km	QUALITY
15S/ 6E- 11DC		44-16.1	122- 3.3	CR-TBR 7/26/77	716	.0 52.0		X
						15.0 45.0		X
						45.0 52.0		X
16S/ 6E- 2CA		44-12.1	122- 3.0	CR-FP 8/ 5/76	70	100.0 150.0	88.3	C
16S/ 4E- 14DBB	WC	44-10.1	122-17.5	BH-3Z 11/26/75	457	12.5 45.0	35.0	D
16S/ 6E- 27BB		44- 9.1	122- 4.7	CR-HC 9/29/76	573	30.0 150.0	70.9	B

A bibliography of all pertinent geologic references is included with this annual report and will also be included with the open-file report.

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WILLAMETTE PASS

The Willamette Pass area is located south and west of the Belknap-Foley area immediately east of the city of Oakridge. The information for the Willamette Pass area to be included in the open-file report is listed in Table 4. These data include an aeromagnetic, gravity, and lineament study map at a scale of 1:250,000 and a geologic map and geologic cross sections at a scale of 1:62,500. Pertinent rock chemistry and potassium-argon age-date results together with geothermal-gradient data will be presented in the form of overlays on the geologic map. Summarized in this annual report are available water-chemistry data and geothermal-gradient data. These data will also be included in the open-file report.

The implications of the aeromagnetic and gravity data are essentially the same as in the Belknap-Foley area a few miles to the north. In addition to the trends observed to the north, the Eugene-Denio lineament trends N.65°W. across the study area, and a major east-west lineament trends along the North Fork of the Middle Fork of the Willamette River. This east-west trend also appears in the gravity data and as a line of Miocene intrusives in the geology. As there is a major Miocene silicic volcanic center located within the Willamette Pass study area, the geologic setting is much more complicated than the Belknap-Foley area. This volcanic center has been dated at around 20 m.y. and represents a lower limit for the Sardine Formation of Peck and others (1964), which overlies this volcanic center.

Available water analyses are shown on Table 5. Unmixed reservoir temperatures based on silica content are below 120°C; however, mixing models calculated by Bowen in an unpublished report to the city of Oakridge suggest

TABLE 4

Contents of open-file release
on Willamette Pass low-temperature geothermal resource area

Item	Scale	Comments
Aeromagnetic map	1:250,000	
Gravity map	1:250,000	
Lineament map	1:250,000	
Geologic map	1:62,500	122°00'00" to 122°00'00" 43°30'00" to 44°00'00"
Geologic cross sections	1:62,500	
Rock chemistry, age data, gradient data, water chemistry	1:62,500	Overlays on geologic map
Well and spring chemistry	--	Table
Geothermal-gradient/ heat-flow data	--	Table
Brief text	--	
Bibliography	--	

reservoir temperatures as high as 150-180°C for some of the thermal waters. For the open-file report, mixing models and silica and sodium-potassium-calcium temperatures will be calculated for all of the spring and well data collected. No holes have been drilled as part of the project, but a number of heat-flow holes are available from previous projects, and several holes are planned for 1980-81. Available data are listed in Table 6. As is the case for the Belknap-Foley area, the geothermal data indicate the west-to-east increase in heat flow toward the High Cascades, with the same or possibly slightly lower background values of gradient and heat flow observed to the north.

TABLE 6. Locations and geothermal gradients for the Willamette Pass low-temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files.

TOWNSHIP/ RANGE-SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	CORR. GRAD. °C/km	QUALITY
20S/ 3E-26DA	WC	43-48.0	122-25.0	CS-WW 9/28/76	719	45.0 70.0	25.1	B
						70.0 140.0	38.8	B
20S/ 4E-27DDD	WH	43-47.9	122-18.8	WALL CRK 6/ 4/80	582	20.0 90.0		
						95.0 135.0		
20S/ 3E-26CD	WC	43-47.9	122-25.2	AE-WW 8/19/76	707	10.0 80.0	25.6	B
						80.0 125.0	36.3	B
21S/ 3E-10AD	WC	43-45.6	122-25.9	FC-WW 9/28/76	548	25.0 100.0	35.6	B
21S/ 4E-28AD		43-43.1	122-20.0	CR-MCHSE 9/29/76	533		60.0	B
21S/ 3E-35B3	WC	43-42.5	122-25.5	DH-Z-2 11/25/75	459	60.0 79.0		C
21S/ 3E-35B1	WC	43-42.5	122-25.5	DH-Z-5 11/25/75	413	20.0 27.5		C
21S/ 3E-35B2	WC	43-42.5	122-25.5	DH-Z-8 11/25/75	459	55.0 63.0		C
22S/ 5E-26BC		43-38.2	122-11.3	CR-MCHSW 9/29/76	975	30.0 150.0	51.8	B

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NORTHERN AND SOUTHERN HARNEY BASIN

For convenience of study, the Harney Basin was divided into two areas, and individual open-file reports whose contents are indicated in Table 7 are being assembled for each area.

An aeromagnetic map of the southern part of Harney Basin (scale 1:250,000) contains the only published geophysical data available for the Basin. On the aeromagnetic map, an elliptical pattern extending from Wright Point to Crane in the area of Malheur Lake may be interpreted, in conjunction with the geologic study, to be the site of a caldera. In addition, there appears to be another caldera near Harney Lake along the west margin of the basin.

A lineament study compiled for both northern and southern areas at a scale of 1:250,000 indicates a complicated pattern of faulting. In the western half of the basin, the dominant trend is the Brothers fault zone (approximately N.45^{o}W.); in the eastern half, the dominant trend is the north-south Basin-Range trend. The juncture of these two trends in the southeast corner of the study area is marked by complex faulting and lineaments, by structural doming, and by recent volcanism at Diamond Craters. The juncture in the northern end of the basin is marked by a structural discontinuity, silicic intrusions, and alteration along Soldier Creek which may represent a right-lateral wrench fault.

The geology of the basin has been detailed on five 15-minute quadrangles and ten 7½-minute quadrangles reduced to a scale of 1:62,500. Shown on the geologic map is a complex sequence of silicic intrusions, silicic ash flows, and basalt flows interspersed with faults. The oldest rocks in the area are the Owyhee, Steens, and Columbia River basalts, with ages ranging from

TABLE 7

Contents of open-file release
on Harney Basin low-temperature geothermal resource area

Item	Scale	Comments
Lineament map of part of North Harney Basin	1:250,000	
Geologic map of part of North Harney Basin	1:62,500	118°30'00" to 119°15'00" 43°30'00" to 43°45'00"
Geologic cross sections	1:62,500	
Rock chemistry, age data, gradient data, water chemistry	1:62,600	Overlays on geologic map
Well and spring chemistry	--	Table
Geothermal-gradient/ heat-flow data	--	Table
Brief text	--	
Bibliography	--	
Aeromagnetic map of part of South Harney Basin	1:250,000	
Lineament map of part of South Harney Basin	1:62,500	118°30'00" to 119°30'00" 43°00'00" to 43°30'00"
Geologic cross sections	1:62,500	
Rock chemistry, age data, gradient data, water chemistry	1:62,500	Overlays on geologic map
Well and spring chemistry	--	Table
Geothermal-gradient/ heat-flow data	--	Table
Brief text	--	
Bibliography	--	

12-20 m.y. The oldest silicic events are dated between 14.7 and 9.6 m.y. The period of ash eruptions extends between 12 and 6.5 m.y. ago. The youngest major sequence of rocks appears to be the basalts capping the highlands on the west margins of the basin and their related vent complexes, with age dates ranging from 2.3 to 2.9 m.y.

As part of the project, age dates have been obtained from several units of ambiguous age, particularly various basaltic vent complexes scattered throughout the basin. All the faulting in the young basalts definitely post-dates approximately 2.5 m.y., and some faults cut the Diamond Craters basalts, which have a hydration-rind age date of approximately 15,000 years. The alluvial fill of the basin does not appear to be offset by young faulting.

The water-chemistry data are shown in Table 8 and indicate moderate- to high-temperature resources. Several ground-water flow regimes appear to exist in the basin, and the effects of these different flow patterns must be sorted out for complete analysis of the geothermal potential based on the water-chemistry data.

The collection of gradient data, in the past, has been limited to logging pre-existing water wells and mineral exploration borings with a very few gradient borings drilled by DOGAMI and USGS. Data from these holes are presented in Tables 9a and 9b. In view of the extensive evidence of persistently high temperatures, the exploration of this area could benefit from an extensive program to drill holes deeper than 150 m. Limited 150-m deep drilling is planned for 1980. Complete analysis must wait until deep drilling is carried out.

TABLE 9A. Locations and geothermal gradients for the North Harney Basin low-temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files. Standard error shown below gradient value.

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km
22S/32E-27BA	HL	43-38.5	118-52.3	TILLER 2 5/22/80	1277	10.0 57.0	78.7 7.6
						20.0 57.0	72.1 4.7
22S/32E-26BB	HL	43-38.3	118-51.6	TVRDY 5/21/80	1279	10.0 40.0	68.1 3.6
22S/32E-27CB	HL	43-38.1	118-52.8	TILLER 1 5/22/80	1265	5.0 45.0	69.8 .8
						45.0 100.0	82.4 2.5
						5.0 100.0	78.6 2.4
22S/33E-27CD	BM	43-37.6	118-38.5	TEMPLE 5/20/80	1268	10.0 125.0	2.2 .4
						125.0 138.0	464.7 5.1
22S/32E-31DB	HL	43-37.2	118-55.7	BLCKBURN 5/22/80	1269	15.0 40.0	53.5 2.2
22S/32E-34CC	HL	43-36.9	118-52.6	RICE 6/11/75	1260	.0 95.0	140.0
22S/32E-34DD	HL	43-36.9	118-51.9	HWY 20 5/20/80	1261	10.0 35.0	573.7 15.2
						35.0 60.0	181.7 .3
						10.0 62.0	354.9 70.2
23S/32E-6CB	BM	43-36.3	118-49.2	HANSON 5/22/80	1259	5.0 51.0	74.5 1.7
22S/32E-27AC	HL	43-36.3	118-54.2	TILLER 3 5/22/80	1286	10.0 25.0	226.0 12.7
						25.0 96.0	72.4 3.5

TABLE 9A. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
23S/29E- 10AD	BM	43-35.6	119-13.7	FED-1-10 10/ 8/77	1463			
24S/32E- 1AD	HL	43-31.3	118-49.3	NINEMILE 5/16/80	1257	10.0 35.0	273.5 3.8	
						35.0 60.0	189.5 .2	
						60.0 130.0	155.7 1.7	
						130.0 160.0	97.8 .1	
						10.0 160.0	165.8 14.1	
24S/32E- 8DA	HL	43-30.2	118-54.3	STEVENS 5/15/80	1256	5.0 176.0	18.5 2.3	

TABLE 9B. Locations and geothermal gradients for the South Harney Basin low-temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files except holes S1, S2, S3, V1, Lawen, MR-1 and MR-2 which have been published by Sass et al. (1976). Standard error shown below gradient value.

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
24S/33E- 9D	HL	43-30.0	118-39.0	S3	1255	40.0 203.0	82.0 1.0	A
						59.0 96.0	58.5 .3	A
24S/32E- 23DD	HL	43-28.3	118-43.9	LAWEN	1256	75.0 150.0	60.9 7.4	A
24S/34E- 19C	HL	43-28.0	118-35.0	S2	1262	60.0 183.0	69.5 .5	A
24S/33E- 35AD	HL	43-26.6	118-36.8	CRANE 7/21/75	1257	30.0 85.0	80.0 7.1	A
25S/31E- 4BB	HL	43-26.2	119- 1.1	BFZ-7511 9/16/75	1262	42.5 60.0	30.9 2.5	C
25S/33E- 3BD	HL	43-25.9	118-38.5	BFZ-7501 11/22/75	1274	10.0 28.6	188.3 18.9	A
25S/33E- 10BA	HL	43-25.2	118-38.3	ADAMS 5/14/80	1259	15.0 35.0	115.8 .1	
25S/33E- 11BBB	HL	43-25.2	118-37.7	ROSSBERG 6/12/75	1257	.0 65.0	60.0 7.0	A
25S/33E- 9CA	HL	43-24.7	118-39.8	WSB-1 5/14/80	1250	5.0 65.0	9.6 .8	
25S/33E- 10CA	HL	43-24.7	118-38.6	WSB-2 5/14/80	1256	15.0 21.0	26.2 2.7	
25S/33E- 10CD	HL	43-24.5	118-38.5	WSB-3 5/14/80	1254	10.0 51.5	45.3 5.9	
25S/33E- 9CC	HL	43-24.5	118-40.0	ARFORD 2 5/14/80	1250	5.0 55.0	27.4 3.9	
25S/33E- 9CD	HL	43-24.5	118-39.3	ARFORD 3 5/14/80	1250	5.0 165.0	6.8 1.3	
25S/33E- 11CD	HL	43-24.4	118-37.2	WSB-4 5/ 8/80	1254	10.0 57.0	9.1 2.5	

TABLE 9B. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
25S/33E-16AB	HL	43-24.3	118-38.5	ARFORD 1 5/14/80	1250	5.0 20.0	59.6 1.9	
						5.0 107.5	34.3 12.5	
25S/31E-21D	HL	43-22.0	119- 2.0	S1	1266	50.0 190.0	81.0 1.0	A
25S/34E-31CC	HL	43-20.3	118-35.3	WINDYPT1 5/ 8/80	1257	10.0 30.0	7.2 1.4	
26S/33E-2CD	HL	43-20.2	118-36.7	WINDYPT2 5/ 8/80	1253	10.0 58.0	86.4 4.2	
26S/33E-11DC	HL	43-19.3	118-36.4	WINDYPT3 5/ 8/80	1252	5.0 45.0	85.1 3.9	
26S/33E-13DA	HL	43-18.5	118-34.9	N TMPSON 5/ 8/80	1257	10.0 52.0	108.9 37.0	
26S/30E-19	XX	43-17.9	119- 9.8	VI	1250			X
26S/33E-33BA	HL	43-16.6	118-39.1	DAVIS 2 5/ 7/80	1268	10.0 16.5	2.8 .2	
26S/33E-35CC	HL	43-15.8	118-37.0	DAVIS 1 5/ 7/80	1254	10.0 34.5	12.5 1.8	
27S/33E-3BA	HL	43-15.7	118-37.9	ALDERTON 5/ 7/80	1256	10.0 30.0	6.3 1.2	
27S/30E-13CD	HL	43-13.2	118-56.0	HP-10 6/ 8/73	1280	25.0 60.0	130.4 2.5	A
						60.0 130.0	61.6 1.5	A
27S/32E-23BB	HL	43-13.1	118-44.2	VOLTAGE 5/13/80	1335	20.0 95.0	49.8 2.2	
						100.0 190.0	67.8 .8	
						20.0 190.0	61.9 3.0	

TABLE 9B. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
27S/33E- 20DB	HL	43-12.7	118-37.5	BECKLEY 5/13/80	1285	10.0 60.5	1.0 3.8	
27S/30E- 21DDB	HL	43-12.5	118-59.7	HP-48 7/25/73	1289	10.0 35.0	223.2 8.5	A
						35.0 110.0	132.8 1.0	A
27S/30E- 27ACA	HL	43-12.1	118-58.7	HP-1 7/26/73	1320	10.0 65.0	160.0 1.8	A
						65.0 75.0	55.0 2.9	A
27S/30E- 26DCB	HL	43-11.5	118-57.2	HP-2B 7/26/73	1340	10.0 67.2	117.9 1.4	A
28S/32E- 36CC	HL	43- 5.3	118-43.0	DMND CRT 6/ 7/80	1277	10.0 54.0	39.4 3.0	
29S/32E- 6B	HL	43- 5.3	118-49.4	MR-1	1262	56.4 64.0	89.0 1.0	A
						40.0 91.0	96.0 .6	A
								A
29S/31E- 2B	HL	43- 5.2	118-50.9	MR-2	1260	57.9 82.5	65.0 2.0	A
						89.3 92.0	83.0 3.0	A
						60.0 100.0	74.2 .8	A
								A

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POWELL BUTTES

The Powell Buttes area is located in central Oregon near the rapidly growing industrial and recreation area of Bend, Redmond, and Prineville. The data compiled for the area are shown in Table 10. The compilation of aeromagnetic, gravity, and lineament data is at a scale of 1:250,000. Also included are a geologic map and geologic cross sections for one 15-minute and four 7½-minute quadrangles presented at a scale of 1:62,500 as well as overlays for potassium-argon ages and water-chemistry and geothermal-gradient data.

The aeromagnetic pattern across the area is essentially flat, whereas the gravity map developed by Pitts (1979) shows a large, ovoid, northeast-trending positive gravity anomaly of 15 to 20 mgal over the buttes. The explanation for this large positive anomaly is not obvious. The lineament study shows primarily northwest-southeast and northeast-southwest trends, and detailed mapping indicates additional trends.

Samples have been collected for potassium-argon dating and for water-chemistry analysis with the available water-chemistry data shown on Table 11. Additional samples are not yet analyzed. A list of the location of sites of temperature-depth information is given in Table 12.

A geothermal anomaly was initially discovered by routine scrounge water-well measurements which indicated anomalously high heat-flow values and geothermal gradients in an area on the northwest side of Powell Buttes. Additional logging of available wells in the area continues to indicate anomalous conditions. At the present time, an area with a linear dimension of at least 10 km and a demonstrated width of 2 km has gradients in excess of 100^{o}C/km to depths in excess of 200 m. The geologic controls on this

TABLE 10

Contents of open-file release
on Powell Buttes low-temperature geothermal resource area

Item	Scale	Comments
Aeromagnetic Map	1:250,000	
Gravity Map	1:250,000	
Lineament Map	1:250,000	
Geologic Map	1:62,500	120°45'00" to 121°07'30" 44°00'00" to 44°22'30"
Geologic Cross-Sections	1:62,500	
Rock Chemistry, Age Data, Gradient Data, Water Chemistry	1:62,500	Overlays on geologic map
Well and Spring Chemistry	--	Table
Geothermal Gradient/ Heat Flow Data	--	Table
Brief Text	--	
Bibliography	--	

system are not obvious. There is very little permeability in the rocks, and most of the holes, even to depths in excess of 300 m, produce only enough water from discontinuous ground-water bodies for domestic use. The cause of the anomaly is apparently at depths in excess of 300 m and, based on the measured data, has a temperature in excess of 40^{o}C (the highest measured bottom-hole temperature is 38^{o}C).

The geology consists of a central intrusive and extrusive complex of presumed John Day age; i.e., 25-35 m.y., against which young flood basalts and fluvial sediments onlap. Age dating of samples from this area is currently in progress in order to verify the age of the complex. The rocks are generally silicic in composition and are relatively highly altered; mercury prospects are found along the western margin of the buttes, and there is some indication that the background uranium content of the rocks is above average.

Because of the proximity to a rapidly growing metropolitan area with a significant amount of industry, this area is very attractive for development of low-temperature utilization. A number of 150-m gradient holes are planned for 1980-81; however, it is clear that holes at least 400-600 m deep must be drilled in this area to verify the presence of a resource and the temperatures characteristic of that resource.

TABLE 12. Locations and geothermal gradients for the Powell Buttes low-temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files. Standard error shown below gradient value.

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
14S/14E- 18CC	BM	44-21.1	121- 6.3	SWIFT 4/18/80	874	25.0 60.1	4.5 1.2	C
15S/16E- 16DA	HL	44-16.1	120-48.7	PRSTUDCO 7/12/77	936	7.5 47.5	68.0	C
15S/14E- 15DD	HL	44-15.9	121- 1.7	CRABTREE 4/16/80	930			D
15S/15E- 29BB	HL	44-14.8	120-57.6	POWBUTNE 4/14/80	986	16.0 35.0	190.0	A
						35.0 172.0	77.1 2.5	A
15S/15E- 28AD	HL	44-14.6	120-55.7	KOOPS 8/11/80	998	15.0 40.0	119.2 18.3	
						40.0 149.0	50.9 1.4	
15S/15E- 30AC	HL	44-14.5	120-58.4	CRAWFORD 4/ 5/80	995	10.0 75.0	81.9 3.7	B
15S/15E- 30AD	HL	44-14.4	120-58.0	LOT24WW 9/20/78	1002	40.0 105.0	70.5 6.7	C
15S/15E- 31AC	HL	44-13.7	120-58.5	DEASON 4/ 6/80	1067	10.0 40.0	266.6 19.8	B
						40.0 244.2	68.7 4.6	B
15S/14E- 35BC	HL	44-13.7	121- 1.5	FLOCK 6/18/80	982	45.0 110.0	127.7 2.3	
						20.0 125.0	111.6 7.3	
15S/15E- 31DA2	HL	44-13.6	120-58.2	KRANTH 2 7/28/79	1100	20.0 120.0	75.5 2.1	A
						90.0 120.0	71.7 .2	A
15S/15E- 31DA1	HL	44-13.6	120-58.2	KRANTH 1 7/28/79	1100	195.0 225.0	69.2 .1	B
						10.0 225.0	73.3 1.6	B

TABLE 12. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
15S/14E- 36AC	HL	44-13.2	120-59.6	FHRNBKWW 9/22/78	1023	20.0 155.0	128.4 2.1	C
16S/14E- 2BC	HL	44-12.8	121- 1.6	HALLETT 8/12/79	1021	5.0 78.5	114.1 13.0	C
16S/14E- 4DD	HL	44-12.6	121- 2.8	SCHOOLHS 8/13/80	991	10.0 20.0	195.0 12.0	
16S/14E- 3CC	HL	44-12.5	121- 2.5	MILLER 4/ 7/80	1003	10.0 45.0	252.5 13.1	A
						45.0 179.0	113.0 6.0	A
16S/14E- 10AB	HL	44-12.4	121- 2.1	POWBUTNW 4/ 8/80	1021	10.0 45.0	198.7 9.6	A
						45.0 170.0	91.5 4.4	A
16S/14E- 10BA	HL	44-12.3	121- 2.3	JENSEN 8/ 8/80	1015	10.0 93.5	129.4 4.9	
16S/14E- 11CC	HL	44-11.8	121- 1.5	MATHERS 4/17/80	1086	20.0 156.0	58.1 1.6	A
16S/14E- 11DC	HL	44-11.7	121- .7	POWBUT 4/17/80	1146	20.0 50.0	33.7 1.5	B
16S/14E- 16DAA	HL	44-11.2	121- 2.8	MCDNL-WW 9/21/78	1024	25.0 160.0	148.4 4.1	B
16S/14E- 16DC	HL	44-11.0	121- 3.3	ALF-PBRD 8/14/80	1010	20.0 123.0	162.2 7.4	
16S/14E- 14CC	HL	44-10.9	121- 1.3	SANTOS 8/14/80	1103	5.0 20.0	107.2 5.5	
						20.0 75.2	58.0 1.1	
16S/14E- 20AC	HL	44-10.5	121- 4.3	MILLER 8/12/80	963	10.0 30.0	30.4 7.0	

TABLE 12. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
16S/14E-20DA	HL	44-10.4	121- 4.0	SLVDLR R 8/12/80	972	10.0 149.0	12.5 12.7	
16S/14E-28AD	HL	44- 9.6	121- 2.9	SHUMWAY 4/ 7/80	981	20.0 65.0	82.9 3.8	B
						110.0 158.5	100.7 2.1	B
16S/15E-26CC	HL	44- 8.9	120-54.3	H MARTIN 8/19/80	1076	40.0 165.0	55.9 1.2	
						50.0 140.0	55.6 .7	
17S/14E-23AC	HL	44- 5.1	121- 1.0	LEWIS 8/20/80	1021	80.0 170.0	74.1 4.8	
						135.0 170.0	68.6 2.0	
17S/15E-20CA	HL	44- 4.7	120-57.6	BOWEN 4/16/80	1036	10.0 120.0	34.2 2.1	B
17S/16E-32CA	HL	44- 3.1	120-50.4	GLOVER 8/21/80	1163	20.0 75.0	87.6 4.8	
						75.0 119.0	43.9 3.9	

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WESTERN SNAKE RIVER PLAIN

The part of the Western Snake River Plain to be included in the open-file report consists of four 15-minute quadrangle maps. Data to be included in the open-file report are listed in Table 13. The geologic map for this area (scale 1:62,500) has been compiled from published sources. Time constraints have not allowed field checking. There appear to be several stratigraphic inconsistencies in the maps that have not yet been resolved at this time. Gravity and magnetotelluric data have been compiled at a scale of 1:250,000, and a local aeromagnetic map for part of the area has been compiled at a scale of 1:62,500. A lineament map has been compiled at a scale of 1:250,000. Available water chemistry, age dates, and hole locations are presented on an overlay to the geologic maps. A table of water-chemistry data from the literature is presented in Table 14, and a list of holes logged for geothermal-gradient data is given in Table 15.

Geophysical, geological, and geochemical data indicate that high temperatures (+200°C) exist at depth, and a deep DOE-supported drill hole has demonstrated a temperature of over 150°C at a depth of approximately 2,300 m. This, however, is a regional temperature, and higher temperatures can be expected to occur at shallow depths in holes centered on geothermal systems.

TABLE 13

Contents of open-file release
on Western Snake River Basin low-temperature geothermal resource area

Item	Scale	Comments
Geologic Map	1:62,500	116°52'30" to 117°30'00" 43°52'30" to 44°15'00"
Geologic Cross-Sections	1:62,500	
Rock Chemistry, Age Data, Gradient Data, Water Chemistry	1:62,500	Overlays on geologic map
Well and Spring Chemistry	--	Table
Geothermal Gradient/ Heat Flow Data	--	Table
Brief Text	--	
Aeromagnetic Map	1:62,500	
Gravity Map	1:250,000	
Audiomagnetotelluric Map	1:250,000	
Bibliography	--	

TABLE 15. Locations and geothermal gradients for the Western Snake River Basin low temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files. Standard error shown below gradient value.

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
15S/43E- 34CD	SB	44-12.9	117-26.5	MCBRIDE 6/24/80	866	20.0 85.0	81.4 2.5	
						10.0 145.0	57.7 10.1	
16S/43E- 10DB	SB	44-11.5	117-26.1	JQRM 10/ 2/72	758	30.0 115.0	71.2 1.5	A
16S/43E- 7D	SB	44-11.4	117-29.5	BAMS 5/ 6/75	850	15.0 65.0	48.8 7.3	B
						65.0 115.0	18.0 5.1	B
16S/43E- 15DA	SB	44-10.6	117-25.8	JQNR 10/ 5/72	758	25.0 105.0	38.6 7.0	A
						105.0 230.0	70.5 3.0	A
16S/43E- 13DD	SB	44-10.4	117-23.2	VALE 10/ 4/72	768	50.0 130.0	51.5 5.0	A
						130.0 170.0	94.7 2.7	A
16S/43E- 23DD	SB	44- 9.4	117-24.4	JQMR 10/ 1/72	749	40.0 110.0	61.8 2.2	A
						110.0 170.0	99.5 13.0	A
17S/45E- 8AA	SB	44- 6.9	117-10.1	VN-75-2 6/ 4/75	721	30.0 60.0	87.3	A
17S/45E- 3DD		44- 6.8	117-11.3	BLMSW 5/ 9/75	774	10.0 35.0		B
						10.0 185.0		B
17S/45E- 2DA	SB	44- 6.5	117-13.6	VN-75-3 5/13/75	814	50.0 125.0	82.0 1.1	A
17S/43E- 9CB	XX	44- 6.2	117-27.5	JQW 10/ 2/72	866	10.0 35.0	134.2 12.0	B

TABLE 15. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
17S/44E- 11DC	SB	44- 6.1	117-17.4	JQPW 10/ 6/72	719	10.0 370.0	94.4 2.2	A
17S/46E- 13AA	XX	44- 5.8	117- 1.6	VN-75-5 10/22/75	732	50.0 150.0	76.5 .3	A
17S/46E- 16CA	SB	44- 5.4	117- 5.9	VN-75-4 6/ 4/75	762	25.0 140.0	115.4 7.0	A
17S/44E- 31BB	XX	44- 3.2	117-23.1	JQBLM 10/14/72	829	15.0 70.0	85.7 2.2	A
18S/47E- 4B	SB	44- 2.2	116-58.5	JOHANSON 6/27/80	658	15.0 59.0	71.6 2.1	
18S/47E- 4DC	SB	44- 1.5	116-58.2	ONTCTYPK 8/19/77	655	55.0 150.0	88.4 .2	A
18S/44E- 23AC	SB	43-59.8	117-17.3	HIATT 7/ 2/80	765	20.0 92.0	91.8 3.2	
18S/44E- 21BA	SB	43-59.6	117-20.3	VWQRB 10/11/72	760	25.0 85.0	66.8 1.1	A
18S/45E- 20CB	SB	43-59.3	117-14.5	VALECTY1 7/ 7/77	684	30.0 40.0	123.2 2.8	A
18S/44E- 21DB	SB	43-59.3	117-20.5	RANDLE 7/ 2/80	783	10.0 49.0	54.1 4.0	
18S/45E- 21CB	SB	43-59.2	117-13.3	TS-RDH 11/30/76	678	15.0 310.0	145.5 6.1	X
						15.0 65.0	200.4 6.7	X
						65.0 230.0	143.2 7.5	X
						230.0 310.0	116.0 7.7	X
18S/45E- 20CC	SB	43-59.1	117-14.6	GRIGGS 6/25/80	683	10.0 100.5	135.6 3.0	
18S/46E- 21CC	SB	43-59.1	117- 6.2	LEE 7/ 8/77	692	35.0 45.0	115.6 12.1	A

TABLE 15. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
18S/45E- 30AB	SB	43-58.8	117-15.1	VALECTY2 7/ 7/77	681	7.5 55.0	82.2 .7	A
18S/45E- 29BA2	SB	43-58.8	117-14.1	VALE CW2 7/30/80	682	20.0 38.0	240.8 .6	
18S/45E- 29BA1	SB	43-58.7	117-14.2	VALE CW1 7/29/80	683	10.0 17.5	100.4 2.0	
18S/45E- 32AB	SB	43-57.9	117-13.9	COLERICK 8/ 1/80	698	25.0 70.0	190.2 1.7	
						10.0 70.0	197.5 10.4	
19S/46E- 5BD	SB	43-56.8	117- 6.9	WINEBRGR 7/ 3/80	808	15.0 90.0	96.5 3.0	
						90.0 260.0	34.0 2.6	
						10.0 269.5	50.2 8.6	
19S/45E- 11BC	SB	43-56.0	117-11.0	BLMN-WW 6/10/76	816	10.0 85.0	259.3 2.3	A
19S/45E- 9DB	SB	43-55.8	117-12.8	N HARPER 7/ 7/77	860	20.0 170.0	105.9 .5	A
						170.0 205.0	78.2 3.2	A
19S/44E- 9DD	SB	43-55.5	117-19.5	JQP-1 6/18/73	701	35.0 160.0	71.5 .5	A
19S/45E- 11CC	SB	43-55.5	117-11.0	CH-1 8/23/72	835	30.0 65.0	185.7 1.6	A
19S/46E- 18DB	SB	43-55.0	117- 8.0	SWW 6/10/76	844	20.0 150.0	104.1 .7	A
19S/46E- 15DC	SB	43-54.8	117- 4.2	NC-WW 10/27/76	771	55.0 150.0	3.7 .7	C
						20.0 55.0	77.1 29.4	C
19S/45E- 14DC	SB	43-54.6	117-10.4	CB-16 9/ 7/72	910	20.0 145.0	175.2 1.1	A

TABLE 15. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
19S/46E-13CD	SB	43-54.6	117- 2.2	CO-WW 11/ 4/76	707	12.5 37.5	135.4 2.2	B
19S/44E-19	SB	43-54.2	117-22.4	WP-1 0/ 0/30	777	31.0 395.0	87.3	A
19S/44E-22DA	SB	43-54.1	117-18.3	SAP 3 7/ 2/80	713	10.0 79.0	80.8 1.3	
19S/44E-22CA	SB	43-54.0	117-19.2	SAP 2 7/ 2/80	716	20.0 55.0	38.1 2.6	
						10.0 62.5	37.5 3.5	
19S/44E-21DD	SB	43-53.8	117-19.7	SAP 1 7/ 2/80	713	5.0 40.0	100.9 4.0	
						40.0 135.0	73.7 1.4	
						5.0 143.0	80.5 4.8	
19S/46E-30BB	SB	43-53.7	117-15.7	VN-75-1 6/ 4/75	879	20.0 150.0	92.6 .2	A
19S/45E-25BB	SB	43-53.6	117-16.8	RDH-F 7/24/72	813	30.0 70.0	232.6 7.1	A
19S/45E-22DB	SB	43-53.6	117-11.7	GULF 7/24/72	843	30.0 115.0	110.4 .3	A
19S/45E-26BD	SB	43-53.4	117-10.7	GULF 7/25/72	822	30.0 175.0	119.3 .6	A
19S/45E-28BD	SB	43-53.4	117-13.0	CB-14 6/14/73	872	10.0 90.0	70.8 1.5	A

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LAKEVIEW

The Lakeview area of south-central Oregon is one of the major foci of this year's study (Table 16). Aeromagnetic and lineament maps have been compiled at a scale of 1:250,000. The aeromagnetic map indicates low values over the deep sedimentary fill in the basin and higher values over the volcanic rocks of the Warner Range. The lineament map is dominated by northwest and northeast trends, as outlined by the variations in the orientation of the range-front fault. The geologic map was compiled on three 7½-minute quadrangle maps reduced to a scale of 1:62,500. The compilation of the geology was from a reconnaissance map by Walker (1965) at a scale of 1:250,000. The only field checking has been along the range front, where detailed mapping has been carried out in order to locate areas of alteration. These areas are presented on the map. One area of interest which has not been studied is located approximately 5 mi north of Lakeview, where a large deposit of sinter and cinnabar was located.

As the presence of warm water near Lakeview has been known for some time, the object of this study was to evaluate the size of the geothermal system and to determine approximate locations for production of thermal water for use in commercial and residential applications in the city of Lakeview. The geologic setting is Basin-Range, with a major fault bounding the Warner Range to the east and the Goose Lake Valley to the west. The age of most of the rocks is Miocene. Several age dates have been obtained in order to document the age of the volcanism in the area. The youngest rocks so far dated are approximately 9.5 m.y. old.

Extensive water-chemistry studies have been completed, and results are shown in Table 17, with detailed interpretation of these data to be included

TABLE 16

Contents of open-file release
on Lakeview low-temperature geothermal resource area

Item	Scale	Comments
Aeromagnetic Map	1:250,000	
Lineament Map	1:250,000	
Geologic Map	1:62,500	120°15'00" to 120°22'30" 42°00'00" to 42°22'30"
Geologic Cross-sections	1:62,500	
Rock Chemistry, Age Data, Gradient Data, Water Chemistry	1:62,500	Overlays on geologic map
Well and Spring Chemistry	--	Table
Geothermal Gradient/ Heat Flow Data	--	Table
Brief Text	--	
Gravity Map	1:62,500	
Bibliography	--	

in the open-file report. Silica temperatures do not indicate the presence of temperatures in excess of 150^{o}C in the system, although sodium-calcium-potassium results suggest somewhat higher temperatures. Completely satisfactory water samples of the actual hot-water system have not yet been obtained.

A number of accessible water wells were located and logged, and a total of seven drill holes was drilled by DOGAMI (see Table 18). At a depth of 30 m, one of these holes intersected water with a temperature of 105^{o}C and a flow of approximately 400 l/m. Two other holes showed gradients in excess of 300^{o}C/km. As a result of this study, at least one successful production well has been drilled during 1980 by Northwest Geothermal Corporation, who plans to develop a system for commercial utilization in Lakeview. This project appears to be well on its way with the drilling of the production wells based on the exploration data obtained by this project.

TABLE 18. Locations and geothermal gradients for the Lakeview low temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files. Standard error shown below gradient value.

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
38S/20E-21DAC	BR	42-15.4	120-21.5	G PLATO 7/31/79	1499	22.5 40.0	37.9 2.0	C
38S/20E-22CBC	BR	42-15.2	120-21.0	CL SMITH 7/31/79	1536	17.5 30.0	86.6 3.3	C
						17.5 56.5	81.6 6.0	C
38S/20E-33ABB1	BR	42-14.2	120-21.8	D LNDSAY 7/30/79	1499	35.0 110.0	551.5 .1	B
						170.0 247.0	76.7	B
38S/20E-33ABB2	BR	42-14.1	120-21.8	STKSBRRY 7/30/79	1492	15.0 56.5	379.4 26.1	B
38S/20E-33DBC	BR	42-13.6	120-21.9	STRBY-WW 7/31/79	1470	17.5 32.5	422.3 2.7	B
						32.5 79.0	20.0 2.5	B
38S/20E-33DCD	BR	42-13.4	120-21.6	LEACH 2 8/23/79	1470	5.0 15.0	65.7	B
						20.0 120.0	58.2	C
38S/20E-33DDC	BR	42-13.4	120-21.5	LEACH 1 8/23/79	1487	20.0 30.0	619.0 .8	B
						65.0 100.0	105.2	C
38S/20E-33CDD	BR	42-13.3	120-22.0	EMCDONLD 8/24/79	1455			
39S/20E-4AAB	BR	42-13.3	120-21.6	INGLDEW 11/ 9/79	1478	20.0 30.0	348.8 .4	C
						20.0 31.0	579.6 4.7	C
39S/20E-3ABA	BR	42-13.3	120-20.5	HMSLCAN3 1/23/80	1567	42.5 82.5	266.4 5.9	B
						15.0 40.0	410.7 26.8	B

TABLE 18. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
39S/20E-4AAA	BR	42-13.3	120-21.5	MUNSELL 11/ 9/79	1484			
39S/20E-3BDB	BR	42-13.1	120-21.0	HMSLCAN1 1/23/80	1507			
39S/20E-3BCB	BR	42-12.9	120-21.2	HMSLCAN2 1/23/80	1457	17.5 67.5	241.5 16.8	A
						17.5 90.0	280.1 16.6	B
39S/20E-4DAC	BR	42-12.8	120-21.5	SNIDR-WW 7/31/79	1458	70.0 125.0	192.1 3.5	A
						15.0 145.0	166.2 8.6	B
39S/20E-4DCA	BR	42-12.7	120-21.7	PR PN CO 1/22/80	1453	12.5 37.5	132.9 1.5	B
						12.5 125.0	138.1 13.0	C
39S/20E-9DAA	BR	42-12.0	120-21.3	FRMT-WW1 8/ 1/79	1444			D
39S/20E-15BAA	BR	42-11.5	120-20.7	LKVWTNLT 1/23/80	1453	42.5 90.0	106.3 4.7	B
39S/20E-14BBB	BR	42-11.5	120-20.1	BULLCAN1 1/23/80	1503	15.0 48.0	111.0 3.4	A
39S/20E-15AAC	BR	42-11.4	120-20.5	BULLCAN2 1/23/80	1486	12.5 87.5	125.4 1.1	A
39S/20E-15ABD	BR	42-11.4	120-20.3	LKVWSWMP 11/15/79	1468	75.0 200.0	111.5 6.8	B
						385.0 548.5	93.5 4.3	B
39S/20E-15CCB	BR	42-10.8	120-21.3	MTCHTT 1 7/30/79	1443	60.0 140.0	108.2 4.1	A
						5.0 167.5	93.5 7.0	B

TABLE 18. (continued)

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
39S/20E- 22ABA	BR	42-10.7	120-20.5	MTCHTT 2 7/30/79	1475	20.0 66.5	111.5 14.9	C
39S/20E- 22ACB	BR	42-10.4	120-20.6	JACKSON 8/24/79	1450	20.0 65.0	99.9 4.3	B
39S/21E- 29AD	BR	42- 9.6	120-15.4	RPK-1 7/22/73	2865	10.0 35.0		X
39S/20E- 27DBB	BR	42- 9.4	120-20.6	BARRY 1/23/80	1566	32.5 70.0	430.8 .1	C
41S/20E- 1CAD	BR	42- 2.3	120-18.5	ROCKFRD1 6/ 9/80	1451	25.0 65.0	405.1 .1	
						66.0 110.0	125.0 .1	
						110.0 310.0	39.2 .9	
						310.0 415.0	54.3 .1	
						110.0 415.0	44.4 2.2	
41S/20E- 1CCD	BR	42- 2.1	120-18.3	ROCKFRD2 6/ 9/80	1440	10.0 120.0	53.2 .1	
41S/20E- 13AAA	BR	42- 1.1	120-17.9	SWINGLE 8/23/79	1469	5.0 28.0	83.9 14.9	C
41S/21E- 18CBC	BR	42- .6	120-17.8	GILMORE 8/23/79	1467	10.0 73.0	83.2 8.4	B

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ALVORD DESERT

The open-file report for the Alvord Desert will present primarily the results of a literature study, although a total of ten 7½-minute maps, reduced to a scale of 1:62,500, have been compiled and field checked. The data available in the area are shown in Tables 19 through 21. The emphasis has been somewhat less than in the other areas because of the general lack of potential utilization of low-temperature fluids in this rather remote and sparsely populated area of southeastern Oregon. There is, however, significant interest in the high-temperature resources of the area, as indicated by the sale of KGRA lands to Anadarko Production Company, Getty Oil, and Al Aquitaine.

TABLE 19

Contents of open-file release
on Alvord Desert low-temperature geothermal resource area

Item	Scale	Comments
Aeromagnetic Map	1:250,000	
Audiomagnetotelluric Data	1:250,000	
Geologic Map	1:62,500	118°15'00" to 118°45'00" 42°15'00" to 42°45'00"
Geologic Cross-Sections	1:62,500	
Rock Chemistry, Age Data, Gradient Data, Water Chemistry	1:62,500	Overlays on geologic map
Well and Spring Chemistry	--	Table
Geothermal Gradient/ Heat Flow Data	--	Table
Brief Text	--	
Bibliography	--	

TABLE 21. Locations and geothermal gradients for the Alvord low temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files except holes MH-1, MH-2, AD-1 and AD-2 which have been published by Sass *et al.* (1976). Standard error shown below gradient value.

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
33S/35E-15	BR	42-40.6	118-21.6	MH-2	1235	10.0 30.0	294.9 .8	A
						30.0 35.0	255.0 2.0	A
						10.0 35.0	289.2 .8	A
33S/34E-24AB	BR	42-40.0	118-27.2	MCW 7/20/73	1290	25.0 240.0		X
33S/35E-14	BR	42-39.7	118-21.5	MH-1	1225	40.0 51.0	146.2 .6	A
35S/35E-5	BR	42-32.2	118-26.6	AD-2	1220			
35S/34E-3	BR	42-32.2	118-29.2	AD-1	1220	54.9 61.0	73.9	A
						88.4 95.7	78.6 .3	A
						55.0 96.0	75.8 .3	A
								A
37S/36E-28AB	BR	42-18.2	118-16.7	G-11 7/30/73	1366	10.0 25.0	130.6 13.7	A
38S/37E-24BA	BR	42-15.8	118-19.1	SP-10 7/28/73	1430	10.0 100.0	83.9 1.2	A
38S/37E-23CC	BR	42-15.3	118-20.8	DH-19 7/28/73	1430	10.0 50.0	88.5 3.9	A

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LA GRANDE

The information available for the La Grande area is shown in Table 22. There are several thermal wells and springs in the La Grande area; however, they are somewhat distant from the main population center. Magma Power Company drilled a 900-m deep well to intersect a fault near Hot Lake in 1972. However, maximum bottom-hole temperature was reported to be only $80^{\circ}C$. A total of four 7½-minute quadrangle maps were mapped by an independent subcontractor and have been published previously as DOGAMI Special Paper 6. Available water-chemistry data for the area are shown in Table 23.

Three holes were drilled in the immediate vicinity of La Grande by DOGAMI as part of this project in order to evaluate the possibility of warm-water flow along the frontal faults close enough to the city to be readily used for low-temperature applications. Major drilling problems were encountered because of the rubbly nature of the rocks at the surface on the downthrown block, and maximum depth reached in the holes was only 100 m. A temperature gradient of $90^{\circ}C/km$ was observed in one of the holes, and the temperatures were warm enough to justify installation of a ground-water-return heat-pump system for the adjacent county hospital. Further evaluation of the possible high gradient observed along the fault would require additional deeper drilling in a very difficult geologic setting and could prove to be quite expensive.

TABLE 22

Contents of open-file release
on La Grande low-temperature geothermal resource area

Item	Scale	Comments
Geologic Map	1:62,500	117°45'00" to 118°15'00" 45°07'30" to 45°22'30"
Well and Spring Chemistry	--	Table
Geothermal Gradient/ Heat Flow Data	--	Table
Brief Text	--	
Bibliography	--	

TABLE 24. Locations and geothermal gradients for the La Grande low temperature geothermal area. Data from published and unpublished information in DOGAMI-SMU files. Standard error shown below gradient values.

TOWNSHIP/ RANGE- SECTION	GEOL. PROV.	N LAT.	W LONG.	HOLE NO. DATE MEASURED	COLLAR ELEV. (meters)	DEPTH INTERVAL (meters)	UNCORR. GRAD. °C/km	QUALITY
2S/37E- 25DB	BM	45-21.8	118- 7.3	THOMAS 8/23/77	1143	20.0 150.0	32.5 .6	B
						90.0 150.0	36.4 .6	B
3S/38E- 4BD	BM	45-20.0	118- 4.1	HIGHDEPT 8/22/77	837	35.0 75.0		C
3S/38E- 3DC	BM	45-19.7	118- 2.7	ISLCTYCM 8/23/77	829	10.0 90.0	17.1 1.0	C
						60.0 90.0	31.4 1.6	C
3S/39E- 2CD	BM	45-19.7	117-54.2	HAMMAN 8/22/77	814	35.0 85.0	23.6 .6	B
3S/38E- 7ADA	BM	45-19.3	118- 5.9	MID SCH 2/ 6/80	859			D
3S/38E- 7ACD	BM	45-19.1	118- 6.2	CENT SCH 2/ 5/80	875	20.0 75.0	41.9 1.3	B
3S/38E- 7ACC	BM	45-19.1	118- 6.3	LGR HOSP 12/14/79	896	20.0 45.0	48.2 1.5	D
3S/39E- 8DA	BM	45-18.9	117-57.2	WEISHAAR 10/26/79	822	15.0 75.0	19.9 .5	C
3S/40E- 14CB 2	BM	45-18.1	117-47.2	COVE 2 8/24/77	978	50.0 105.0	71.8 1.8	B
						20.0 105.0	53.0 2.6	B
3S/40E- 14CB 1	BM	45-18.0	117-47.2	COVE 1 8/24/77	978	23.0 45.0	25.0	C
2S/39E- 28AC	BM	45-16.5	117-56.5	B JONES 8/24/77	821	10.0 45.0	70.9 2.6	C
						27.5 45.0	55.9 1.1	B
4S/40E- 18BA	BM	45-13.5	117-51.7	UNIONCTY 8/23/77	845	.0 310.0	38.0	B
4S/40E- 18CD	BM	45-12.8	117-51.7	UNIONGRN 8/24/77	848	12.5 75.0	65.4 .8	B

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GOVERNOR

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AREA
OR
LowTemp

May 5, 1980

RECEIVED
MAY 12 1980
GEOTHERMAL ENERGY
BRANCH

Dr. Leland L. Mink
Energy and Technology Division
Idaho Operations Office, DOE
550 Second Street
Idaho Falls, Idaho 83401

Dear Dr. Mink:

Subject: Cooperative Agreement No. DE-FC07-79ET-7220; Technical Progress Report No, 1

Submitted herewith is a summary report on the progress to date on the low-temperature resource assessment of the La Grande and Lakeview areas. Upon assimilation of all data, a final report (DOGAMI Open File) will be written for the Lakeview area.

Future technical progress reports will be submitted for the Willamette Pass and Belknap-Foley areas later this year after temperature gradient holes are drilled.

La Grande

Geologic mapping of four 7½' quadrangles (Hilgard, La Grande SE, Glass Hill, and Craig Mountain) has been completed by Geoscience Research Consultants under contract to DOGAMI. The geologic maps and text have been published as Special Paper 6. Six copies of the publication will be sent to you under separate cover.

Because of interest shown by the Grande Ronde Hospital and the local school system, including Eastern Oregon State College, in developing a suitable geothermal resource for space heating and cooling, three heat flow holes were drilled to a maximum depth of 367 feet within the city limits of La Grande on property owned by the hospital and the school system (Federal land was not available). Drilling difficulties were encountered because of caving due to bouldery to blocky debris which comprises the alluvium and/or shallow bed-rock; thus the 6-inch diameter holes could not be drilled to the proposed depth of 500 feet. Casing had to be driven to maintain integrity of the hole with the casing collapsing due to driving.

Waters at a temperature of 62.5°F and at an estimated flow of 100^{+} gpm were encountered on the hospital and the Central School sites (Fig. 1). The

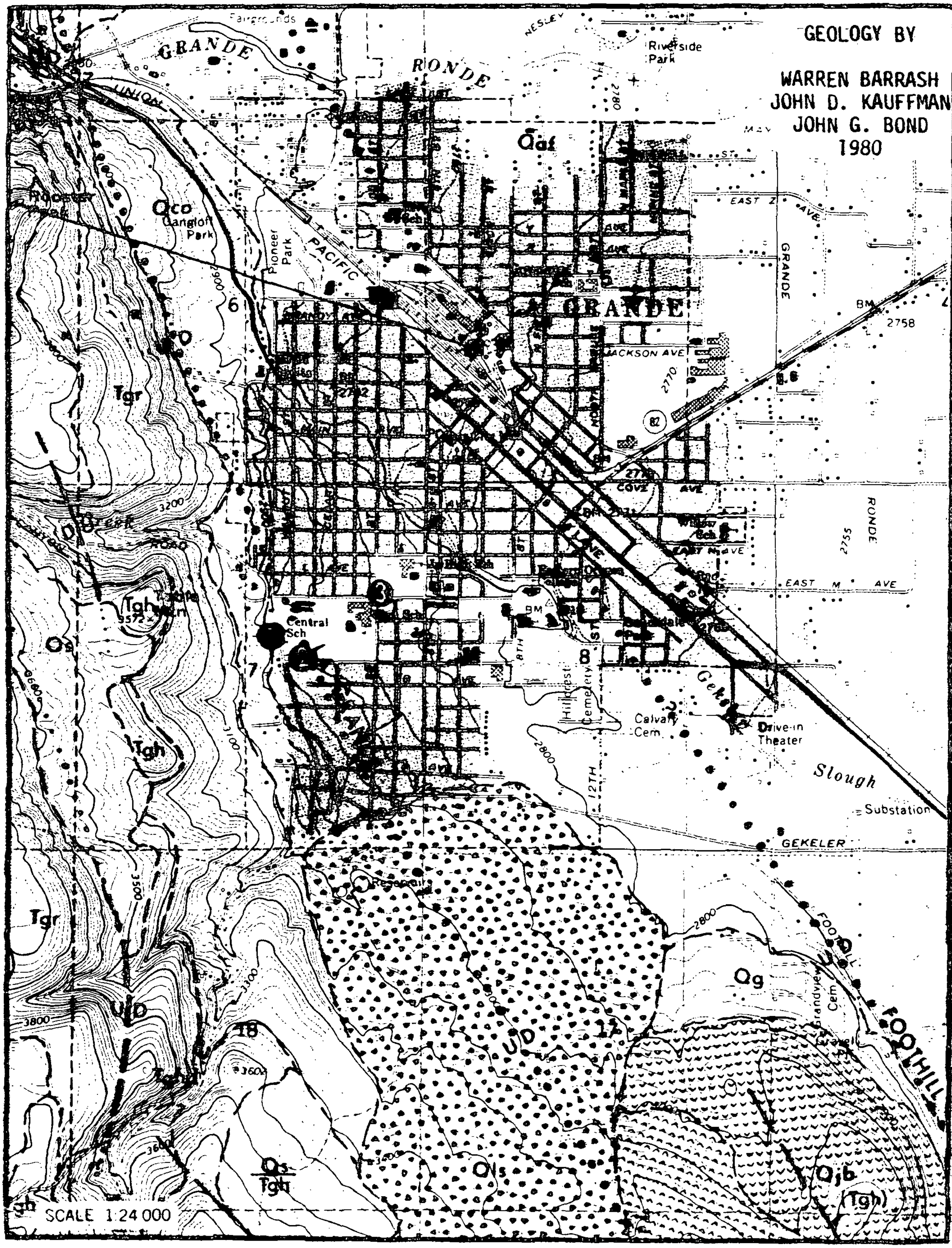


Figure 1. Location of temperature-gradient holes, La Grande area, Oregon.

hospital is aggressively pursuing the use of this resource utilizing water-to-water heat pumps to heat and cool a contemplated major expansion of the existing building. Oregon Institute of Technology (Geo-Heat Utilization Center) has been contacted by the hospital for assistance. DOGAMI will provide OIT with data obtained from our study. According to Oregon Air Reps, Inc., (Templifter heat pump), the 62.5°F water could be boosted to 140°F. It is believed that successful use of this resource will entice other entities such as the school system, college, and local government to follow suit. Warm waters (70°-81°F at 75-500 gpm) also underlie the area of the Union Pacific Railroad yards (Fig. 1).

Water samples from known springs and thermal wells in the Craig Mountain - Cove area, including La Grande, have and are currently being chemically analyzed. Chemical data are being sent periodically to Jim Swanson, USGS, Menlo Park, California, for insertion in the GEOTHERM file.

Whatever "free" holes that were available for temperature/gradient measurements have been completed within the greater La Grande area. However, most "free" holes are not deep enough to overcome the effects of ubiquitous flows of cold ground water.

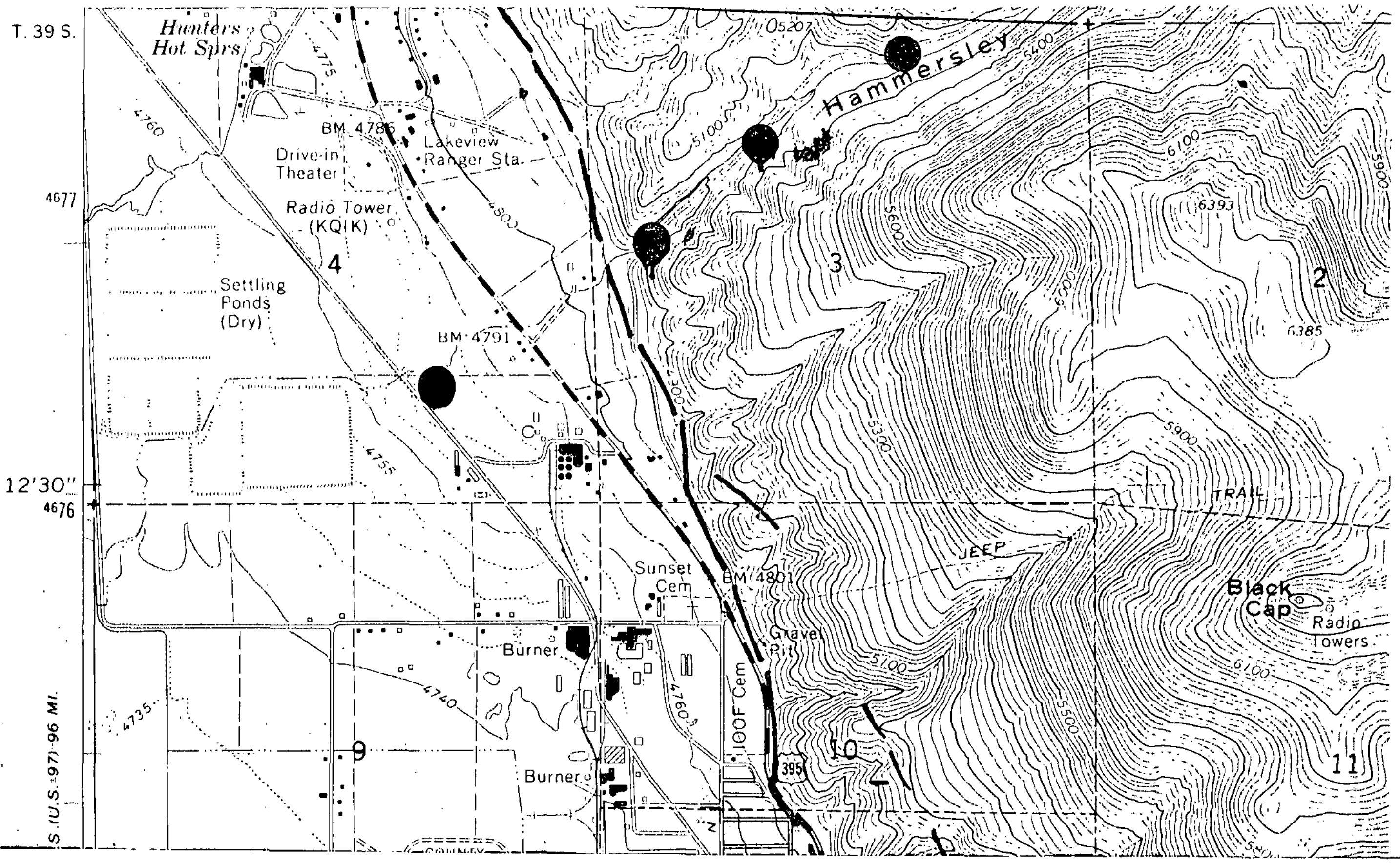
Based on available data, it is believed that the warm thermal waters are the result of migrating thermal fluids along the basin boundary faults which mix with colder ground water. Typical ground water temperatures in the immediate area range from 42° to 48°F. A deep hole to at least 2000 feet in depth is needed in this area to better appraise the geothermal resource. Because of the drilling problems, a much larger hole diameter is warranted and casing is needed to combat the caving conditions. Use of drilling mud did not appreciably help solve the problem to the shallow depths explored.

Lakeview

Geologic mapping and compilation of three 7½' quadrangles (Lakeview NE, Crane Creek, and Crooked Creek Valley) has been completed except for office routine including final drafting, cross-sections, and geophysical overlays.

The Lakeview area is situated in the northern portion of the Basin and Range geomorphic province with typical horst and graben structure. The oldest rocks exposed in the Lakeview area are in the Warner Mountains at the base of the range east of Lakeview. The rocks consist of a thick section of volcanic rocks, primarily andesite and basalt flows with pyroclastics and related sedimentary rocks. Selected samples of rocks have been sent to UURI for K/Ar dating.

In the Goose Lake graben west of the frontal fault (Fig. 2) that separates the valley from the Warner Range, only unconsolidated to poorly indurated and loosely- to well-cemented Pleistocene to Holocene sedimentary rocks are exposed. These are mainly lacustrine and fluvial deposits of varied texture and composition. The terminus of a large prominent delta deposit is about 3 miles north of Lakeview. This feature extends north and west for several


T. 39 S.
Hunters Hot Sprs
4760
4775
BM 4786
Lakeview Ranger Sta.
Drive-in Theater
Radio Tower (KQIK)
4677
4
Settling Ponds (Dry)
BM 4791
4755
12'30"
4676
Hammersley
5207
5400
5100
6100
6393
5900
3
2
6385
5600
5300
5900
TRAIL
JEEP
Black Cap
Radio Towers
Sunset Cem
BM 4801
Gravel Pit
Burner
4740
4735
4760
IOOF Cem
9
10
11
395
Burner
5500
6100

miles and in outcrop shows typical cross-bedding, channeling, and fore- and top-set beds. Slight tilting of the layered materials can be discerned and minor faulting has slightly offset some of the layers.

The dominant structure of the area is the roughly N-S trending frontal fault that separates the Goose Lake Valley from the Warner Mountains. Patches of Pleistocene gravels at elevations 5100, 5300, and 5600 feet in the Warner Range tend to indicate that movement along this fault system occurred during late Pleistocene-Holocene time. A less apparent structural grain within the volcanics trends N30W to N60W and in the field is usually seen as narrow discontinuous fractures or faults filled by basaltic dikes.

In the immediate Lakeview area, the frontal fault appears to be a nearly vertical to steeply westward dipping (78°) fractured zone about 50 feet wide which is often hydrothermally altered. The areas of greatest rock alteration have been mapped and will be shown on the final geologic map.

Siliceous sinter representing an abandoned hot spring deposit comprised of opal and agate with occasional cinnabar at least 10 feet thick covers an area of about 1/3 square mile in sec. 12, T. 38 S., R. 20 E., and Sec. 7, T. 37 S., R. 21 E. Minor silica-cemented lacustrine sands also occur in sec. 28, T. 38 S., R. 25 E.

Higher than normal ground water temperatures (to 99°C) including hot springs occur in a narrow north-trending zone along the east side of Goose Lake Valley, north and south of Lakeview. The zone is about 20 miles long and appears to be confined to about 1/2 mile of the frontal fault. The highest temperature springs (70° to 95°C) are localized north and south of Lakeview within the areal limits of the altered rock. Apparently geothermal fluids are migrating upward along the frontal fault and move laterally into the porous segments and issue as springs. Other springs, however, issue at the base of the Warner Range.

Existing hot and/or thermal springs were sampled and chemically analyzed. Chemical data have been sent to the USGS, Menlo Park, California for insertion in the GEOTHERM file. Samples obtained from existing hot wells as well as fluids from temperature/gradient holes have been similarly treated.

Whatever "free" holes that were available for temperature/gradient measurements have been completed (Table I). Eight 6- to 8-inch diameter temperature/gradient holes have been drilled by DOGAMI to a maximum depth of 400 feet (Fig. 2). Temperature depth curves for the logged holes are shown in Figs. 3 and 4.

Temperature gradients have been contoured for the area encompassed by secs. 3 and 4, T. 39 S., R. 20 E., and secs. 32 and 34, T. 38 S., R. 20 E. (Fig. 5). HFU and gradient profiles along Hammersley Canyon (secs. 3 and 4, T. 39 S., R. 20 E. are shown on Fig. 6. HFU, gradient and temperature profiles along Bullard Canyon (secs. 15 and 16, T. 39 S., R. 20 E., are shown on Fig. 7.).

Geothermal fluids at 99°C at an estimated flow of 100 gpm were measured for Hammersley Canyon #1. At the Barry hole (T. 39 S., R. 20 E., 27 Dbb), a temperature of 55°C and an estimated flow of 50 gpm were noted.

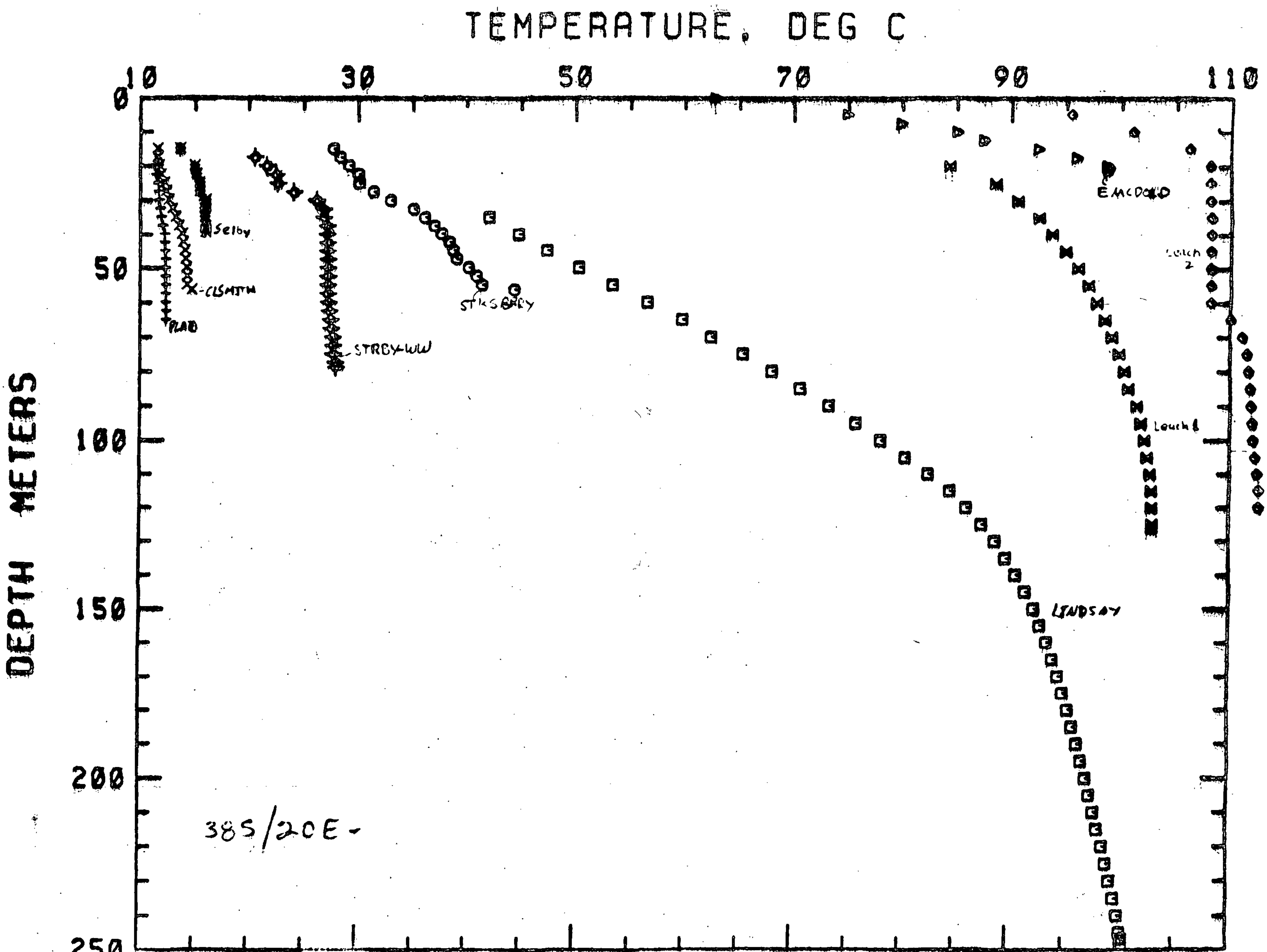
Location	Hole Name	Abbrev.	Least Squares Grad.	Est. Poros.	Ka	Terrain Corrected Gradient	Q (HFU) Least Square	Q (HFU) Terrain Corr.
38S20E 21DAC	GPLATO	PL	20.0	---	(3.0)	---	(.6)	---
38S20E 22CBC	CLSMITH	SM	42.0	10%	5.3	---	2.3	---
38S20E 28CAA	SELBY	SBY	98.2	---	(3.0)	---	(2.9)	---
38S20E 33ABB1	DLNDSAY	LN	566.0	---	(4.0)	---	(266)	---
38S20E 33ABB2	STKSBRRY	SB	323.2	---	(4.0)	---	(12.9)	---
38S20E 33CDD	EMCDONLD	MCD	1709	---	(3.0)	---	(51.3)	---
38S20E 33DBC	STRBY-WW	STWW	409.0	---	(3.0)	---	(12.3)	---
38S20E 33DCD	LEACH 2	L2	814.1	---	(3.2)	---	(21.1)	---
38S20E 33DDC	LEACH 1	L1	675.2	10%	3.4	---	22.9	---
*39S20E 3ABA	HMSLCAN 3	H3	267.8	10%	3.55	288.8	9.5	10.2
*39S20E 3BCB	HMSLCAN 2	H2	280.1	10%	3.54	303.8	9.9	10.8
*39S20E 3DBE	HMSLCAN 1	H1	976.3	10%	3.68	(991.33)	35.7	(36.5)
39S20E 4AAA	MUNSELL	MU	1831	---	(3.4)	---	(54.3)	---
39S20E 4AAB	INGLDEW	IN	451.6	---	(3.2)	---	(14.4)	---
39S20E 4DAC	SNIDFRWW	SNWW	186.0	---	(3.0)	---	(5.6)	---
*39S20E 4DCA	PRPNCO	PR	134.0	30%	3.0	---	4.0	---
*39S20E 14BBB	BULLCAN 1	B1	111.9	10%	5.6	109.8	6.2	6.1
*39S20E 15AAC	BULLCAN 2	B2	124.2	10%	3.83	(120.2)	4.8	(4.6)
39S20E 15ABD	LKVWSWMP	LVSP	81.7	---	(3.8)	---	(3.1)	---
*39S20E 15BAA	LKVWTNLT	LVLT	125.3	30%	3.28	---	4.2	---
39S20E 15CCB	MTCHTT 1	M1	106.2	---	(3.0)	---	(3.2)	---
39S20E 17AB	UTLEY 1	UT1	61.0	---	(3.0)	---	(1.8)	---
39S20E 22ABA	MTCHTT 2	M2	132.3	10%	4.64	(120)	6.1	(5.6)
39S20E 22ACB	JACKSON	JK	128.4	---	(3.2)	---	(4.1)	---
*39S20E 27DBB	BARRY	BY	850.9	20%	4.12	(800)	35.0	(33.0)

* Temperature/gradient holes drilled by DOGAMI

( ) Values are estimates

NOTE: PRELIMINARY DATA, SUBJECT TO CHANGE.

TABLE I


TEMPERATURE, DEG C
10
30
50
70
90
110
0
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150
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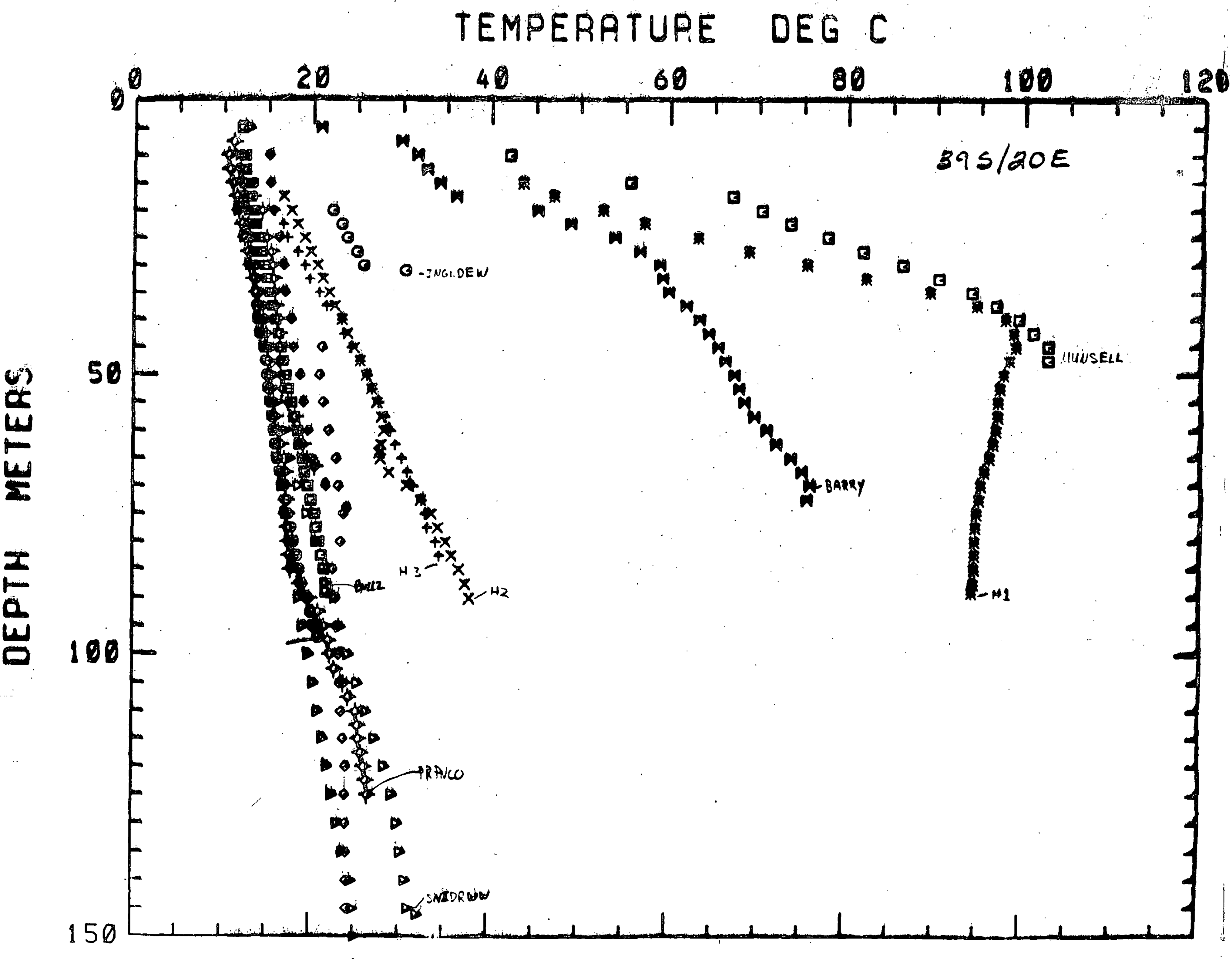
250
DEPTH METERS
Selby
CLSMITH
STRBY-WW
LINDSAY
38S/20E-

Figure 3


TEMPERATURE DEG C
0
20
40
60
80
100
120
DEPTH METERS
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150
39S/20E
MUNSELL
BARRY
H1
H2
H3

Figure 4

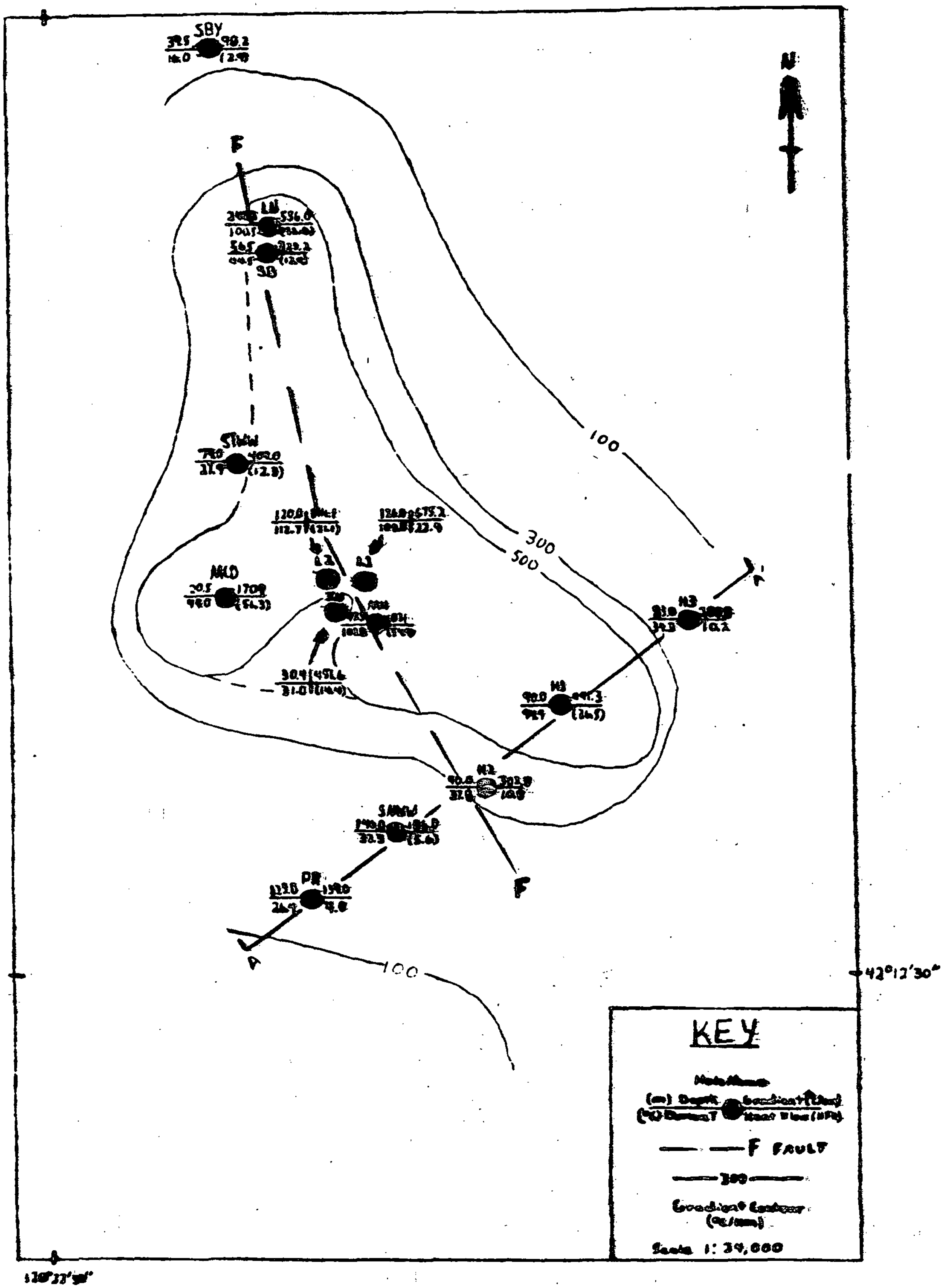
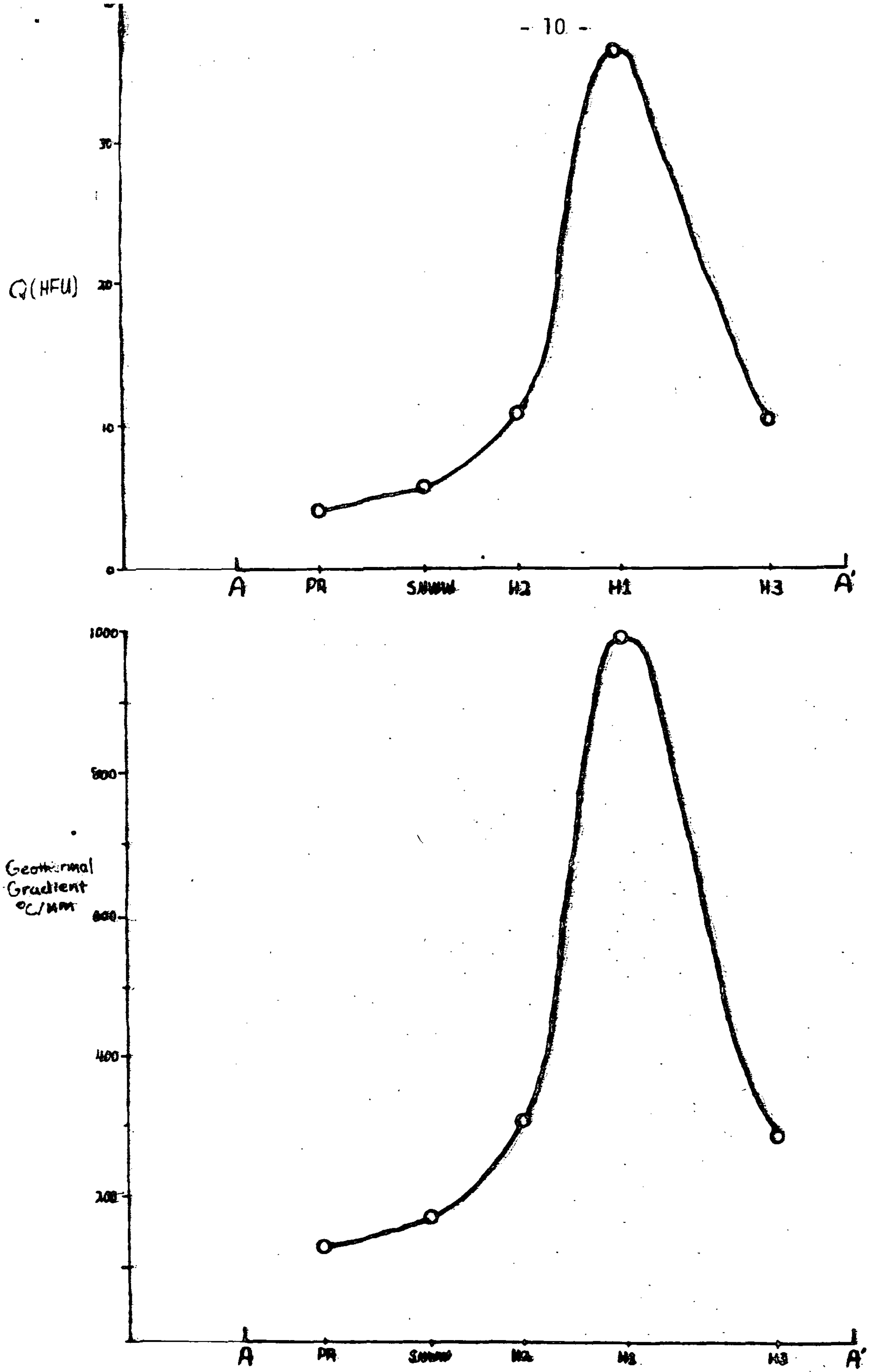


Figure 5



Profiles - Hammersley Canyon

Figure 6

Profiles Through Bullard Canyon

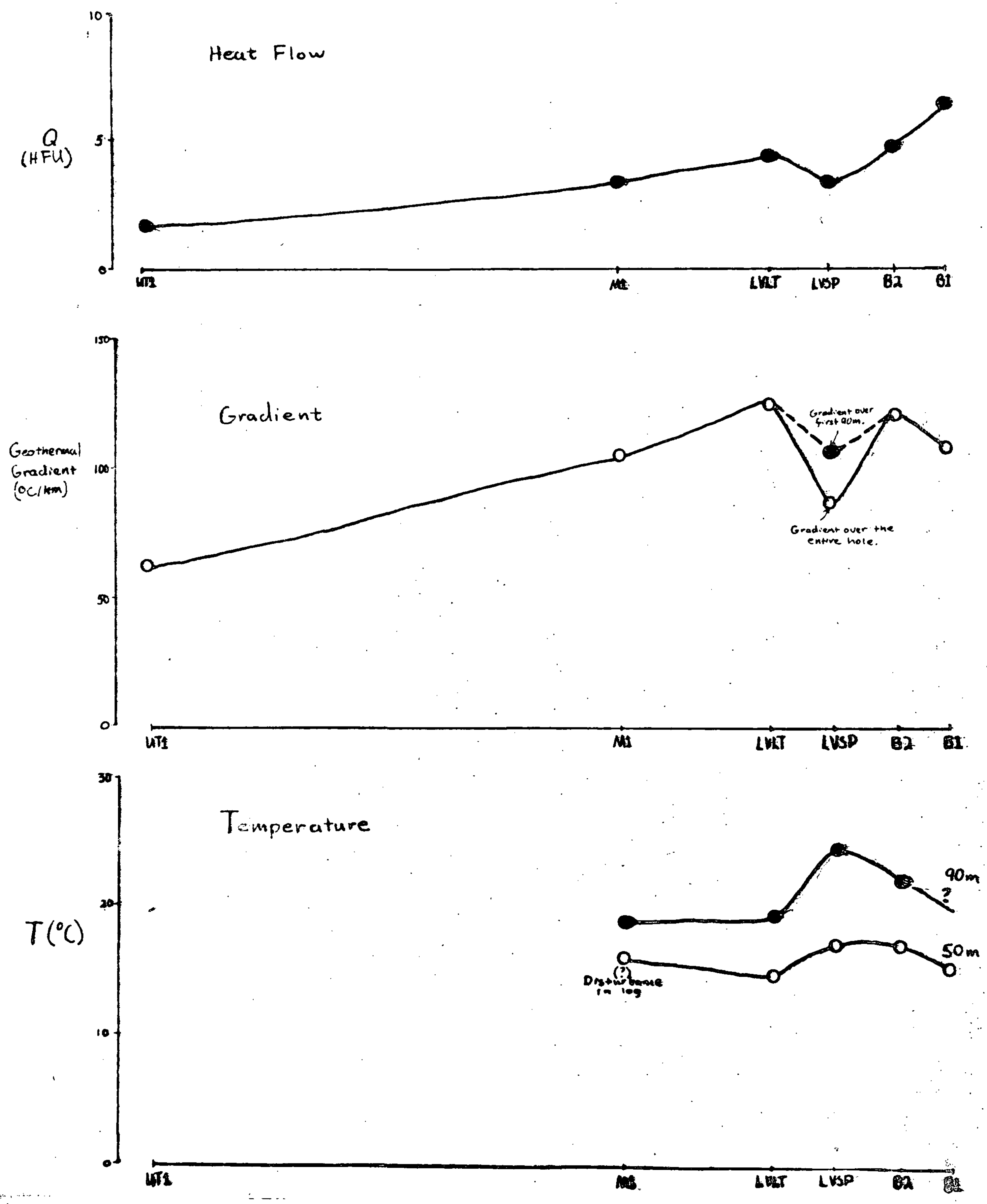


Figure 7

Based on the temperature/gradient holes and associated data obtained by DOGAMI, the area east of the frontal fault (horst block) to a distance of at least .75 mile wide (Fig. 2) appears to be underlain by a low to intermediate shallow geothermal resource. Thus, exploration that has been previously restricted to Goose Lake Valley can be extended eastward. Geothermal fluids apparently occur in fractures and joints on the horst block associated with the frontal and the intersecting northwest trending faults. Many of the fractures seen in outcrop and in cuttings are filled with calcite and possibly acidizing may improve permeability.

Based partially on the foregoing and on geologic studies of their own, Northwest Natural Gas Company tentatively plans to drill three 1000-foot-deep exploratory holes this year (farm-out from Gulf Oil Co.) at the following locations: near the Leach wells in sec. 33, T. 38 S., R. 20 E.; at the site of Hammersley Canyon #1 in sec. 3, T. 39 S., R. 20 E.; and north of the Barry hole in sec. 27, T. 39 S., R. 20 E. The latter hole is programmed to intersect the frontal fault near total depth.

Besides the City of Lakeview, Lake County has shown interest in utilizing the geothermal resource for space heating/cooling and industrial applications for contemplated industrial parks.

It is recommended that an exploratory hole be drilled in the area underlain by the siliceous sinter in sec. 12, T. 38 S., R. 20 E. This was not done in the current study due to the lack of drilling funds.

If you have any questions or need additional data, please call me or Joe Riccio.

Sincerely yours,

Donald A. Hull
Principal Investigator

DAH:lk