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HEAT FLOW STUDY OF THE BROTHERS FAULT ZONE, OREGON

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ABSTRACT

During 1975 and 1976 38 holes were drilled in central and eastern Oregon to obtain data for calculation of heat flow along the Brothers fault zone and a possible eastward extension of the zone. The holes were drilled to variable depths with the majority of holes in the depth range of 60-150 m. (197-492 ft.). Geothermal gradients and estimated heat flow values were also obtained from 15 water wells and mineral exploration holes.

Heat flow is variable along the zone and many of the values appear to be influenced by ground water movement. Most of the heat flow values in the fault zone between Pine Mountain on the west and Riley Junction on the east are 1.9 HFU or greater whereas values north of the zone are approximately 1.6 HFU. The systematic decrease in the age of silicic volcanism from east to west along the fault zone as defined by MacLeod and others (1976) is not reflected by a systematic variation in heat flow values. Anomalously high heat flow at Glass Buttes and at several localities in and west of Harney Basin outlines a broad area, parallel to the fault zone, which deserves further study. At Glass Buttes high heat flow coincides with an area of intensive hydrothermal alteration and low electrical resistivity and these features collectively define a promising exploration target.

Heat flow values of 1.7 - 2.0 HFU in three holes along the eastern border of Oregon limit the western extent of the Battle Mountain heat flow high as defined by previous workers (Sass and others, 1976A).

INTRODUCTION

Purpose

The purpose of the research described herein was to measure crustal heat flow along and across the Brothers fault zone, a major regional geologic lineament which crosses central Oregon (figure 1). Previous work had shown that the zone contained a geologic environment favorable for the occurrence of geothermal energy (Walker, 1974 and Groh, 1966). Measurement of heat flow was adjudged to be the most direct and appropriate technique for evaluating the geothermal potential of the study area.

Scope

The study consisted of the drilling of 38 holes, measurement of geothermal gradients (the increase in temperature with depth) in the holes, subsequent laboratory measurement of thermal conductivity on rock samples from the holes and finally calculation of heat flow which is the product of the gradient and thermal conductivity values. Holes were initially drilled in 1975 in a variety of rock types along profiles oriented perpendicular to the west-northwest trend of the Brothers fault zone. The 1975 holes were located in the zone and near the north and south margins of the zone as defined by regional geologic mapping (Walker and others, 1967 and Greene and others, 1972). In 1976 holes were

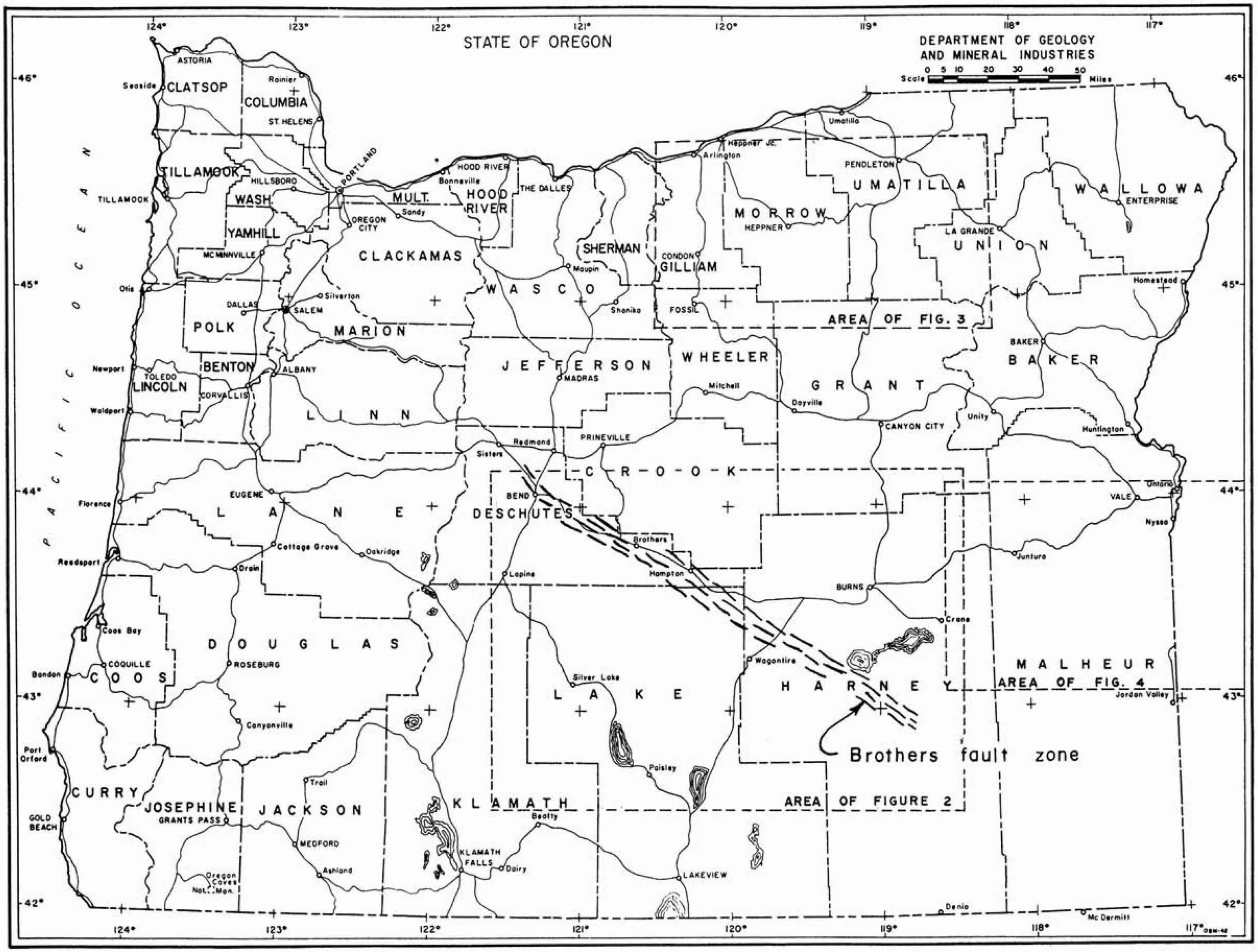

Figure 1 - Index Map

drilled in and near silicic volcanic centers at the west end of the zone, across a possible eastern projection of the zone and in older rocks north of the zone to provide regional background data.

Definition of terms

Metric units are used throughout the report and English units are included in parentheses for convenience where appropriate.

Heat flow is used throughout this report to mean crustal heat flow as measured in shallow holes, and we have made no calculations of reduced heat flow. Heat flow data are presented in heat flow units (HFU) of microcalories /cm.^{2} sec. Geothermal gradients are measured in degrees Celsius per kilometer of depth and thermal conductivity is expressed in millicalories /cm. sec. ^{o}C.

Drill hole numbers express hole location by township, range and section in a manner similar to established practice of the U.S. Geological Survey for water wells. The refinement of location within a section is based on a quadrant subdivision of A, B, C, or D for the northeast, northwest, southwest or southeast $\frac{1}{4}$ or $\frac{1}{4}$ - $\frac{1}{4}$ section. Thus a hole in the northwest $\frac{1}{4}$ of the southwest $\frac{1}{4}$ of section 10, township 9 south, range 14 east is numbered 9S/14E - 10 CB. The first letter after the section number represents the $\frac{1}{4}$ section and the second letter designates the $\frac{1}{4}$ - $\frac{1}{4}$ section. Due to the lack of detailed topographic maps in portions of the study area it was not possible to refine some of the hole locations to $\frac{1}{4}$ - $\frac{1}{4}$ section and for these hole numbers the second letter is not given. Township and range designations refer to the Willamette base line and meridian respectively.

Acknowledgements

The success of the project is due to a number of individuals. Edward E. Widman, William Hoffstetter and Gerald L. Black assisted with the drilling and logging of the holes. Chu Jiaw, John Steele and Charles Brott measured the thermal conductivity values. John H. Sass of the U.S. Geological Survey provided helpful suggestions and technical guidance during the course of the study. The drilling was performed under contract by Larry Burd Well Drilling Company of Pendleton, Oregon and Boyles Brothers Drilling Company of Reno, Nevada; both firms did an excellent job. The majority of the holes were drilled on Federal lands and we received outstanding cooperation from officials of both the U.S. Bureau of Land Management and the U.S. Forest Service. The project benefited from the stimulating discussions of geology with Norman S. MacLeod of the U.S. Geological Survey, Lawrence A. Chitwood and Edward A. Groh of Bend, Robert J. Pulfrey of Burns, Jack Roberts of Vale, Chris Broili of Lakeview and Rodney D. Wimer of Portland. Leonard Wilkerson of the Department of State Lands was helpful in our work on state lands.

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Related Studies

The heat flow study of the Brothers fault zone is a segment of a continuing state-wide heat flow investigation. The Department of Geology and Mineral Industries recently completed a companion study in the Western Cascade Range and the U.S. Geological Survey recently published the results of their heat flow work in an area in southern Oregon which lies south of the Brothers fault zone (Sass, J.H., and others, 1976B).

The preliminary results of our work in 1975 were described by Bowen and others (1976). A heat flow study of the western Snake River Plain, which adjoins the area investigated in this report, is described by Brott and others (1977).

LOCATION

The Brothers fault zone (figure 1) crosses central Oregon and lies between the Cascade Range on the west and Steens Mountain on the east. The majority of the heat flow holes drilled as part of this study lie between the city of Bend on the west and Harney Basin near the city of Burns on the east (figure 2). Additional holes were drilled in the Blue Mountains in northeastern Oregon (figure 3) and near the eastern border of the state between the towns of Adrian and Jordan Valley (figure 4). The study area encompasses portions of Crook, Deschutes, Harney, Lake, Malheur and Morrow Counties.

GEOLOGY

The Brothers fault zone is a major structural lineament which forms the northern boundary of the Basin and Range geologic province across much of central Oregon (Lawrence, 1976). Recent work by Stewart and others (1975) demonstrated that the Brothers fault zone is colinear with, and possibly a northwestern portion of a structural zone termed the Oregon-Nevada lineament which extends as far southeast as central Nevada.

The Brothers fault zone is considered to be a zone of right-lateral tear faulting (Lawrence, 1976). Peterson and others (1976) describe the zone as a belt of closely spaced en-echelon normal faults. Walker (1969) notes that "The normal faults of the zone and the many volcanic vents along the zone represent only the surface manifestation of deformation, the exact nature of which is not known. The pattern of normal faults within and near the Brothers fault zone and the relation of many small monoclinal folds to the fault suggest, however, that the zone overlines a deeply buried fault with lateral displacement; the normal faults denote only adjustment of surface and near-surface volcanic and tuffaceous sedimentary rocks."

The time of onset of tectonic activity along the Brothers fault zone is not accurately known. The individual faults along the zone have displaced all the rocks in the area except the latest Pleistocene lavas and a slickensided and obviously young fault plane along the zone is exposed near Hampton Butte (Peterson and others, 1976), however, the zone does not appear to be seismically active at the present time. A summary of earthquakes in Oregon between 1841 and 1970 showed only a single event along the Brothers fault zone, an intensity III earthquake near Bend in 1943 (Couch and Lowell, 1971).

The Brothers fault zone lies in the High Lava Plains physiographic province. The zone traverses an interlayered sequence of volcanic and sedimentary rocks ranging in age from Miocene to Holocene. The volcanic rocks at the surface are predominantly basalt flows and rhyolitic ash-flow tuffs with scattered rhyolite and rhyodacite domes. The sedimentary rocks are poorly indurated tuffaceous sandstone, siltstone and claystone of fluviatile and lacustrine origin. Regional geologic maps by Walker and others (1967) and Greene and others (1972) cover the eastern and western portions of the fault zone respectively.

The rhyolite and rhyodacite domes along the Brothers fault zone and a broad area to the south, show a general progressive decrease in age from Harney Basin westward to the Cascade Range (MacLeod and others, 1976) although silicic complexes at Pine Mountain near the west end of the area with an age of 21 million years (MacLeod, oral communication, March, 1977) and Iron Mountain near the east end of the area with an age of 2.7 million years are exceptions to this pattern (Parker, 1974). The basalt flows do not show any systematic age progression and Holocene to Pliocene flows and cinder cones are found intermittently along the zone from the Cascade Range to Diamond Craters in Harney Basin. The trend of centers of young basalt volcanism continues east from Diamond Craters to Jordan Craters near the town of Jordan Valley, Oregon whereas the structural lineament extends southeast from Harney Basin at least as far as the major fault bounding the east side of Steens Mountain.

The hydrology along the western portion of the Brothers fault zone is poorly understood as there are few water wells in the area. A compilation of available data from the Newberry volcano area indicated that the static water level is 120 - 600 m. (400 - 1968 ft.) below the surface and that the Brothers fault zone may have a controlling effect on the ground water levels in the area (C. Wassinger, written communication, February, 1977). The movement of ground water appears to be north from the vicinity of Fort Rock and Newberry volcano towards the city of Bend and northwest from the towns of Brothers and Millican also towards Bend. The static water level becomes shallower along the eastern portion of the Brothers fault zone and in Harney Basin it lies at depths generally less than 30 m. (98 ft.). Perched ground water apparently is common in the vicinity of the fault zone. Ground water studies which cover portions of the Brothers fault zone include those by Trauger (1950) who compiled data for Lake County, and Piper and others (1939) and Leonard (1970) who studied ground water in Harney Basin.

The heat flow holes drilled west of longitude 120° W did not penetrate the static water level whereas many of the holes to the east were drilled in part below this level.

METHODS

Drilling

During the heat flow study holes were drilled to variable depths ranging from 17.5m. (57 ft.) to 248 m. (815 ft.) with truck mounted rotary drills. The drills used for various phases of the work were an Ingersoll Rand model T4 and a Failing model CF 1500. A variety of drilling techniques were used including down-hole air hammer, air rotary and diamond coring. Most of the footage was drilled with the down-hole hammer and coring was confined to selected intervals and constituted about two percent of the total footage.

Holes were drilled in a variety of rock types with variable success. Basalt flows are the predominant rock type at the surface in the study area, and they present especial problems for heat flow drilling because they are ground-water aquifers and moving ground-water at depth may distort conductive heat flow patterns. In addition the basalt flows in the vincinity of the Brothers fault zone are generally only a few meters to a few tens of meters thick and unconsolidated or poorly consolidated sediments and cinders are commonly interlayered with the flows, resulting in caving of the drill holes. The relatively thin basalt flows are characterized by marked variations in porosity which results in significant variations in thermal conductivity values within a given drilled section.

The widespread silicic welded ash-flow tuff sheets offer good drilling conditions but their maximum thickness in the study area is approximately 76 m. (250 ft.) and temperature gradients measured in the welded tuffs cannot reliably be projected to any great depth. Also unconsolidated pumice and/or sediments at the contacts of the tuffs tend to cave.

The rhyolite and rhyodacite domes present relatively good drilling conditions but their resistance to erosion and, in some cases, their relatively young age result in marked topographic relief which limits access for drilling and necessitates topographic correction of the geothermal gradient data. These silicic domes are widely and irregularly spaced and appear to be "mushroom" shaped. Some of the drill holes collared on the flanks of the domes passed out of the silicic rocks at shallow depths.

Three holes were drilled in late 1976 along Sucker Creek in Malheur County in a predominantly sedimentary section in the Sucker Creek Formation of Miocene age. This unit offers good drilling conditions except for interlayered thin basalt flows which act as aquifers and require grouting. A single hole was drilled in trondjemite of Mesozoic age in Morrow County and this lithology presented no problem.

The direct drilling cost in individual holes varied from \$5.77/m. (\$1.76/ft.) to \$89.43/m. (\$27.76/ft.). A total of 2670 m. (8,762 ft.) of hole was drilled during the course of the project at a total direct cost of \$50,045, ie., an average cost per meter of \$18.73 (or \$5.71/ft.).

The relatively shallow holes drilled in 1975 to a depth of 61 m. (200 ft.) or less had a mean cost of $13.22/m. ($4.03/ft.) whereas the drilling in 1976 to a target depth of 152 m. (500 ft.) resulted in a cost of $23.56/m. ($7.18/ft.).

Penetration rates for individual holes varied considerably. The various volcanic and sedimentary units along the Brothers fault were drilled with the down-hole air hammer at rates of 10-20 m./hour (33-66 ft./hour). Caving zones and coring slowed progress considerably but individual holes were generally completed in one or two days. The trondjemite at Black Mountain was drilled with the downhole air hammer at an average penetration rate of 7.5m./hr. (24.5 ft./hr.).

Geothermal gradient

Temperatures were measured at depth intervals of $2\frac{1}{2}$ or 5 m. (8.2 or 16.4 ft.) using a previously calibrated thermistor (temperature dependent electrical resistance element) probe. A detailed description of the instrumentation is given by Roy and others (1968). The thermistor element has a temperature precision of 0.005°C although the precision of repeated temperature measurements at a particular depth in a hole is approximately 0.05°C due to the difficulty in repositioning the probe at the same depth. The temperature gradients tabulated herein are calculated by fitting a least squares straight line to the data.

The time required for temperatures to reach equilibrium in a hole after drilling is exceedingly variable and ranges from a few days to a few months. The time varies depending upon drilling method, drilling medium (air versus water), lithology, permeability of the host rock, groundwater conditions and the nature of the material used to backfill the hole (cement versus drill cuttings versus drill mud).

Thermal conductivity

During drilling samples of cuttings were taken at intervals of 6.1 or 12.2 m. (20 or 40 ft.) for subsequent laboratory measurement of thermal conductivity. Intermittent core samples were taken to check the conductivity values measured on the cuttings and to provide more accurate values for rocks of variable porosity. Conductivity measurements were also made on outcrop samples of basalt and rhyolite.

The divided bar method of measuring thermal conductivity was used on cuttings as described by Sass and others (1971B).

Due to the lack of knowledge of the average porosity for most of the lithogic units encountered in drilling, the measured thermal conductivity values for some holes are subject to uncertainties of as much as 20 percent. In order to reduce the uncertainty in conductivity values, continuous cores are needed, however core drilling would increase the unit cost of drilling and decrease the total amount of drilling by a factor of 2-4 times. The tradeoff between data quality and data quantity is a moot point. In the present study it was decided that the overall goals of the project would be best attained by maximizing the number of holes st some sacrifice in the quality of the conductivity measurements.

HEAT FLOW

Heat flow data from 68 drill holes are listed in table 1 and the hole sites are shown on figures 2, 3 and 4. Included in table 1 and figure 2 are data from 15 holes previously reported by Bowen and others (1975), Sass and others (1976B) and Sass and Munroe (1973). Thirty-eight of the new heat flow measurements are from holes drilled specifically for heat flow information; 34 of these holes are in central Oregon (figure 2), 3 are in eastern Oregon (figure 4) and 1 is in northeastern Oregon (figure 3). The remainder of the new values are from water wells and mineral exploration holes.

The information from the various holes in table 1 are listed by township from north to south and for a particular township the holes are ordered by range from west to east. The heat flow values for central Oregon are discussed first and the remainder of the data are reviewed at the end of this section.

Twenty-five of the heat flow holes in central Oregon were drilled in the summer of 1975 and 9 were drilled in 1976. The objective of the drilling in 1975 was to utilize shallow wells so that a broad area and a variety of rock types could be tested as inexpensively as possible. A nominal drill hole depth of 61 m. (200 ft) was selected because of the relatively high geothermal gradients noted in previous studies (Bowen and others, 1975) and the low thermal conductivity anticipated for the various rock units in the area. Because of the scarcity of previous drilling in the study area, little subsurface geologic and hydrologic information were available prior to drilling except for the

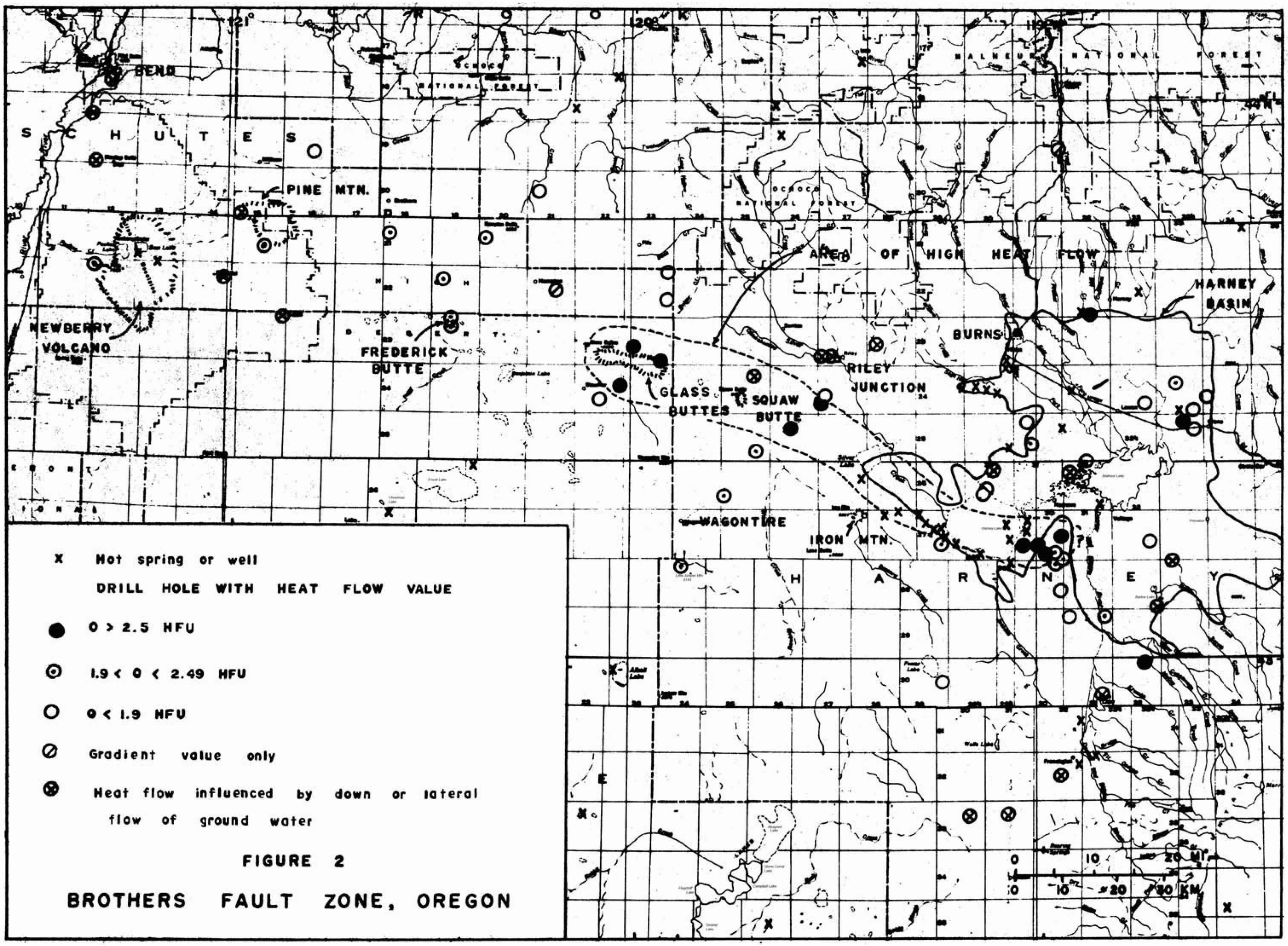


FIGURE 2

BROTHERS FAULT ZONE, OREGON

TABLE 1 - GEOTHERMAL DATA FROM BROTHERS FAULT ZONE, OREGON

1/ N represents the number of samples of drill cores or cuttings on which thermal conductivity determinations were made. Values in millicalories/cm. sec. °C.

2/ Values in parentheses are terrain corrected.

3/ The variable quality of the heat flow values is shown by an alphabetical symbol ranging from "A" (best) to "D" (poorest). The hole or section of hole marked by a D1 is affected by regional water flow, D2 by intra-bore hole water flow, D3 by possible lateral surface temperature variations, and D4 by an unknown disturbance.

4/ Values in parentheses are estimates based on lithology.

5/ Symbols in parentheses represent geologic map units of Walker and others (1967) and Greene and others (1972).

6/ Reported by Bowen (1975).

7/ Reported by Bowen and others (1977).

8/ Reported by Sass and others, (1976B), number in parentheses is well number used by author.

9/ Reported by Sass and Munroe (1973).

10/ Gradient values of lower reliability are enclosed in parentheses

Table 1. Geothermal data from Brothers fault zone, Oregon

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity		Gradient °C/km	Heat flow	Quality	Lithology
					N[1]	In-situ				
4S/28E-21DB	45°12.3'	119°20.1	1219	55-125	13	7.3	36.3 ± 0.6	2.6(1.9)[2]	A[3]	Trondjemite
18S/11E-25BD	43°59.4'	121°21.4'	1195	30-105			[10] (34.5) 3.2		D1	Basalt
				105-130			(-54.0) 68.4		D1	Basalt
18S/12E-5BC	44°02.8'	121°19.1'	1102	10-230			(2.6) 2.9		D1	Basalt
18S/45E-21CB	43°59.2'	117°13.3'	678	15-310		(2.8)	145.5 6.1	4.1	B	Siltstone, sandstone, basalt
19S/11E-25BA	43°54.4'	121°21.5'	1373	23-93			(5.3) 9.1		D4	Basalt (?)
				93-123			(38.3) 12.0		C	
19S/16E-16DC	43°54.9'	120°49.1'	1376	25-300		(3.6)[4]	51.1 8.1	1.8	B	Basalt (Tob)[5]
20S/14E/25AA	43°48.8'	120°59.4'	1428	20-45	2	4.4	52.0 5.2	<2.3	D4	Rhyolite & pumice (QTsv)
				45-125	4	4.4	34.4 1.0	<1.5	C	Rhyolite
20S/21E-7BA	43°51.4'	120°15.3'	1460	12.5-57.5	6	3.5	52.9 3.1	1.85	B	Basalt or andesite (Ta)

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N[1]	In-situ	Gradient °C/km		Heat Flow	Quality	Lithology
21S/11E-25BB	43°43.9'	121°21.7'	1515	10-27.5			30.7	± 3.5		D4	Obsidian and cinders
				27.5-35	2	3.6	65.3	4.3	2.4	C	Rhyolite
21S/15E-16AB	43°45.2'	120°56.2'	1476	20-70	5	4.4	30.8	4.3	< 1.4	D3?	Rhyolite, pumice & lithic tuff (QTsv)
				70-150	6	4.2	55.0	1.5	2.3	C	
21S/17E-1AD	43°47.0'	120°36.9'	1440	15-40	2	(1.7)	113.6	4.0	1.9		Rhyolite & rhyodacite (QTs
				40-90	4	(2.4)	82.5	3.1	2.0		
							Best value		2.0	B	
21S/19E-12D	43°45.9'	120°22.9'	1380	10-20	1	(2.4)	84.5	10.5	2.0		Rhyolite
				20-30	1	(4.6)	42.5	3.4	2.0		Basalt
				30-40		(2.4)	88.0	8.4	2.1		Sediments
				40-47.5	2	(1.6)	128.0	12.2	2.1		Pumiceous tuff
				47.5-60	1	(2.2)	88.4	8.8	1.9		Rhyolite tuff
							Best value		2.0	B	
21S/23E-26C	43°42.8'	119°55.8'	1340	12.5-60	3	3.6	42.4	1.2	1.5	B	Basalt (Tob)
22S/14E-3AC	43°41.9'	121°02.3'	1580	15-75			4.0	1.4		D1	Obsidian & scoria
22S/15E-35AD	43°37.6'	120°52.6'	1660	20-40			20.5	6.8		D1	Obsidian (QTsv), scoria & cinders

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N[1]/	Thermal Conductivity In-situ	Gradient °C/km	Heat Flow	Quality	Lithology
22S/19E-5CC	43°41.4'	120°28.7'	1450	10-27.5	3	(2.4)	75.7 ± 5.6	1.84		Basalt (QTb)
				27.5-35	1	(4.6)	49.3	2.25		
				35-37.5	1	(2.4)	84.0	1.98		
							Best value	2.0	B	
22S/19E-32AD	43°37.6'	120°27.4'	1520	10-15	1	(2.4)	96.	2.33		Basalt (QTb)
				15-37.5	2	(4.6)	39.6 1.9	1.81		Rhyodacite
				37.5-42.5	1	(2.4)	66.	1.56		"
				42.5-47.5	1	(1.6)	118	1.94		Pumice
							Best value	1.9	B	
22S/21E-9(?)[6]/				20-40	-	-	51.5	-		
22S/23E-14CB	43°39.6'	119°56.2	1290	12.5-17.5	4	2.4	61	1.5	D	Sandstone, siltstone (Tst
22S/32E-34CC	43°36.9'	118°52.6'	1260	0-95		(2.3)	(140)	3.2	C	Claystone
23S/19E-5B	43°37.0'	120°28.4'	1550	10-25	1	(2.4)	73.3 5.0	1.78		Basalt (Qtb)
				25-40	2	(4.6)	44.0 6.0	2.01		Rhyodacite
				40-45	1	(2.4)	82	1.94		"
				45-55	1	(1.6)	121	1.98		Pumice
				55-70	1	(2.2)	95.3 7.6	2.07		Rhyodacite
				70-150	1	(3.9)	50.9 1.2	1.99		Welded tuff
							Best value	2.0	A	

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N[1]	In-situ	Gradient °C/km	Heat Flow	Quality	Lithology
23S/23E-18C	43°34.3'	120°00.6'	1460	10-27.5	3	2.4	133.7 ± 7.6	3.2		Tuffaceous sediments (Tst
				27.5-35	1	(1.6)	185.3 18.2	3.0		Pumice
				35-62.5	3	2.4	133.1 1.9	3.2		Obsidian
							Best Value	3.1	A	
23S/23E-27[7]	43°32.3'	119°56.8'	1450	40-200		> 2.3	203.4 2.3	> 4.6	B	Rhyolite and obsidian
				200-220			43.2 1.3		D2	"
23S/26E-25AB	43°33.2'	119°32.8'	1300	10-30			88		D1	Alluvium (Qal)
				30-125			(33-76)		D1	
23S/27E-29BB	43°33.3'	119°31.0'	1300	10-115			(14-50)		D1	Alluvian (Qal)
23S/28E-18D	43°34.8'	119°24.3'	1370	10-42.5	4	4.8	27.1 2.2	1.3		Welded tuff (Tdo)
				42.5-60	1	4.6	33.3 1.0	1.5		" "
							Best value	1.4	B	
23S/46E-21BC	43°33.5'	117°06.6'	803	45-140	10	2.8	63.0 2.7	1.8	A	Claystone
24S/22E-2DD	43°30.5'	120°02.6'	1460	15-60	4	2.4	120.2 2.2	2.9	B	Tuffaceous sandstone

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N[1]	In-situ	Gradient °C/km		Heat Flow	Quality	
24S/22E-20AA	43°29.1'	120°05.8'	1390	10-20	3	2.7	32.5	± 4.7	0.9		Alluvium (Qp)
				20-32.5		(1.6)	114.8	4.8	1.8		Pumice
				32.5-60	3	2.6	73.1	4.6	1.9		Tuffaceous sand & silt
							Best value		1.9	A	
24S/25E-3BD	43°31.1'	119°42.9'	1450	15-42.5	7	2.4	104.0	10.2	2.5	B	Basalt & rhyolite
				42.5-60			9.7	5.2		D2	" "
24S/26E-13DC	43°29.0'	119°32.6'	1340	10-50	6	2.4	73.8	14.8	1.8		Basalt & tuffaceous sed.
				50-145	6	4.0	47.2	2.7	1.8		Welded tuff (Tdo)
							Best value		1.8		
24S/26E-24AC	43°28.5'	119°32.6'	1340	5-37.5	4	1.6	213.5	12.8	3.4		Pumiceous tuff (Trr)
				37.5-45		2.4	134.7	6.1	3.1		Tuffaceous sediments
				45-60	1	4.2	80.0	3.8	3.5		Welded tuff (Tdo)
							Best value		3.3	B	
24S/32½E-23DD	43°28.3'	118°43.9'	1256	75-150		(2.3)	60.9	7.4	1.4	B	Claystone
24S/33E-9D(S3)[8]	43°30'	118°39'	1255	40-203		2.1	82	±1	1.7		—

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N[1]	In-situ	Gradient °C/km	Heat Flow	Quality	Lithology
24S/33E-35AD	43°26.6	118°36.8'	1257	30-85		(2.3)	80.0 ± 7.1	1.8	C	-
24S/34E-19C(S2)[8]	43°28'	118°35'	1262	60-183		2.1	69.5 ±0.5	1.5		-
25S/25E-22B	43°23.5'	119°42.5'	1372	35-45			(50.0)			-
25S/26E-4CC	43°25.6'	119°37.0'	1360	12.5-25	3	4.0	57.6 7.8	2.3	D	Basalt (QTb)
25S/31E-4BB	43°26.2'	119°01.1'	1262	42.5-60	5	3.1	30.9 2.5	1.0	D3	Tuff, claystone, sandstone (Tst)
25S/31E-21D(S1)[8]	43°22'	119°02'	1266	50-190		2.1	81 ±1	1.7		-
25S/33E-3BD	43°25.9'	118°38.5'	1274	10-28.6	2	2.4	188.3 18.9	4.5	B	Tuffaceous sediment (Ts
25S/33E-11BB	43°25.2'	118°37.7'	1257	0-65		(2.3)	(60-70)	1.5	B	Sediments (Qs)

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N 1/	Thermal Conductivity In-situ	Gradient °C/km		Heat Flow	Quality	Lithology
25S/46E-18AA	43°23.6'	117°07.7	1127	10-150	10	3.3	52.5	± 2.6	1.7	A	Tuffaceous sandstone
26S/24E-24AD	43°18.3'	119°46.7'	1420	17.5-60	7	2.3	84.2	2.9	1.9	A	Tuffaceous sediments (Ts
26S/25E-20BB				17.5-22.5	2		20		0.8	D4	Sediments, cinders, basa
26S/30E-3BB	43°21.1'	119°07.0'	1273	7.5-30	8	2.4	47.6		1.1	D3	Tuffaceous claystone (Ts
26S/30E-19 (?) (V1) 9/	43°17.9'	119°09.8'	1250								-
26S/30E-20DB	43°17.7'	119°08.7'	1250	10-25	6	2.6	69.7	1.8	1.8	C	Sand & gravel (Qs)
26S/46E-28AB	43°16.6'	117°05.8'	1233	15-125	10	2.7	74.7	2.8	2.0	A	Tuffaceous sandstone
27S/29E-21AC	43°13.0'	119°14.8'	1400	12.5-45	13	3.9	54.2		2.1	B	Welded tuff (Tdo)
27S/30E-13DD 7/	43°13.2'	118°56.3'	1273	25-60 60-130		(2.3) (3.1)	130.4 61.6 Best value	2.5 1.4	3.0 (2.8) 1.9 (1.8) 2.5		Tuff, claystone, siltstone

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N[1]	In-situ	Gradient °C/km	Heat Flow	Quality	Lithology
27S/30E-19DC[7]	43°12.6'	119°02.2'	1250	46-108		(2.3)	131.3	3.0	B	Tuff, claystone, siltstone
27S/30E-21DD[7]	43°12.4'	118°59.9'	1289	10-35	9	3.1	223.2 ± 8.5	6.9	D	"
				35-110	19	2.3	132.8 1.0	3.1	A	
27S/30E-26DC[7]	43°11.5'	118°57.9	1340	10-57.2		(2.3)	117.9 1.4	2.7(3.0)	B	"
27S/30E-27AC[7]	43°11.9'	118°59.3'	1320	10-65		(2.3)	160.0 1.8	3.7	B	"
				65-70			55.0 2.9		D2	
27S/30E-36BA[5]	43°11.2'	118°57.0'	1258	10-45	4	2.6	73.1 1.3	1.9	B	"
27S/30E-36CC	43°10.6'	118°57.1'	1259	10-67.5	2	2.3	88.4 2.1	2.0	A	Tuffaceous setiments (Tst)
27S/32E-23BB	43°13.0'	118°42.2'	1330	30-95			52.8			
				95-140		(2.3)	74.4 2.1	1.7	B	
27S/33E-33CB	43°10.8'	118°39.6'	1282	10-30			(-1.3) 4.3		D1	Basalt (Qb)

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N[1]	In-situ	Gradient °C/km	Heat Flow	Quality	Lithology
28S/24E-4BA	43°11.1'	119°53.3'	1510	10-30	2	3.9	51.3 ± 6.3	2.0	C	Welded tuff (Tdo)
28S/30E-13DA	43°08.2'	118°56.3'	1265	20-25		(2.3)	82	1.9	C	Tuffaceous sediments (Tst)
28S/32E-36CC	43°05.3'	118°43.1'	1277	20-37.5 37.5-50	5	3.1	(39.4) 5.4 (2.4) 2.1	1.2	D2 D2	Basalt & sand Sand & clay
29S/31E-2B(MR-2)[8]	43°05'	118°51'	1260	57.9-62.5 89.3-92.0 60-100	4 4 8	2.37 2.19 2.28	65 ± 2 83 ± 3 74.2 ± 0.8 Best value	1.54 1.82 1.69 1.7		-
29S/32E-6B(MR-1)[8]	43°05'	118°49'	1262	40-91 or 56.4-64.	4 4	2.19 2.19	96.0 0.6 89. 1 Best value	2.10 1.95 2.0		-
29S/32E-34DC	43°00.1'	118°44.9'	1326	10-25 25-52	4 3	3.9 2.6	84.0 5.1 140.2 7.7 Best value	3.3 3.7 3.5	B	Welded tuff (Tdv) Sediments

Location	North Latitude	West Longitude	Elev. Meters	Depth Interval Meters	Thermal Conductivity N[1]	Thermal Conductivity In-situ	Gradient °C/km	±	Heat Flow	Quality	Lithology
30S/29E-15A(BLM)[8]	42°58'	119°15'	1530	61-107		2.2	78	± 2	1.7		-
30S/31E-23BC	42°57.2'	118°51.3'	1277	15-30	4	2.2	50.0	15.5	1.1	D4	Tuffaceous sediments (Tts)
32S/32E-16BA	42°48.3	118°57.6	1434	20-60	3	3.9	17.5	0.5	0.7	B	Basalt

Harney Basin. The relatively shallow hole depth was designed to develop data over a broad area although the extensive areal coverage desired required some sacrifice in data quality for individual holes.

In 1976 holes were drilled to a target depth of 152 m. (500 ft.) to verify heat flow values calculated from 1975 data and to increase confidence in results from an area at the west end of the Brothers fault zone not previously studied. These drilling strategies were only partly successful and drilling problems due to caving and groundwater conditions proved to be the practical limitation on hole depth in several areas. The deep static water level in the western portion of the study area (west of longitude 120°W) precluded measurement of temperature gradients below the water level.

Sixteen of the holes drilled in 1975 in central Oregon reached depths of 45 - 67.5 m. and useful gradient data were obtained from 14 of them. Of the remaining two holes, one was completed as a shallow water well (no. 28S/32E - 36CC) and the other (no. 25S/31E-4BB) resulted in ambiguous data. Five other holes were completed to depths in the range of 30 - 45 m. (98 - 148 ft.) and six were terminated at depths less than 30 m. (98 ft.) due to caving. Two of the holes to depths of 30- 45 m. (98 -148 ft.) gave useful data, two others had low but measurable gradients and one of the five provided no useful information. For holes less than 30 m. (98 ft.) deep, three gave useable data and one resulted in low gradients.

Seven of the holes drilled in central Oregon 1976 were bottomed at depths of 60 - 150 m. and all but one gave useful data. Two other holes were stopped at depths of less than 60 m. (197 ft.) due to excessively expensive drilling caused by caving and only one of them resulted in useful gradient information.

In summary, twenty-eight of the holes drilled in central Oregon during the study resulted in useful heat flow measurements with poor quality data being obtained from six other holes. In addition, heat flow information of variable quality was obtained for 14 water wells and mineral exploration holes.

Factors which helped to improve the data quality in the relatively shallow holes drilled in this study are the low topographic relief and lack of forest cover, thus holes could be sited in areas of low relief and undisturbed natural sagebrush vegetation. Terrain corrections have not been made for any of the holes listed in table 1 except 4S/28E-21DB. Corrections were made for several of the other holes with largest apparent corrections and none exceeded 5 percent. In view of the other uncertainties such an error is negligible.

The heat flow data in central Oregon are discussed by sub-area in sequence from west to east as holes were generally drilled along profiles spaced at 20 - 30 km. (12-19 mi.) east-west intervals and oriented north-northeast perpendicular to the strike of the Brothers fault zone. On each profile, holes were spaced at intervals of 5-20 km. (3-12 mi.).

In addition an attempt was made to locate at least one hole in or near several of the major silicic volcanic vent areas along the zone. The silicic centers were chosen because it was anticipated that they offered better drilling conditions than the more extensive basalt flows, previous work at Glass Buttes had suggested that geothermal anomalies might be associated with silicic vent areas (Bowen and others, 1977) and to evaluate geothermal energy potential associated with the systematic age progression of the silicic domes reported by Walker (1974). The goal of drilling in or near these silicic centers was only partly successful as road access to several of them was limited or non-existent. In addition, the subsurface extent of the silicic rocks is unpredictable and holes slightly "off-center" from the vents passed through interlayered basalt-rhyolite (or rhyodacite) sequences with repeated caving of the holes at the geologic contacts.

Newberry volcano area

Five holes were drilled and four water wells were logged for temperature data in the vicinity of Newberry volcano and the city of Bend although none of the holes and wells are on the volcano. Holes in the Newberry area are 18S/11E-25BD, 18S/12E-5BC, 19S/11E-25BA, 19S/16E-16DC, 20S/14E-25AA, 21S/11E-25BB, 21S/15E-16AB, 22S/14E-3AC and 22S/15E-35AD. Two holes in 18S/11E and 18S/12E have very irregular temperature-depth curves and it is not possible to determine a single uniform gradient for them. Hole 18S/11E-25BD has a gradient of 34.4°C/km in basalt between 30-105 m., however, the temperature decreases 1°C abruptly at that depth. The hole was later deepened for use as a water well and could not be relogged so the significance of the sharp reversal in gradient is not clear. Holes 19S/11E-25BA and 21S/11E-25BB showed gradients increasing with depth, of 38°C/km. at 93-123 m. in the former and 65°C/km. from 27.5-35 m. in the latter.

The estimated heat flow for 21S/11E-25BB is 2.4 HFU but the value is of low reliability because of the very shallow depth of the hole and the variable lithology consisting of interfingered basalt and rhyolite which causes a variable, but unknown porosity. The erratic gradients in all four of these holes on the west side of Newberry volcano are due at least in part to regional groundwater flow in the porous Quaternary basalts.

Four holes were drilled east of Newberry volcano in or near silicic volcanic centers at Pine Mountain, China Hat and Quartz Mountain. A fifth gradient was measured in a water well northeast of Pine Mountain (19S/16E-16DC). The holes at Pine Mountain (20S/14E-25AA and 21S/15E-16AB) were drilled to depths of 125 m. (410 ft.) and 152 m. (500 ft.) respectively. The former has a gradient decreasing with depth and averaging 34.4°C/km. in the deeper part of the hole resulting in a heat flow of 1.5 HFU. The latter hole has an average gradient of 55°C/km. although it increases with depth. It has a heat flow of 2.3 HFU, assuming a porosity of 0.05 for the rhyolite host rock. The silicic complex at Pine Mountain has been dated at approximately 21 million years (N. MacLeod, personal communication, March, 1977). These two heat flow values are not very similar and the gradient in both of the holes is curved although in opposite directions. The reason for this lack of agreement is not apparent.

Shallow holes at China Hat (22S/14E-3AC) and Quartz Butte (22S/15E-35AD) have very low gradients of 4°C/km. and 20.5°C/km. respectively. Both holes are in poorly consolidated volcanic rocks and the gradients may be affected by groundwater movement.

The best quality data in the Newberry volcano area is from a water well (19S/16E-16DC) in Pliocene basalt (Tob unit of Walker and others, 1967) with a gradient of 51.1°C/km. from 25-300 m. (82-904 ft.). The estimated thermal conductivity is 3.6 mcal/cm.sec.°C, based on samples from other holes in the same lithologic unit, resulting in a heat flow value of 1.8 HFU.

The data from the Newberry Volcano area show abundant evidence of moving groundwater as is typical of many young volcanic terrains where topographic relief combined with relatively high precipitation and subhorizontal layers of very permeable lava and ash result in rapid and copius groundwater flow. Typical conductive heat flow measurements can be made only below such flow where the rocks are more indurated by alteration and mineral deposition. Such depths may be deep or shallow depending on the pervasiveness of hydrothermal alteration. The relatively high heat flow at McKay Butte may represent an area of less groundwater influence on the subsurface temperature or some other effect. A deeper hole at this site would be very interesting.

Frederick Butte area

Five holes were drilled along a profile extending northeast from Frederick Butte, a rhyolite dome located in T. 22 S., R. 19 E. and a sixth hole was drilled about 15 km. west of the profile. Frederick Butte has a radiometric age of 3.9 million years (MacLeod and others, 1976). Holes 22S/19E-32AD and 23S/19E-5B were drilled at the northeast and south margins of Frederick Butte respectively. Holes 22S/19E-5CC and 21S/19E-12D were drilled in Pliocene sedimentary strata and volcanic units covered by a thin veneer of Pliocene-Pleistocene basalt. There was a poor return of drill cuttings from these holes and they were bottomed at depths 37.5 m. (123 ft.) for 5CC and 60 m. (197 ft.) for 12D because of the drilling problems. The northernmost hole on the profile (20S/21E-7BA) was drilled north of the Brothers fault zone to a depth of 57.5 m. (189 ft.) in altered andesite of the Clarno Formation of

Eocene and Oliogocene age. The sixth hole in the Frederick Butte area (21S/17E-1 AD) was drilled to a depth of 90 m. (295 ft.) in silicic volcanic rocks.

The four southern holes (22S/19E-32 AD, 23S/19E-5 B, 23 and 21S/19E-12 D) encountered basalt at a depth of about 25 m. (82 ft.) and pumice at 45-50 m. (148-164 ft.) in the holes that reached 50 m. depth. All four holes have a striking similarity in geothermal gradient and they appear to have penetrated similar lithologic units.

Heat flow values for the holes at the southern end of the profile on the northeast and south sides of Frederick Butte are 1.9 and 2.0 HFU respectively. Holes 22S/19E-5 CC and 21S/19E-12 D have values of 2.0 HFU. The northernmost hole on the profile, 20S/21E-7 BA, has a value of 1.85 HFU. A hole drilled west of the profile reached a depth of 90 m. (295 ft.) in silicic rocks. The gradient from 40-90 m. is 82.5°C/km. and the heat flow is 2.0 HFU.

Glass Buttes area

Five holes were drilled along a 30 km. (18 mi.) long profile oriented northeast through Glass Buttes. One of the holes (22S/23E- 14 CB) is only 17.5 m. deep due to drilling problems but the other four holes gave reliable heat flow values. Preliminary heat flow data for three of these holes (23S/23E-18 C, 24S/22E-2 DD and 24S/22E-20 AA) were discussed by Bowen and others (1977). An approximate heat flow value of 4.6 HFU was previously estimated for a water well (23S/23E-27) at Glass Buttes by Bowen and others (1977). Glass Buttes is a large silicic vent complex with an area in excess of 100 $km.^2$. Potassium-argon dating indicates an age of 4.9 million years for at least part of the complex (MacLeod and others, 1976). There is extensive hydrothermal alteration and low grade mercury mineralization associated with the silicic rocks (Brooks, 1963). A dipole-dipole electrical resistivity study at Glass Buttes revealed a broad area at depth with low apparent resistivity interpreted to be less than 5 ohm meters (Hull, 1976).

The northernmost heat flow hole along the Glass Buttes profile, number 21S/23E-26C, was drilled to a depth of 60 m. in Pliocene basalt. The gradient is 42.4°C/km. and the heat flow value is 1.5 HFU. The next hole to the south, number 22S/23E-14 CB is only 19 m. (62 ft.) deep and the heat flow is estimated to be 1.5 HFU.

Holes 23S/23E-18 C and 24S/22E-2 DD are located on the north and south flanks of Glass Buttes and have anomalously high heat flow values of 3.1 and 2.9 HFU respectively. The high heat flow values for these holes and water well 23S/23E-27 define a broad area of anomalous heat flow. The southernmost hole on this profile, number 24S/22E-20 AA, was drilled to a depth of 60 m. (197 ft.) in sediments, silicic volcanic rocks and basalt. The heat flow value is 1.9 HFU which is the same as the values at the south side of the fault zone farther west.

The geology, geophysics and thermal character of the Glass Buttes area are favorable for the occurrence of geothermal resources and more detailed exploration is justified.

Wagontire-Riley Junction area

Seven holes were drilled along a profile adjacent to U.S. Highway 395 between Wagontire and Riley Junction and an eighth hole was drilled

5 km. (3 mi.) north of Squaw Butte, a silicic dome with a radiometric age of 5.1 million years (MacLeod and others, 1976). Other silicic vent complexes in the area include Egli Ridge (6.4 million years) and Wagontire Mountain (14.7 million years). From north to south the holes are 23S/28E-18D, 24S/25E-3BD, 24S/26E-13DC, 24S/26E-24AC, 25S/26E-4CC, 26S/24E-24AD, 26S/25E-20BB and 28S/24E-4BA. In addition three water wells were logged along the profile, (23S/26E-25AB, 23S/27E-29BB and 25S/25E-22B).

The heat flow value for the northernmost hole, 23S/28E-18D, is 1.4 which is low for eastern Oregon. This hole was drilled to 61 m. (200 ft.) in poorly consolidated sediments and the welded tuff of Double-O Ranch (Greene and others, 1972). Progressing southward along the profile the next holes are water wells 23S/26E-25AB and 23S/27E-29BB, both of which show irregular non-linear gradients. The low heat flow value is hole 23S/28E-18D and the irregular gradients in these two water wells is probably due to lateral ground water flow in the area.

Holes 24S/26E-13DC and 24S/26E-24AC were drilled less than two kilometers apart at a point approximately 8 km. (5 mi.) southwest of Riley Junction. The holes penetrate the same lithology, silicic tuffs with a variable degree of welding, but they have very different gradients and heat flow values. The heat flow values are 1.8 for 24S/26E-13DC and 3.3 for 24S/26E-24AC.

The average geothermal gradient for hole 25S/26E-4CC is 57.6°C/km. while the gradient for water well 25S/25E-22B is 50°C/km. We lack lithologic information on the latter and the former has an erratic gradient and is only 25 m. (82 ft.) deep, hence heat flow values are of poor quality. Drilling in hole 26S/25E-20 BD was stopped at 22.5 m. (73 ft.) due to loss of circulation and no useful data were obtained.

At the southern end of the profile in the vicinity of Wagontire holes 26S/24E-24 AD and 28S/24E- 4 BA were drilled to depths of 60 m. (197 ft.) and 30 m. (98 ft.) respectively. The former is in silicic tuff and obsidian with a heat flow of 1.9 HFU and the latter is in welded ash flow tuff with a heat flow of 2.0 HFU.

Hole no. 24S/25E- 3 BD, north of Squaw Butte, lies between the Glass Buttes and Wagontire-Riley Junction profiles. The 60 m. (197 ft.) deep hole encountered a sequence of basalt and silicic volcanic rocks. It has a gradient of 104°C/km. above 42.5 m. depth and a very low gradient of 9.7°C/km. from 42.5-60 meters. The erratic gradient may be due to shallow groundwater conditions and a reliable heat flow cannot be calculated.

Harney Basin area

Harney Basin is a broad area of internal surface drainage and low relief characterized by a shallow static water level and unconsolidated to poorly consolidated sediments. The Brothers fault zone passes tangentially across the south end of Harney Basin and may terminate at the Steens Mountain approximately 60 km. (37 mi.) southeast of Harney Lake. There are numerous hot springs in the area and previous heat flow investigations revealed a broad range of geothermal gradient values (Sass, and others, 1976B and Bowen and others, 1977).

During the present study eleven shallow holes were drilled in Harney Basin. Four of these were along a northeast trending profile in the west side of the Basin, six were along a parallel profile on the east side of the Basin and the remaining hole was drilled between these profiles near Coyote Buttes.

The holes along the western profile, which passed near Double-O Ranch, are 25S/31E-4 BB, 26S/30E-3 BB, 26S/30E-20 DB and 27S/29E-21 AC. The first three holes were drilled in unconsolidated fluvial and lacustrine sediments and poorly consolidated claystone, siltstone and sandstone. In hole 25S/31E-4 BB the gradient increases erratically with depth from -10 to 30°C/km. and no reliable gradient was obtained. Holes 26S/30E-3 BB and 26S/30E-20 DB were terminated at shallow depth due to caving and the gradients are of poor quality. Sass and others (1976B) reported heat flow values of 1.8 HFU for two 150 m. deep holes in this portion of Harney Basin. A heat flow of 2.1 HFU was obtained from hole 27S/29E-21 AC drilled in the Double-O welded tuff although there is some uncertainty in the thermal conductivity value for this tuff due to the variable degree of welding and our lack of knowledge of the resulting porosity variation.

The eastern profile of heat flow holes passes through Diamond Craters, a Holocene basalt extrusive center characterized by numerous maars and craters. The six holes along this profile are 25S/33E-3 BD, 27S/33E-33 CB, 28S/32E-36 CC, 29S/32E-34 DC, 30S/31E-23 BC and 32S/32E-16 BA.

The northernmost hole on the profile, number 25S/33E-3 BD was drilled 1 km. south of Crane hot springs to 29 m. (95 ft.) in poorly consolidated sedimentary strata. The high heat flow of 4.5 HFU may be related to the hot spring but details of the hydrology are not known. Two water wells near the hot spring, 24S/33E-35 AD and 25S/33E-11 BB, with depths of 85 m.

(279 ft.) and 65 m. (213 ft.) respectively, have estimated heat flow values of 1.8 and 1.5 HFU. Sass and others (1976B) report heat flow values for nearby water wells of 1.5 and 1.7. The thermal conductivity values used by Sass and others (1976B) appear to be slightly lower than we obtained and we estimate the heat flows to be closer to 1.6 and 1.9 HFU units for these wells located at 24S/34E-19C and 24S/33E-9D respectively.

Hole 27S/33E-33CB was terminated at a depth of 30 m. (98 ft.) in vesicular basalt above the static water level. The gradient is close to zero suggesting the influence of shallow groundwater on heat flow. A 140 m. deep water well 10 km. to the west, number 27S/32E-23BB, has an estimated heat flow value of 1.7 HFU. Hole 28S/32E-36CC near Diamond Craters encountered a substantial influx of groundwater and it was completed as a water well by the landowner, thus precluding measurement of a reliable geothermal gradient.

Hole 29S/32E-34DC has a distinctly anomalous heat flow of 3.5 HFU in an area without known hot springs. The hole was drilled to 52 m. (171 ft.) in welded tuff underlain by poorly consolidated sedimentary strata. The source of the heat flow anomaly is not known.

The southernmost holes on the Diamond Craters profile have low heat flow values. Hole 30S/31E-23BC is 31 m. (102 ft.) deep and has a very irregular but low gradient. Hole 32S/32E-16BA was drilled in Catlow Valley in basalt to 60 m. (197 ft.) and it has a very linear but low gradient of 17.5°C/km. resulting in an anomalously low heat flow of 0.7 HFU. Sass and others (1976) report heat flow values for 5 holes farther south in Catlow Valley, averaging 1.3 HFU with a maximum of 1.5 HFU.

The low values in holes 30S/31E-23BC and 32S/32E-16BA may be due to lateral transport of heat by groundwater moving in a large aquifer system.

A single hole (27S/30E-36CC) was drilled near Coyotte Buttes, between the Double-O Ranch and Diamond Craters profiles to verify the anomalous heat flow in an area of previously reported high temperature gradients (Bowen and others, 1975). The hole was drilled to a depth of 67.5 m. (221 ft.) in claystone and sandstone. The gradient is 88.4°C/km. resulting in a heat flow for these relatively porous, low conductivity rocks of 2.0 HFU as previously reported by Bowen and others (1977).

The geothermal gradients and heat flow values are shown in table 1 and a map summarizing the heat flow data is included as figure 2. Included are heat flow values by Sass and others (1976B), which have been increased approximately 10 percent to make them more comparable with the values calculated during the present study. Sass and others (1976B) used a thermal conductivity value for the sedimentary units of 2.1 mcal./cm. sec.°C whereas we used a value of 2.3 mcal./cm. sec. °C in our calculations. The higher conductivity value is also more consistent with measured values for their hole near Diamond Craters (29S/31E-2B).

Black Mountain area

In order to obtain a reliable heat flow value in pre-Tertiary rocks north of the Brothers fault zone, the final hole was drilled in the Blue Mountains in a trondjemite stock of Mesozoic age. The hole is located west of Black Mountain in Morrow County, Oregon (figure 3).

The hole was drilled to a depth of 248 m. (815 ft.) but a failure in the observation pipe limits gradient measurement to the interval above 130 m. (427 ft.). The uncorrected gradient is linear and has a value of 36°C/km. Due to the relatively high thermal conductivity of quartz-rich host rock, the terrain-corrected heat flow is 1.9 HFU.

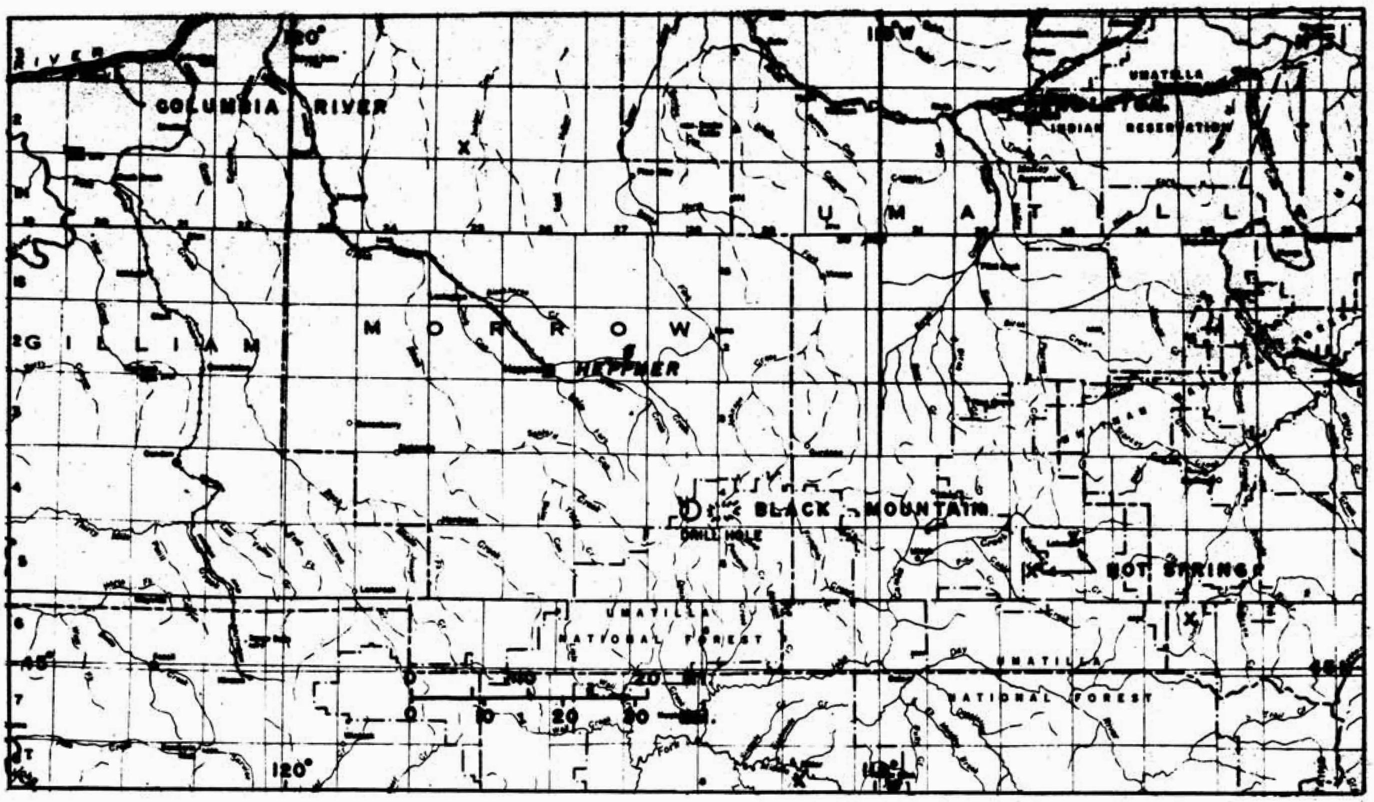


Figure 3 - Heat flow hole, Black Mountain, Morrow County, Oregon

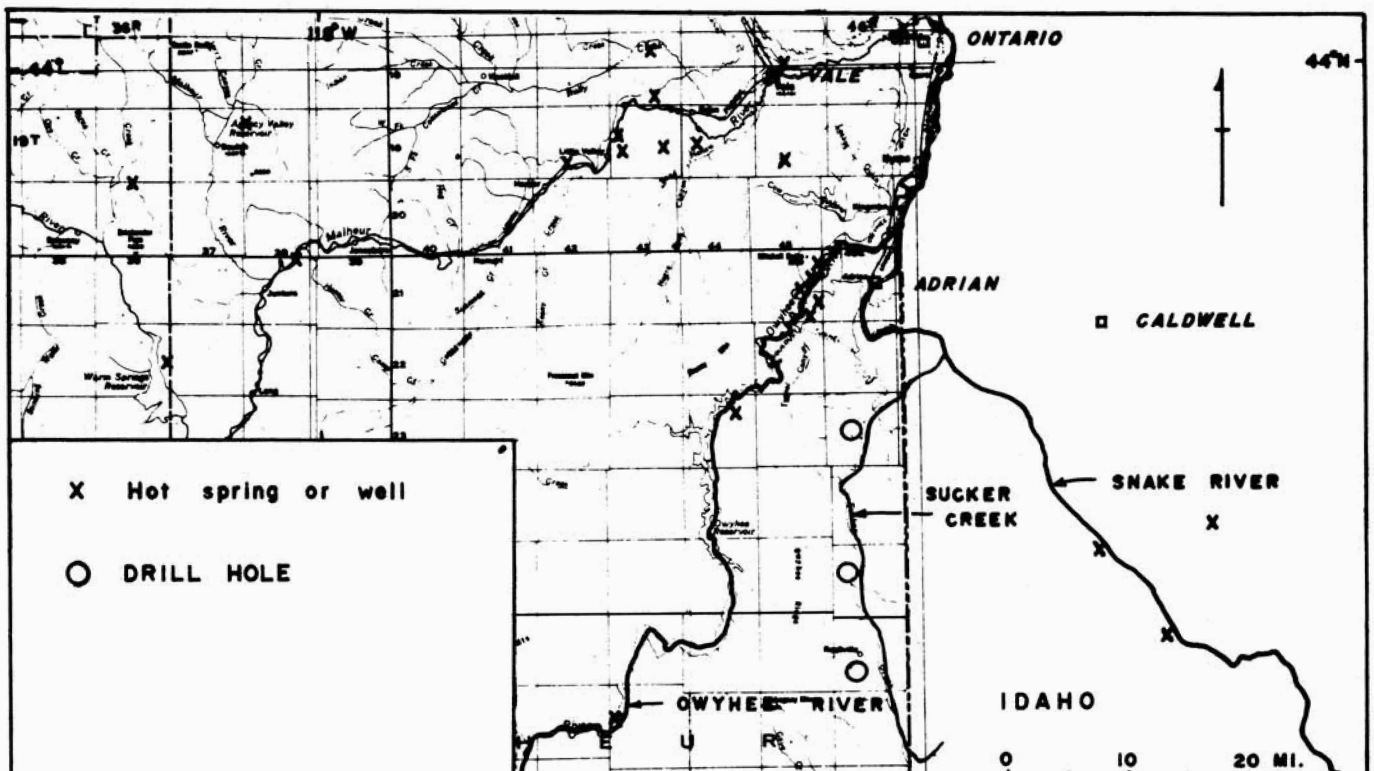


Figure 4 - Heat flow holes, Sucker Creek, Harney County, Oregon

Sucker Creek area

The Brothers fault zone is the locus of several centers of basaltic volcanism of Pleistocene and Holocene age, between the Cascade Range on the west and Diamond Craters in Harney Basin on the east. Although the structural lineament continues southeast from Harney Basin to Steens Mountain, the trend of young mafic volcanic centers diverges and extends eastward to Jordan Craters and projects towards the Snake River Plain in Idaho. A heat flow map of the United States by Sass and others (1976A) shows the western edge of the Battle Mountain High, an area of heat flow in excess of 2.5 HFU, extending into Oregon in the vicinity of the Sucker Creek area. In order to extend the data collected along the Brothers fault zone, test this young volcanic trend, and investigate the northwestern limits of the Battle Mountain High, three holes were drilled in a north-south profile along Sucker Creek adjacent to the eastern border of Oregon between the towns of Adrian on the north and Jordan Valley on the south (figure 4).

The holes were drilled mainly in claystone, siltstone and sandstone of the Sucker Creek Formation of Miocene age. From north to south the hole numbers are 23S/46E-21BC, 25S/46E-18AA and 26S/46E-28AB with depths of 140 m. (460 ft.), 150 m. (492 ft.) and 125 m. (410 ft.) respectively. The northernmost hole, 23S/46E-21BC has a gradient of 63.0^{o}C/km. and a heat flow of 1.8 HFU. Hole number 25S/46E-18AA has a gradient of 52.5^{o}C/km. and a heat flow of 1.7 and the southernmost hole, 26S/46E-28AB has gradient and heat flow values of 74.7^{o}C/km. and 2.0 HFU. The heat flow in all three holes is significantly lower than in the Battle Mountain High to the east and also lower than many values in the Vale area, which lies just north of the Sucker Creek area (figure 4), where earlier work by Bowen and others (1977) revealed anomlously high heat flow.

DISCUSSION

Heat flow along the Brothers fault zone is characterized by a wide range of values. The values presented herein are based on relatively shallow holes drilled in variable lithologies. The hydrology of the western one-half of the study area is poorly known and holes drilled in this area were bottomed above the static water level. In contrast, in the eastern one-half of the area the static water level generally lies at depths of 0-50 m. (0-164 ft.) beneath the surface. Movement of shallow groundwater has influenced the natural heat flow along the zone in some cases so severely that calculation of conductive heat flow is not possible.

The holes at the western end of the Brothers fault zone appear to be markedly influenced by regional groundwater movement and conductive heat flow probably cannot be measured in basalt under these conditions in holes less than 300 m. (1000 ft.) deep in the vicinity of Newberry volcano and the city of Bend. Better quality data were obtained in holes in silicic volcanic rocks at Pine Mountain although the gradient in hole 20S/14E-25AA drilled to a depth of 125 m. (410 ft.) appears to show the effect of moving groundwater.

The crustal heat flow measured in holes along profiles between Pine Mountain and Riley Junction appears to be higher in the fault zone than in the area north of the fault zone. The average of the four most reliable values north of but near the zone is 1.6 HFU while the values in the fault zone are 1.9 HFU or greater, ie., an increase of about 15 percent.

There are few published heat flow values for central Oregon north of the Brothers fault zone other than the values obtained in this study.

Bowen and others (1977) describe values from four holes in basalt of the Columbia River Group near Arlington ranging from 1.0 to 2.1 HFU with an average of 1.4 HFU. They also give an estimated heat flow value of 1.4 HFU for a well near Dufur, Oregon (1S/13E-20DA) in basalt of the Columbia River Group and a value of 2.0 HFU for a well near John Day (13S/31E-27DD) in serpentinite of pre-Late Triassic age. Observed heat flow for holes in south-central Washington in basalt of the Columbia River Group ranges from 1.36 to 1.52 HFU (Sass and others, 1971A). The most reliable single heat flow value measured in Oregon north of the Brothers fault zone is in a hole, near Black Mountain in Morrow County, described below, with a value of 1.9 HFU.

Published heat flow values for the Basin and Range province in Oregon south of the Brothers fault zone exhibit a wide range and many values appear to be influenced by groundwater movement (Sass and others, 1976B). A compilation of the more reliable values by Diment and others (1975) indicates that observed heat flow in central Oregon south of the Brothers fault zone ranges from 1.5 to greater than 3.0 HFU. A compilation of 24 heat flow values by Bowen and others (1977) for southeastern Oregon, including values from the Brothers fault zone but not from the Snake River Basin, revealed an arithmetic mean of 2.64 HFU although many of the values are from shallow holes and due to the relatively small sample population this "average" value cannot be considered to be firmly established.

The only extensive heat flow anomaly measured in the western one-half of the Brothers fault zone during the present study is at Glass Buttes where three holes outline a broad area with values at least 50 percent above the regional average. The source of the anomalous heat flow at Glass Buttes is uncertain. The radiometric age of 4.9 million years, if representative of the volcanic event which produced the entire silicic complex, may be too old to explain the heat flow anomaly. Calculations by Smith and Shaw (1975) indicate that most, if not all, of the original heat associated with the silicic volcanism would have been lost. There are uncertainties in the assumptions underlying this calculation, especially in the subsurface volume of the original magma, hence an igneous intrusive with residual magmatic heat cannot be eliminated as a possible causative body for the heat flow anomaly.

There are three higher than average heat flow values on the Wagontire-Riley Junction profile and it is possible to outline these values, the anomalously high values at Glass Buttes and the Coyotte Buttes anomaly by an area elongated in a northwest-southeast direction parallel to the Brothers fault zone (figure 2). This area includes the string of hot springs west of Harney Lake and Iron Mountain, a silicic dome located 21 km. (13 mi.) west of Harney Lake and dated at 2.7 million years (Parker, 1974). The connection of all of these areas into a single zone of high heat flow is plausible, but speculative. This band of high heat flow, if it exists, may be related to the volcanism along the Brothers fault zone, and/or to crustal disruption and possible thinning associated with the faulting.

In Harney Basin the background heat flow value is about 1.7 ± 0.2 HFU, however, there are several areas with anomalously high heat flow values exceeding 2.5 HFU including the Coyotte Buttes area, Crane hot springs area, and the area represented by hole 29S/32E-34DC south of Diamond Craters.

Additional evidence for anomalous heat flow is provided by the numerous hot springs and wells in Harney Basin (Bowen and Peterson, 1970 and Leonard, 1970). Estimated reservoir temperature based on geochemical geothermometers have been determined for many of the springs and are listed in table 2. Most of the silica geothermometer temperatures are in the range of 110-140°C (based on equilibrium with quartz) while the temperatures based on the sodium-potassium-calcium geothermometer exhibit more scatter and range up to 170°C. The distribution of hot springs and wells suggests that the areas of high heat flow may be larger than presently known. For example, an extensive group of hot springs extends 30 km. (19 mi.) to the west from the Coyotte Buttes heat flow anomaly and there are numerous warm wells along the northern side of Harney Basin near the towns of Hines and Burns.

The depth to the hot aquifer or aquifers is not known with certainty. The geothermal gradient associated with the background heat flow is approximately 75°C/km. while the gradients in the areas of high heat flow are in the range of 100-150°C/km.; thus the extrapolation of the gradients to depths of 1.5 and 1.0 km. respectively would result in temperatures consistent with these estimated from geochemical thermometers. It is likely, however, that the thermal conductivity of the rocks in the basin decreases with increasing depth because of lithologic changes and loss of porosity due to compactions and cementation. The near surface poorly consolidated sedimentary strata are likely underlain by volcanic rocks with the latter having a higher average conductivity than the former. For these reasons the geothermal gradients measured in relatively shallow holes will likely

Table 2

Geothermal gradient calculations and geochemical temperatures for wells in Harney Basin. The chemical data are from Leonard (1970) except as noted. Geochemical temperatures are calculated from formulas given by Truesdell (1975).

Well location	Depth, Meters	Measured Temperature °C	Gradient °C/km. (estimated)*	Estimated SiO_2 (Adiabatic) Temp. °C.	Reservoir SiO_2 (Conductive) Temp. °C.	Temperature NaCaK Temp. °C
22S/30E-27 DDC	38.7	14	78	108	106	66
22S/31E-34 AAA	221.0	14	14	111	111	58
22S/32E-34 AAA1	304.8	72	200	128	131	104
22S/32½E-30 CDB	197.2	--	--	112	111	62
22S/32½E-36 AAB	55.5	14	54	113	113	78
23S/30E-23 CDA	105.2	17	57	111	111	82
23S/30E-35 AAD	61.0	25	230	108	106	70
23S/30E-35 DDD	--	22	--	100	98	70
23S/31E- 5 AAC	121.9	11	0	110	109	46
23S/31E-24 AAC	34.8	11	0	95	92	59
23S/32E- 7 CAB	28.4	11	-	105	103	51
23S/32E-28 ACD	76.2	16	66	105	104	137
24S/30E- 1 ABD	171.9	27	93	100	98	64
24S/32E- 5 AAD	82.3	13	24	99	96	140
24S/32E- 8 DAB	857.1	46	41	119	120	105
24S/32½E-13 ACB	73.8	14	41	106	105	168
24S/32½E-22 BCC	--	12	--	106	105	95
24S/32½E-30 ADD	56.4	14	53	111	111	169
24S/33E-24 AAC	103.7	--	--	111	111	145
24S/33E-34 CCA**	--	80	--	124	125	121
24S/34E-31 BAC	277.0	12	4	106	105	41
24S/34E-31 DDA	92.0	12	11	106	105	41
25S/32E- 7 BAB	410.0	41	73	107	106	120
25S/32E-24 BDB	18.3	11	--	95	92	152
25S/32E-35 BDB	121.9	--	--	119	120	161
25S/32½E-25AAB	--	12	--	105	104	145
27S/29½E-36##	--	68	--	129#	132#	130#

* Geothermal gradient estimated from aquifer temperature and hole depth given by Leonard (1970) based on assumed mean annual surface temperature of °C.

** Crane Hot Spring

\# Temperature from Mariner et al. (1974)

\## Unnamed hot spring near Harney Lake

decrease with depth so that the reservoir temperatures estimated from geochemical data will be encountered at depths perhaps 30-40 percent greater than the 1.5 and 1.0 km. estimated from the shallow gradient data for areas of normal and high heat flow respectively. A gradient of 45°C/km. measured below 1 km. (3281 ft.) was reported by Sass and Munroe (1973).

In summary, there is widespread evidence in Harney Basin of the existence of hot water in the range of 110-170°C which would be suitable for non-electric energy applications. The nature of the heat source is not known. The youngest silicic domes near the basin appear to be about 8 million years old (MacLeod, 1976) although extensive ash-flow tuff peripheral to Harney Basin has an age of 6.4 million years and there is widespread basaltic volcanism of Holocene and Pleistocene age. There is no evidence in the published geochemical data for the very high temperatures (greater than 200°C) that would be needed for economical electric power generation using existing conversion technology. The meager existing data do not permit definitive conclusions, however, in regard to the nature and reservoir temperature of the geothermal resource in Harney Basin and further geological and geophysical studies are needed.

MacLeod and others (1976) have described an east to west progression in the age of silicic volcanism along the Brothers fault zone and a broad area to the south. The silicic volcanism began about 9 million years ago in Harney Basin and progressed westward at a rate of 1-3 cm./year to its present location at Newberry volcano. The lack of heat flow anomalies associated with most of the younger silicic volcanic centers west of Glass Buttes may be due to one or more of the following factors. The relatively shallow depth of the holes drilled in and near the younger silicic complexes may preclude the accurate detection of residual magmatic heat as a significant groundwater gradient may act to sweep heat out of the areas drilled. Alternatively the areal extent of the silicic domes at the surface may exceed their subsurface area; drilling at McKay Butte west of Newberry volcano indicated that at least some of the domes may be "mushroom" shaped. If the subsurface area of these bodies is significantly less than their surface area, they may have cooled quickly and lack residual heat even though they are only 0.7-3 million years old. Unfortunately the quantitative data on subsurface size are lacking and therefore accurate calculations re their residual heat content are not possible. It is entirely possible that the heat source for the thermal manifestations in Harney Basin and for the higher than average heat flow in the area between Glass Buttes and Harney Basin as outlined in figure 2, may be related to the Pliocene to Holocene basalt volcanism rather than silicic volcanism or alternatively the source of heat could be deep groundwater circulation associated with the fault zone without any direct heat contribution from the volcanic rocks.

In summary there is no discernible systematic pattern of changing heat flow from east to west parallel to the progressive age migration of silicic volcanism. There is a measureable increase in heat flow in the Brothers fault zone as compared to the area north of the zone. This increase coincides with, and may reflect a major change in, crustal structure associated with the fault zone. Lawrence (1970) has noted that the Brothers fault zone is the northern terminus of the Basin and Range province in central Oregon and it appears that this zone marks the thermal as well as tectonic boundary of the province.

There are three areas along and near the Brothers fault zone that are especially promising for geothermal resource development: (1) Harney Basin, (2) Glass Buttes, and (3) Newberry volcano (the last based on geological considerations). It is possible that the area of high heat flow noted at Glass Buttes may extend eastward at least as far as Coyotte Buttes. The geothermal resource in Harney Basin appears to be best suited to non-electric applications. Geochemical data on hot waters are lacking for the Glass Buttes area and no estimate of subsurface reservoir temperature is possible. There are no known hot springs in the Glass Buttes area. The discovery of a geothermal anomaly at Glass Buttes was serendipitous and resulted from drilling of a water well. Similarly, there are no known hot springs along the Brothers fault zone between Glass Buttes and Pine Mountain and it is entirely possible that "blind" geothermal resources are present in the western half of the zone. The west end of the fault zone and Newberry volcano are geologically promising areas for geothermal resources but the reliable measurement of heat flow in holes less than 152 m. (500 ft.) deep in silicic rocks is not possible due to groundwater conditions. Holes in basalt will need to be at least 300 m. (1000 ft.) deep.

REFERENCES

Bowen, Richard G., Blackwell, David D., and Hull, Donald A., 1977, Geothermal exploration studies in Oregon: Oregon Dept. of Geology and Mineral Industries Geothermal report 1, in press.

Bowen, Richard G., Blackwell, David D., Hull, Donald A., and Peterson, Norman V., 1976, Progress report on heat-flow study of the Brothers fault zone, central Oregon: Oregon Dept. of Geology and Mineral Industries, Ore Bin, v. 38, no. 3, p. 39-46.

Bowen, Richard G., 1975, Geothermal gradient data: Oregon Dept. of Geology and Mineral Industries open-file report 0-75-3, 114 p.

Bowen, Richard G., Blackwell, David D., and Hull, Donald A., 1975, Geothermal studies and exploration in Oregon: Oregon Dept. of Geology and Mineral Industries open-file report 0-75-7, 65 p.

Bowen, Richard G., and Peterson, Norman V., 1970, Thermal springs and wells in Oregon: Oregon Dept. of Geology and Mineral Industries Misc. Paper no. 14.

Brooks, Howard C., 1963, Quicksilver in Oregon: Oregon Dept. of Geology and Mineral Industries Bull. 55, 223 p.

Brott, Charles A., Blackwell, David D., and Mitchell, John A., 1977, Tectonic implications of the heat flow of the western Snake River Plain, Idaho: paper submitted for publication in Bulletin of the Geological Society of America.

Couch, Richard W., and Lowell, Robert P., 1971, Earthquakes and seismic energy release in Oregon: Oregon Dept. of Geology and Mineral Industries, Ore Bin, v. 33, no. 4, p. 61-84.

Diment, W.H., Urban, T.C., Sass, J.H., Marshall, B.V., Munroe, R.J., and Lachenbruch, A.H., 1975, Temperatures and heat contents based on conductive transport of heat: p. 84-103 in White, D.F. and Williams, D.L., ed., Assessment of Geothermal resources of the United States: U.S. Geol. Survey Circ. 726, 155 p.

Greene, Robert C., Walker, George W., and Corcoran, Raymond E., 1972, Geologic map of the Burns quadrangle, Oregon: U.S. Geol. Survey Map I-680.

Groh, Edward A., 1966, Geothermal energy potential in Oregon: Oregon Dept. of Geology and Mineral Industries, Ore Bin, v. 28, no. 7, p. 125-135.

Hull, Donald A., 1976, Electrical resistivity survey and evaluation of the Glass Buttes geothermal anomaly: Oregon Dept. of Geology and Mineral Industries open-file report O-76-1, 11 p.

Lawrence, Robert D., 1976, Strike-slip faulting terminates the Basin and Range province in Oregon: Geol. Soc. America Bull., v. 87, no. 6, p. 846-850.

Leonard, A.R., 1970, Groundwater resources in Harney Valley, Harney County, Oregon: Oregon State Engineer Ground Water Report 16, 85 p.

MacLeod, Norman S., Walker, George W., and McKee, Edwin H., 1976, Geothermal significance of eastward increase in age of upper Cenozoic rhyolitic domes in southeastern Oregon: p. 465-474 in Proceedings Second U.N. Symposium on the Development and Use of Geothermal Resources, v. 1, 844 p.

Mariner, R.H., Rapp, J.B., Willey, L.M., and Presser, T.S., 1974, The chemical composition and estimated minimum thermal reservoir temperatures of selected hot springs in Oregon: U.S. Geol. Survey open-file report, 27 p.

Parker, Donald J., 1974, Petrology of selected volcanic rocks of the Harney Basin, Oregon, Oregon State Univ.: PhD dissertation, 119 p.

Peterson, Norman V., Groh, Edward A., Taylor, Edward M., and Stensland, Donald E., 1976, Geology and mineral resources of Deschutes County, Oregon: Oregon Dept. of Geology and Mineral Industries Bulletin 89, 66 p.

Piper, A.M., Robinson, T.W., and Park, C.F., Jr., 1939, Geology and ground-water resources of the Harney Basin, Oregon: U.S. Geol. Survey Water-Supply Paper 841, 189 p.

Roy, R.F., Decker, E.R., Blackwell, D.D., and Birch F., 1968, Heat flow in the United States: Jour. Geophys. Research, v. 73, no. 16, p. 5207-5221.

Sass, J.H., Diment, W.H., Lachenbruch, A.H., Marshall, B.V., Munroe, R.J., Moses, T.H., Jr., and Urban, T.D., 1976A, A new heat-flow contour map of the conterminous United States: U.S. Geol. Survey open-file report 76-756, 24 p.

Sass, J.H., Galanis, S.P., Jr., Munroe, R.J., and Urban, T.C., 1976B, Heat-flow data from southeastern Oregon: U.S. Geol. Survey open-file report 76-217, 52 p.

Sass, J.H., and Munroe, Robert J., 1973, Temperature gradients in Harney County, Oregon: U.S. Geol. Survey open-file report, 3 p.

Sass, J.H., Lachenbruch, A.H., Munroe, R.J., Green, G.W., and Moses, T.H., Jr., 1971A, Heat-flow in the western United States, J. Geophys. Research, v. 76, p. 6376-6413.

Sass, J.H. Lachenbruch, A.H., and Munroe, R.J., 1971B, Thermal conductivity of rocks from measurements on fragments and its application to heat-flow determinations: J. Geophys. Research, v. 76, p. 3391-3401.

Smith, R.L., and Shaw, H.R., 1975, Igneous-related geothermal systems: p. 58-83 in White, D.F., and Williams, D.L., ed., Assessment of Geothermal Resources of the United States - 1975, U.S. Geol. Survey Circ. 726, 155 p.

Stewart, J.H., Walker, George W., and Kleinhampl, F.J., 1975, Oregon-Nevada lineament: Geology, v. 3, no. 5, p. 265-268.

Trauger, F.D., 1950, Basic ground-water data in Lake County, Oregon: U.S. Geol. Survey open-file report, 287 p.

Truesdell, A.H., 1976, Summary of section III, geochemical techniques in exploration: Proceedings second U.N. symposium on the development and use of geothermal resources, v. 1, p. lili-lxxix.

Walker, George W., 1974, Some implications of late Cenozoic volcanism to geothermal potential in the High Lava Plains of south-central Oregon: Oregon Dept. of Geology and Mineral Industries, Ore Bin, v. 36, no. 7, p. 109-119.

Walker, George W., 1969, Geology of the High Lava Plains province: p. 77-79 in Mineral and water resources of Oregon: Oregon Dept. of Geology and Mineral Industries Bull. 64, 462 p.

Walker, George W., Peterson, Norman V., and Greene, Robert C., 1967, Reconnaissance geologic map of the east half of the Crescent quadrangle, Lake, Deschutes, and Crook Counties, Oregon: U.S. Geol. Survey Map I-493.

APPENDIX A

GEOTHERMAL GRADIENT TABLES

LOCATION: MORROW COUNTY, OREGON
HOLE NUMBER: 4S/28E-21DB
DATE MEASURED: 2/15/1976

DEPTH, METERS	DEPTH, FEET	TEMPERATURE DEG. C	DEG. F	GEOTHERMAL GRADIENT DEG. C/KM.	DEG. F/100 FT.
15.0	49.2	9.15	48.47	.0	.0
20.0	65.6	9.13	48.43	-4.0	-0.22
25.0	82.0	9.15	48.47	4.0	0.22
30.0	98.4	9.20	48.56	10.0	0.56
35.0	114.8	9.28	48.70	16.0	0.90
40.0	131.2	9.36	48.85	16.0	0.90
45.0	147.6	9.48	49.06	24.0	1.35
50.0	164.0	9.60	49.28	24.0	1.35
55.0	180.4	9.73	49.51	26.0	1.46
60.0	196.8	9.89	49.80	32.0	1.80
65.0	213.2	10.09	50.16	40.0	2.24
70.0	229.6	10.27	50.49	36.0	2.02
75.0	246.0	10.44	50.79	34.0	1.91
80.0	262.4	10.61	51.10	34.0	1.91
85.0	278.8	10.79	51.42	36.0	2.02
90.0	295.2	10.98	51.76	38.0	2.13
95.0	311.6	11.16	52.09	36.0	2.02
100.0	328.0	11.35	52.43	38.0	2.13
105.0	344.4	11.53	52.75	36.0	2.02
110.0	360.8	11.71	53.07	36.0	2.02
115.0	377.3	11.90	53.42	38.0	2.13
120.0	393.6	12.09	53.76	38.0	2.13
125.0	410.0	12.27	54.09	36.0	2.02

LOCATION: DESCHUTES CO, OREGON
PWL
HOLE NUMBER: 18S 11E 25BD
DATE MEASURED: 6/03/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
10.0	32.8	8.240	46.83	.0	.0
12.5	41.0	8.320	46.98	32.0	1.8
15.0	49.2	8.410	47.14	36.0	2.0
17.5	57.4	8.410	47.14	.0	.0
20.0	65.6	8.440	47.19	12.0	.7
22.5	73.8	8.470	47.25	12.0	.7
25.0	82.0	8.450	47.21	-8.0	-.4
27.5	90.2	8.310	46.96	-56.0	-3.1
30.0	98.4	7.900	46.22	-164.0	-9.0
32.5	106.6	8.070	46.53	68.0	3.7
35.0	114.8	8.200	46.76	52.0	2.9
37.5	123.0	8.220	46.80	8.0	.4
40.0	131.2	8.320	46.98	40.0	2.2
42.5	139.4	8.400	47.12	32.0	1.8
45.0	147.6	8.470	47.25	28.0	1.5
47.5	155.8	8.530	47.35	24.0	1.3
50.0	164.0	8.600	47.48	28.0	1.5
52.5	172.2	8.660	47.59	24.0	1.3
55.0	180.4	8.710	47.68	20.0	1.1
57.5	188.6	8.780	47.80	28.0	1.5
60.0	196.8	8.840	47.91	24.0	1.3
65.0	213.2	8.960	48.13	24.0	1.3
70.0	229.6	9.100	48.38	28.0	1.5
75.0	246.0	9.250	48.65	30.0	1.6
80.0	262.4	9.450	49.01	40.0	2.2
85.0	278.8	9.650	49.37	40.0	2.2
90.0	295.2	9.770	49.59	24.0	1.3
95.0	311.6	10.020	50.04	50.0	2.7
100.0	328.0	10.290	50.52	54.0	3.0
105.0	344.4	10.570	51.03	56.0	3.1
110.0	360.8	9.240	48.63	-266.0	-14.6
115.0	362.4	9.210	48.58	-60.0	-3.3
120.0	393.6	9.210	48.58	.0	.0
125.0	410.0	9.220	48.60	2.0	.1
130.0	426.4	9.220	48.60	.0	.0

LOCATION: DESCHUTES CO, OREGON
BS-W
HOLE NUMBER: 18S 12E 5BC
DATE MEASURED: 5/02/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
10.0	32.8	9.670	49.41	.0	.0
20.0	65.6	9.620	49.32	-5.0	-.3
30.0	98.4	9.840	49.71	22.0	1.2
40.0	131.2	10.130	50.23	29.0	1.6
50.0	164.0	10.220	50.40	9.0	.5
60.0	196.8	10.320	50.58	10.0	.5
70.0	229.6	10.400	50.72	8.0	.4
80.0	262.4	10.340	50.61	-6.0	-.3
90.0	295.2	10.350	50.63	1.0	.1
100.0	328.0	10.340	50.61	-1.0	-.1
110.0	360.8	9.940	49.89	-40.0	-2.2
120.0	393.6	9.900	49.82	-4.0	-.2
130.0	426.4	9.900	49.82	.0	.0
140.0	459.2	9.900	49.82	.0	.0
150.0	492.0	9.900	49.82	.0	.0
160.0	524.8	9.910	49.84	1.0	.1
170.0	557.6	9.920	49.86	1.0	.1
180.0	590.4	9.920	49.86	.0	.0
190.0	623.2	9.920	49.86	.0	.0
200.0	656.0	9.960	49.93	4.0	.2
210.0	688.8	9.980	49.96	2.0	.1
220.0	721.6	10.050	50.09	7.0	.4
230.0	754.4	10.230	50.41	18.0	1.0

LOCATION: BOISE AMS, OREGON
18S/45E/21CB
HOLE NUMBER: TS-RCH
DATE MEASURED: 11/30/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
15.0	49.2	15.070	59.13	.0	.0
20.0	65.6	15.900	60.62	166.0	9.1
25.0	82.0	16.870	62.37	194.0	10.6
30.0	98.4	17.750	63.95	176.0	9.7
35.0	114.8	18.790	65.82	208.0	11.4
40.0	131.2	19.810	67.66	204.0	11.2
45.0	147.6	20.840	69.51	206.0	11.3
50.0	164.0	21.940	71.49	220.0	12.1
55.0	180.4	23.090	73.56	230.0	12.6
60.0	196.8	24.080	75.34	198.0	10.9
65.0	213.2	25.090	77.16	202.0	11.1
70.0	229.6	25.640	78.15	110.0	6.0
75.0	246.0	26.480	79.66	168.0	9.2
80.0	262.4	27.080	80.74	120.0	6.6
85.0	278.8	27.770	81.99	138.0	7.6
90.0	295.2	28.610	83.50	168.0	9.2
95.0	311.6	29.480	85.06	174.0	9.5
100.0	328.0	30.010	86.02	106.0	5.8
105.0	344.4	30.490	86.88	96.0	5.3
110.0	360.8	30.980	87.76	98.0	5.4
115.0	377.2	31.400	88.52	84.0	4.6
120.0	393.6	32.140	89.85	148.0	8.1
125.0	410.0	32.820	91.08	136.0	7.5
130.0	426.4	33.450	92.21	126.0	6.9
135.0	442.8	33.860	92.95	82.0	4.5
140.0	459.2	34.330	93.79	94.0	5.2
145.0	475.6	35.220	95.40	178.0	9.8
150.0	492.0	36.550	97.79	266.0	14.6
155.0	508.4	37.440	99.39	178.0	9.8
160.0	524.8	38.250	100.85	162.0	8.9
165.0	541.2	38.980	102.16	146.0	8.0
170.0	557.6	39.720	103.50	148.0	8.1
175.0	574.0	40.760	105.37	208.0	11.4
180.0	590.4	41.560	106.81	160.0	8.8
185.0	606.8	42.360	108.25	160.0	8.8
190.0	623.2	43.430	110.17	214.0	11.7
195.0	639.6	44.260	111.67	166.0	9.1
200.0	656.0	45.040	113.07	156.0	8.6
205.0	672.4	45.860	114.55	164.0	9.0
210.0	688.8	46.550	115.79	138.0	7.6
215.0	705.2	47.130	116.83	116.0	6.4
220.0	721.6	47.470	117.45	68.0	3.7
225.0	738.0	47.980	118.36	102.0	5.6
230.0	754.4	48.710	119.68	146.0	8.0
235.0	770.8	49.470	121.05	152.0	8.3
240.0	787.2	50.310	122.56	168.0	9.2
245.0	803.6	50.960	123.73	130.0	7.1
250.0	820.0	51.650	124.97	138.0	7.6

LOCATION: BOISE AMS, OREGON
18S/45E/21CB
HOLE NUMBER: TS-RDH
DATE MEASURED: 11/30/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
255.0	836.4	52.300	126.14	130.0	7.1
260.0	852.8	52.840	127.11	108.0	5.9
265.0	869.2	53.420	128.16	116.0	6.4
270.0	885.6	53.990	129.18	114.0	6.3
275.0	902.0	54.610	130.30	124.0	6.8
280.0	918.4	55.220	131.40	122.0	6.7
285.0	934.8	55.780	132.40	112.0	6.1
290.0	951.2	56.210	133.18	86.0	4.7
295.0	967.6	56.860	134.35	130.0	7.1
300.0	984.0	57.140	134.85	56.0	3.1
305.0	1000.4	57.470	135.45	66.0	3.6
310.0	1016.8	57.990	136.38	104.0	5.7

LOCATION: LAVA BUTTE, OREGON
19S/11E-25BA
HOLE NUMBER: FS-1
DATE MEASURED: 10/1/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
23.0	75.4	7.710	45.88	.0	.0
33.0	108.2	7.670	45.81	-4.0	-.2
43.0	141.0	7.430	45.37	-24.0	-1.3
53.0	173.8	7.490	45.48	6.0	.3
63.0	206.6	7.570	45.63	8.0	.4
73.0	239.4	7.680	45.82	11.0	.6
83.0	272.2	8.110	46.60	43.0	2.4
93.0	305.0	8.080	46.54	-3.0	-.2
103.0	337.8	8.340	47.01	26.0	1.4
113.0	370.6	8.840	47.91	50.0	2.7
123.0	403.4	9.230	48.61	39.0	2.1

LOCATION: BEAR RIDGE, OREGON
19S/16E-16DC
HOLE NUMBER:
DATE MEASURED: 10/2/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
25.0	82.0	12.430	54.37	.0	.0
50.0	164.0	13.540	56.37	44.4	2.4
75.0	246.0	13.560	56.41	.8	.0
100.0	328.0	15.230	59.41	66.8	3.7
125.0	410.0	17.620	63.72	95.6	5.2
150.0	492.0	18.490	65.28	34.8	1.9
175.0	574.0	20.010	68.02	60.8	3.3
200.0	656.0	20.890	69.60	35.2	1.9
225.0	738.0	22.490	72.48	64.0	3.5
250.0	820.0	24.040	75.27	62.0	3.4
275.0	902.0	25.510	77.92	58.8	3.2
300.0	984.0	26.480	79.66	38.8	2.1

LOCATION: DESCHUTES CO, OREGON
PM-RDH
HOLE NUMBER: 20S 14E 25AA
DATE MEASURED: 8/17/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
10.0	32.8	9.660	49.39	.0	.0
15.0	49.2	9.950	49.91	58.0	3.2
20.0	65.6	10.230	50.41	56.0	3.1
25.0	82.0	10.580	51.04	70.0	3.8
30.0	98.4	10.780	51.40	40.0	2.2
35.0	114.8	11.050	51.89	54.0	3.0
40.0	131.2	11.310	52.36	52.0	2.9
45.0	147.6	11.530	52.75	44.0	2.4
50.0	164.0	11.710	53.08	36.0	2.0
55.0	180.4	11.890	53.40	36.0	2.0
60.0	196.8	12.080	53.74	38.0	2.1
65.0	213.2	12.280	54.10	40.0	2.2
70.0	229.6	12.420	54.36	28.0	1.5
75.0	246.0	12.580	54.64	32.0	1.8
80.0	262.4	12.750	54.95	34.0	1.9
85.0	278.8	12.910	55.24	32.0	1.8
90.0	295.2	13.080	55.54	34.0	1.9
95.0	311.6	13.250	55.85	34.0	1.9
100.0	328.0	13.420	56.16	34.0	1.9
105.0	344.4	13.580	56.44	32.0	1.8
110.0	360.8	13.720	56.70	28.0	1.5
115.0	377.2	13.880	56.98	32.0	1.8
120.0	393.6	14.070	57.33	38.0	2.1
125.0	410.0	14.280	57.70	42.0	2.3

LOCATION: FREDRICK B. LEG, OREGON
20S/21E-7BA
HOLE NUMBER: BR-75-25
DATE MEASURED: 10/ 2/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	9.550	49.19	.0	.0
7.5	24.6	9.480	49.06	-28.0	-1.5
10.0	32.8	9.750	49.55	108.0	5.9
12.5	41.0	9.915	49.85	66.0	3.6
15.0	49.2	10.035	50.06	48.0	2.6
17.5	57.4	10.160	50.29	50.0	2.7
20.0	65.6	10.295	50.53	54.0	3.0
22.5	73.8	10.420	50.76	50.0	2.7
25.0	82.0	10.560	51.01	56.0	3.1
27.5	90.2	10.695	51.25	54.0	3.0
30.0	98.4	10.835	51.50	56.0	3.1
32.5	106.6	10.965	51.74	52.0	2.9
35.0	114.8	11.095	51.97	52.0	2.9
37.5	123.0	11.225	52.20	52.0	2.9
40.0	131.2	11.350	52.43	50.0	2.7
42.5	139.4	11.470	52.65	48.0	2.6
45.0	147.6	11.610	52.90	56.0	3.1
47.5	155.8	11.750	53.15	56.0	3.1
50.0	164.0	11.885	53.39	54.0	3.0
52.5	172.2	12.010	53.62	50.0	2.7
55.0	180.4	12.150	53.87	56.0	3.1
57.5	188.6	12.290	54.12	56.0	3.1

LOCATION: DESCHUTES CO, OREGON
MB-R[illegible]
HOLE NUMBER: 21S 11E 25BB
DATE MEASURED: 3/04/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
10.0	32.8	7.350	45.23	.0	.0
12.5	41.0	7.380	45.28	12.0	.7
15.0	49.2	7.450	45.41	28.0	1.5
17.5	57.4	7.510	45.52	24.0	1.3
20.0	65.6	7.580	45.64	28.0	1.5
22.5	73.8	7.700	45.86	48.0	2.6
25.0	82.0	7.770	45.99	28.0	1.5
27.5	90.2	7.840	46.11	28.0	1.5
30.0	98.4	7.990	46.38	60.0	3.3
32.5	106.6	8.180	46.72	76.0	4.2
35.0	114.8	8.340	47.01	64.0	3.5

LOCATION; DESCHUTES CO, OREGON
PMS-RDH
HOLE NUMBER: 21S 15E 16AB
DATE MEASURED: 8/17/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
10.0	32.8	8.250	46.85	.0	.0
15.0	49.2	8.310	46.96	12.0	.7
20.0	65.6	8.390	47.10	16.0	.9
25.0	82.0	8.510	47.32	24.0	1.3
30.0	98.4	8.710	47.68	40.0	2.2
35.0	114.8	8.960	48.13	50.0	2.7
40.0	131.2	8.990	48.18	6.0	.3
45.0	147.6	9.080	48.34	18.0	1.0
50.0	164.0	9.200	48.56	24.0	1.3
55.0	180.4	9.400	48.92	40.0	2.2
60.0	196.8	9.580	49.24	36.0	2.0
65.0	213.2	9.760	49.57	36.0	2.0
70.0	229.6	9.930	49.87	34.0	1.9
75.0	246.0	10.180	50.32	50.0	2.7
80.0	262.4	10.430	50.77	50.0	2.7
85.0	278.8	10.740	51.33	62.0	3.4
90.0	295.2	11.040	51.87	60.0	3.3
95.0	311.6	11.340	52.41	60.0	3.3
100.0	328.0	11.590	52.86	50.0	2.7
105.0	344.4	11.860	53.35	54.0	3.0
110.0	360.8	12.130	53.83	54.0	3.0
115.0	377.2	12.380	54.28	50.0	2.7
120.0	393.6	12.610	54.70	46.0	2.5
125.0	410.0	12.870	55.17	52.0	2.9
130.0	426.4	13.130	55.63	52.0	2.9
135.0	442.8	13.410	56.14	56.0	3.1
140.0	459.2	13.740	56.73	66.0	3.6
145.0	475.6	14.060	57.31	64.0	3.5
150.0	492.0	14.330	57.79	54.0	3.0
152.5	500.2	14.460	58.03	52.0	2.9

LOCATION: DESCHUTES CO, OREGON
BR-RDH
HOLE NUMBER: 21S 17E 1AD
DATE MEASURED: 8/03/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
7.5	24.6	8.300	46.94	.0	.0
10.0	32.8	8.430	47.17	52.0	2.9
12.5	41.0	9.020	48.24	236.0	13.0
15.0	49.2	9.190	48.54	68.0	3.7
17.5	57.4	9.520	49.14	132.0	7.2
20.0	65.6	9.810	49.66	116.0	6.4
22.5	73.8	10.120	50.22	124.0	6.8
25.0	82.0	10.400	50.72	112.0	6.1
27.5	90.2	10.670	51.21	108.0	5.9
30.0	98.4	10.930	51.67	104.0	5.7
32.5	106.6	11.230	52.21	120.0	6.6
35.0	114.8	11.450	52.61	88.0	4.8
37.5	123.0	11.760	53.17	124.0	6.8
40.0	131.2	12.030	53.65	108.0	5.9
42.5	139.4	12.230	54.01	80.0	4.4
45.0	147.6	12.440	54.39	84.0	4.6
47.5	155.8	12.640	54.75	80.0	4.4
50.0	164.0	12.820	55.08	72.0	4.0
55.0	180.4	13.230	55.81	82.0	4.5
60.0	196.8	13.730	56.71	100.0	5.5
65.0	213.2	14.230	57.61	100.0	5.5
70.0	229.6	14.680	58.42	90.0	4.9
75.0	246.0	15.090	59.16	82.0	4.5
80.0	262.4	15.450	59.81	72.0	4.0
85.0	278.8	15.820	60.48	74.0	4.1
90.0	295.2	16.190	61.14	74.0	4.1

LOCATION: FREDRICK B. LEG, OREGON
21S/19E-12D
HOLE NUMBER: BR-75-24
DATE MEASURED: 10/ 2/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
2.5	8.2	11.680	53.02	.0	.0
5.0	16.4	9.580	49.24	-840.0	-46.1
7.5	24.6	8.860	47.95	-288.0	-15.8
10.0	32.8	9.020	48.24	64.0	3.5
12.5	41.0	9.255	48.66	94.0	5.2
15.0	49.2	9.410	48.94	62.0	3.4
17.5	57.4	9.630	49.33	88.0	4.8
20.0	65.6	9.860	49.75	92.0	5.0
22.5	73.8	9.965	49.94	42.0	2.3
25.0	82.0	10.055	50.10	36.0	2.0
27.5	90.2	10.170	50.31	46.0	2.5
30.0	98.4	10.285	50.51	46.0	2.5
32.5	106.6	10.465	50.84	72.0	4.0
35.0	114.8	10.680	51.22	86.0	4.7
37.5	123.0	10.920	51.66	96.0	5.3
40.0	131.2	11.165	52.10	98.0	5.4
42.5	139.4	11.450	52.61	114.0	6.3
45.0	147.6	11.785	53.21	134.0	7.4
47.5	155.8	12.125	53.82	136.0	7.5
50.0	164.0	12.345	54.22	88.0	4.8
52.5	172.2	12.590	54.66	98.0	5.4
55.0	180.4	12.860	55.15	108.0	5.9
57.5	188.6	13.035	55.46	70.0	3.8
60.0	196.8	13.230	55.81	78.0	4.3

LOCATION: GLASS BUTTES LEG, OREGON
21S/23E-26C
HOLE NUMBER: BR-75-18
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	11.055	51.90	.0	.0
7.5	24.6	11.020	51.84	-14.0	-.8
10.0	32.8	11.340	52.41	128.0	7.0
12.5	41.0	11.500	52.70	64.0	3.5
15.0	49.2	11.605	52.89	42.0	2.3
17.5	57.4	11.735	53.12	52.0	2.9
20.0	65.6	11.880	53.38	58.0	3.2
22.5	73.8	12.000	53.60	48.0	2.6
25.0	82.0	12.100	53.78	40.0	2.2
27.5	90.2	12.195	53.95	38.0	2.1
30.0	98.4	12.295	54.13	40.0	2.2
32.5	106.6	12.395	54.31	40.0	2.2
35.0	114.8	12.500	54.50	42.0	2.3
37.5	123.0	12.605	54.69	42.0	2.3
40.0	131.2	12.705	54.87	40.0	2.2
42.5	139.4	12.810	55.06	42.0	2.3
45.0	147.6	12.905	55.23	38.0	2.1
47.5	155.8	13.005	55.41	40.0	2.2
50.0	164.0	13.105	55.59	40.0	2.2
52.5	172.2	13.205	55.77	40.0	2.2
55.0	180.4	13.310	55.96	42.0	2.3
57.5	188.6	13.410	56.14	40.0	2.2
60.0	196.8	13.515	56.33	42.0	2.3

LOCATION: DESCHUTES CO, OREGON
CH-RDH
HOLE NUMBER: 22S 14E 3AC
DATE MEASURED: 8/04/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
10.0	32.8	5.290	41.52	.0	.0
12.5	41.0	5.490	41.88	80.0	4.4
15.0	49.2	5.570	42.03	32.0	1.8
17.5	57.4	5.600	42.08	12.0	.7
20.0	65.6	5.590	42.06	-4.0	-.2
22.5	73.8	5.600	42.08	4.0	.2
25.0	82.0	5.610	42.10	4.0	.2
27.5	90.2	5.640	42.15	12.0	.7
30.0	98.4	5.650	42.17	4.0	.2
32.5	106.6	5.640	42.15	-4.0	-.2
35.0	114.8	5.610	42.10	-12.0	-.7
37.5	123.0	5.600	42.08	-4.0	-.2
40.0	131.2	5.590	42.06	-4.0	-.2
42.5	139.4	5.590	42.06	.0	.0
45.0	147.6	5.600	42.08	4.0	.2
47.5	155.8	5.600	42.08	.0	.0
50.0	164.0	5.620	42.12	8.0	.4
52.5	172.2	5.620	42.12	.0	.0
55.0	180.4	5.640	42.15	8.0	.4
57.5	188.6	5.660	42.19	8.0	.4
60.0	196.8	5.680	42.22	8.0	.4
62.5	205.0	5.700	42.26	8.0	.4
65.0	213.2	5.720	42.30	8.0	.4
67.5	221.4	5.750	42.35	12.0	.7
70.0	229.6	5.780	42.40	12.0	.7
75.0	246.0	5.820	42.48	8.0	.4

LOCATION: DESCHUTES CO, OREGON
QM-RDH
HOLE NUMBER: 22S 15E 35AD
DATE MEASURED: 8/04/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
10.0	32.8	6.930	44.47	.0	.0
12.5	41.0	7.050	44.69	48.0	2.6
15.0	49.2	7.150	44.87	40.0	2.2
17.5	57.4	7.170	44.91	8.0	.4
20.0	65.6	7.210	44.98	16.0	.9
22.5	73.8	7.300	45.14	36.0	2.0
25.0	82.0	7.330	45.19	12.0	.7
27.5	90.2	7.340	45.21	4.0	.2
30.0	98.4	7.440	45.39	40.0	2.2
32.5	106.6	7.440	45.39	.0	.0
35.0	114.8	7.470	45.45	12.0	.7
37.5	123.0	7.590	45.66	48.0	2.6
40.0	131.2	7.620	45.72	12.0	.7

LOCATION: FREDRICK B. LEG, OREGON
22S/19E-5CC
HOLE NUMBER: BR-75-27
DATE MEASURED: 10/ 2/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
2.5	8.2	12.780	55.00	.0	.0
5.0	16.4	10.045	50.08	-1094.0	-60.0
7.5	24.6	9.155	48.48	-356.0	-19.5
10.0	32.8	9.265	48.68	44.0	2.4
12.5	41.0	9.495	49.09	92.0	5.0
15.0	49.2	9.730	49.51	94.0	5.2
17.5	57.4	9.905	49.83	70.0	3.8
20.0	65.6	10.080	50.14	70.0	3.8
22.5	73.8	10.240	50.43	64.0	3.5
25.0	82.0	10.400	50.72	64.0	3.5
27.5	90.2	10.590	51.06	76.0	4.2
30.0	98.4	10.700	51.26	44.0	2.4
32.5	106.6	10.825	51.48	50.0	2.7
35.0	114.8	10.960	51.73	54.0	3.0
37.5	123.0	11.170	52.11	84.0	4.6

LOCATION: DESCHUTES CO, OREGON
FBE-RD4
HOLE NUMBER: 22S 19E 32AD
DATE MEASURED: 8/03/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
10.0	32.8	9.030	48.25	.0	.0
12.5	41.0	9.330	48.79	120.0	6.6
15.0	49.2	9.510	49.12	72.0	4.0
17.5	57.4	9.620	49.32	44.0	2.4
20.0	65.6	9.700	49.46	32.0	1.8
22.5	73.8	9.810	49.66	44.0	2.4
25.0	82.0	9.930	49.87	48.0	2.6
27.5	90.2	10.020	50.04	36.0	2.0
30.0	98.4	10.120	50.22	40.0	2.2
32.5	106.6	10.220	50.40	40.0	2.2
35.0	114.8	10.310	50.56	36.0	2.0
37.5	123.0	10.400	50.72	36.0	2.0
40.0	131.2	10.560	51.01	64.0	3.5
42.5	139.4	10.730	51.31	68.0	3.7
45.0	147.6	11.060	51.91	132.0	7.2
47.5	155.8	11.320	52.38	104.0	5.7
50.0	164.0	11.470	52.65	60.0	3.3

LOCATION: GLASS BUTTES LEG, OREGON
22S/23E-14CB
HOLE NUMBER: BR-75-19
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	10.190	50.34	.0	.0
7.5	24.6	10.235	50.42	18.0	1.0
10.0	32.8	10.630	51.13	158.0	8.7
12.5	41.0	10.850	51.53	88.0	4.8
15.0	49.2	11.000	51.80	60.0	3.3
17.5	57.4	11.155	52.08	62.0	3.4
19.0	62.3	11.150	52.07	-3.3	-.2

LOCATION: BURNS, OREGON
22S/32E-34CC
HOLE NUMBER: DR-1
DATE MEASURED: 6/11/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	17.040	62.67	.0	.0
10.0	32.8	20.590	69.06	710.0	39.0
15.0	49.2	25.150	77.27	912.0	50.0
20.0	65.6	26.080	78.94	186.0	10.2
25.0	82.0	26.100	78.98	4.0	.2
30.0	98.4	26.140	79.05	8.0	.4
35.0	114.8	26.200	79.16	12.0	.7
40.0	131.2	26.250	79.25	10.0	.5
45.0	147.6	26.360	79.45	22.0	1.2
50.0	164.0	26.480	79.66	24.0	1.3
55.0	180.4	26.550	79.79	14.0	.8
60.0	196.8	26.610	79.90	12.0	.7
65.0	213.2	26.790	80.22	36.0	2.0
70.0	229.6	26.880	80.38	18.0	1.0
75.0	246.0	27.010	80.62	26.0	1.4
80.0	262.4	27.050	80.69	8.0	.4
85.0	278.8	27.120	80.82	14.0	.8
90.0	295.2	27.260	81.07	28.0	1.5
95.0	311.6	27.390	81.30	26.0	1.4

LOCATION: LAKE CO, OREGON
FBS-RDH
HOLE NUMBER: 23S 19E 5B
DATE MEASURED: 3/03/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
10.0	32.8	8.760	47.77	.0	.0
15.0	49.2	9.150	48.47	78.0	4.3
20.0	65.6	9.520	49.14	74.0	4.1
25.0	82.0	9.860	49.75	68.0	3.7
30.0	98.4	10.080	50.14	44.0	2.4
35.0	114.8	10.330	50.59	50.0	2.7
40.0	131.2	10.520	50.94	38.0	2.1
45.0	147.6	10.930	51.67	82.0	4.5
50.0	164.0	11.540	52.77	122.0	6.7
55.0	180.4	12.140	53.85	120.0	6.6
60.0	196.8	12.600	54.68	92.0	5.0
65.0	213.2	13.050	55.49	90.0	4.9
70.0	229.6	13.570	56.43	104.0	5.7
75.0	246.0	13.810	56.86	48.0	2.6
80.0	262.4	14.080	57.34	54.0	3.0
85.0	278.8	14.310	57.76	46.0	2.5
90.0	295.2	14.600	58.28	58.0	3.2
95.0	311.6	14.880	58.78	56.0	3.1
100.0	328.0	15.080	59.14	40.0	2.2
105.0	344.4	15.380	59.68	60.0	3.3
110.0	360.8	15.620	60.12	48.0	2.6
115.0	377.2	15.860	60.55	48.0	2.6
120.0	393.6	16.130	61.03	54.0	3.0
125.0	410.0	16.420	61.56	58.0	3.2
130.0	426.4	16.650	61.97	46.0	2.5
135.0	442.8	16.870	62.37	44.0	2.4
140.0	459.2	17.130	62.83	52.0	2.9
145.0	475.6	17.440	63.39	62.0	3.4
150.0	492.0	17.640	63.75	40.0	2.2

LOCATION: GLASS BUTTES LEG, OREGON
23S/23E-18C
HOLE NUMBER: BR-75-21
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	11.040	51.87	.0	.0
7.5	24.6	10.895	51.61	-58.0	-3.2
10.0	32.8	11.350	52.43	182.0	10.0
12.5	41.0	11.670	53.01	128.0	7.0
15.0	49.2	11.950	53.51	112.0	6.1
17.5	57.4	12.290	54.12	136.0	7.5
20.0	65.6	12.620	54.72	132.0	7.2
22.5	73.8	12.980	55.36	144.0	7.9
25.0	82.0	13.390	56.10	164.0	9.0
27.5	90.2	13.690	56.64	120.0	6.6
30.0	98.4	14.105	57.39	166.0	9.1
32.5	106.6	14.610	58.30	202.0	11.1
35.0	114.8	15.080	59.14	188.0	10.3
37.5	123.0	15.440	59.79	144.0	7.9
40.0	131.2	15.780	60.40	136.0	7.5
42.5	139.4	16.095	60.97	126.0	6.9
45.0	147.6	16.425	61.56	132.0	7.2
47.5	155.8	16.760	62.17	134.0	7.4
50.0	164.0	17.100	62.78	136.0	7.5
52.5	172.2	17.440	63.39	136.0	7.5
55.0	180.4	17.780	64.00	136.0	7.5
57.5	188.6	18.095	64.57	126.0	6.9
60.0	196.8	18.430	65.17	134.0	7.4
62.5	205.0	18.740	65.73	124.0	6.8

LOCATION: HARNEY CO, OREGON
GV-WW2
HOLE NUMBER: 23S 26E 25AB
DATE MEASURED: 7/09/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
10.0	32.8	8.680	47.62	.0	.0
20.0	65.6	9.600	49.28	92.0	5.0
30.0	98.4	10.440	50.79	84.0	4.6
32.5	106.6	10.470	50.85	12.0	.7
35.0	114.8	10.490	50.88	8.0	.4
37.5	123.0	10.540	50.97	20.0	1.1
40.0	131.2	10.570	51.03	12.0	.7
42.5	139.4	10.590	51.06	8.0	.4
45.0	147.6	10.610	51.10	8.0	.4
47.5	155.8	10.630	51.13	8.0	.4
50.0	164.0	10.650	51.17	8.0	.4
55.0	180.4	10.710	51.28	12.0	.7
60.0	196.8	10.800	51.44	18.0	1.0
65.0	213.2	10.970	51.75	34.0	1.9
70.0	229.6	11.110	52.00	28.0	1.5
75.0	246.0	11.310	52.36	40.0	2.2
80.0	262.4	11.470	52.65	32.0	1.8
85.0	278.8	11.550	52.79	16.0	.9
90.0	295.2	11.650	52.97	20.0	1.1
95.0	311.6	11.880	53.38	46.0	2.5
100.0	328.0	12.200	53.96	64.0	3.5
105.0	344.4	12.620	54.72	84.0	4.6
110.0	360.8	12.970	55.35	70.0	3.8
115.0	377.2	13.300	55.94	66.0	3.6
120.0	393.6	13.570	56.43	54.0	3.0
125.0	410.0	14.120	57.42	110.0	6.0

LOCATION: HARNEY CO, OREGON
GV-W-1
HOLE NUMBER: 23S 27E 29BB
DATE MEASURED: 7/09/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
10.0	32.8	9.490	49.08	.0	.0
20.0	65.6	8.840	47.91	-65.0	-3.6
30.0	98.4	9.070	48.33	23.0	1.3
32.5	106.6	9.090	48.36	8.0	.4
35.0	114.8	9.100	48.38	4.0	.2
37.5	123.0	9.120	48.42	8.0	.4
40.0	131.2	9.140	48.45	8.0	.4
42.5	139.4	9.180	48.52	16.0	.9
45.0	147.6	9.200	48.56	8.0	.4
47.5	155.8	9.210	48.58	4.0	.2
50.0	164.0	9.210	48.58	.0	.0
55.0	180.4	9.240	48.63	6.0	.3
60.0	196.8	9.260	48.67	4.0	.2
65.0	213.2	9.280	48.70	4.0	.2
70.0	229.6	9.310	48.76	6.0	.3
75.0	246.0	9.330	48.79	4.0	.2
80.0	262.4	9.350	48.83	4.0	.2
85.0	278.8	9.370	48.87	4.0	.2
90.0	295.2	9.410	48.94	8.0	.4
95.0	311.6	9.520	49.14	22.0	1.2
100.0	328.0	9.670	49.41	30.0	1.6
105.0	344.4	9.900	49.82	46.0	2.5
110.0	360.8	10.120	50.22	44.0	2.4
115.0	377.2	10.410	50.74	58.0	3.2

LOCATION: WAGONTIRE LEG, OREGON
23S/28E-18D
HOLE NUMBER: BR-75-12
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
5.0	16.4	11.395	52.51	.0	.0
7.5	24.6	10.865	51.56	-212.0	-11.6
10.0	32.8	11.245	52.24	152.0	8.3
12.5	41.0	11.365	52.46	48.0	2.6
15.0	49.2	11.440	52.59	30.0	1.6
17.5	57.4	11.490	52.68	20.0	1.1
20.0	65.6	11.535	52.76	18.0	1.0
22.5	73.8	11.590	52.86	22.0	1.2
25.0	82.0	11.650	52.97	24.0	1.3
27.5	90.2	11.710	53.08	24.0	1.3
30.0	98.4	11.775	53.19	26.0	1.4
32.5	106.6	11.845	53.32	28.0	1.5
35.0	114.8	11.915	53.45	28.0	1.5
37.5	123.0	11.985	53.57	28.0	1.5
40.0	131.2	12.055	53.70	28.0	1.5
42.5	139.4	12.125	53.82	28.0	1.5
45.0	147.6	12.205	53.97	32.0	1.8
47.5	155.8	12.290	54.12	34.0	1.9
50.0	164.0	12.375	54.27	34.0	1.9
52.5	172.2	12.455	54.42	32.0	1.8
55.0	180.4	12.545	54.58	36.0	2.0
57.5	188.6	12.620	54.72	30.0	1.6
60.0	196.8	12.705	54.87	34.0	1.9

LOCATION: BOISE AMS, OREGON
23S/46E/21BC
HOLE NUMBER: RDH-CKC
DATE MEASURED: 12/ 8/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
10.0	32.8	13.850	56.93	.0	.0
20.0	65.6	14.610	58.30	76.0	4.2
25.0	82.0	15.000	59.00	78.0	4.3
30.0	98.4	15.270	59.49	54.0	3.0
35.0	114.8	15.610	60.10	68.0	3.7
40.0	131.2	15.780	60.40	34.0	1.9
45.0	147.6	16.020	60.84	48.0	2.6
50.0	164.0	16.290	61.32	54.0	3.0
55.0	180.4	16.550	61.79	52.0	2.9
60.0	196.8	16.780	62.20	46.0	2.5
65.0	213.2	17.180	62.92	80.0	4.4
70.0	229.6	17.550	63.59	74.0	4.1
75.0	246.0	17.900	64.22	70.0	3.8
80.0	262.4	18.190	64.74	58.0	3.2
85.0	278.8	18.520	65.34	66.0	3.6
90.0	295.2	18.810	65.86	58.0	3.2
95.0	311.6	19.060	66.31	50.0	2.7
100.0	328.0	19.470	67.05	82.0	4.5
105.0	344.4	19.840	67.71	74.0	4.1
110.0	360.8	20.200	68.36	72.0	4.0
115.0	377.2	20.530	68.95	66.0	3.6
120.0	393.6	20.860	69.55	66.0	3.6
125.0	410.0	21.170	70.11	62.0	3.4
130.0	426.4	21.500	70.70	66.0	3.6
135.0	442.8	21.780	71.20	56.0	3.1
140.0	459.2	22.000	71.60	44.0	2.4

LOCATION: GLASS BUTTES LEG, OREGON
24S/22E-2DD
HOLE NUMBER: BR-75-22
DATE MEASURED: 10/ 2/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
2.5	8.2	13.800	56.84	.0	.0
5.0	16.4	11.340	52.41	-984.0	-54.0
7.5	24.6	11.560	52.81	88.0	4.8
10.0	32.8	11.665	53.00	42.0	2.3
12.5	41.0	12.335	54.20	268.0	14.7
15.0	49.2	12.545	54.58	84.0	4.6
17.5	57.4	12.830	55.09	114.0	6.3
20.0	65.6	13.110	55.60	112.0	6.1
22.5	73.8	13.400	56.12	116.0	6.4
25.0	82.0	13.680	56.62	112.0	6.1
27.5	90.2	13.990	57.18	124.0	6.8
30.0	98.4	14.250	57.65	104.0	5.7
32.5	106.6	14.590	58.26	136.0	7.5
35.0	114.8	14.895	58.81	122.0	6.7
37.5	123.0	15.180	59.32	114.0	6.3
40.0	131.2	15.500	59.90	128.0	7.0
42.5	139.4	15.790	60.42	116.0	6.4
45.0	147.6	16.140	61.05	140.0	7.7
47.5	155.8	16.455	61.62	126.0	6.9
50.0	164.0	16.760	62.17	122.0	6.7
52.5	172.2	17.065	62.72	122.0	6.7
55.0	180.4	17.355	63.24	116.0	6.4
57.5	188.6	17.660	63.79	122.0	6.7
60.0	196.8	17.955	64.32	118.0	6.5

LOCATION: GLASS BUTTES LEG, OREGON
24S/22E-20AA
HOLE NUMBER: BR-75-23
DATE MEASURED: 10/ 2/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
5.0	16.4	10.515	50.93	.0	.0
7.5	24.6	10.425	50.76	-36.0	-2.0
10.0	32.8	10.660	51.19	94.0	5.2
12.5	41.0	10.740	51.33	32.0	1.8
15.0	49.2	10.800	51.44	24.0	1.3
17.5	57.4	10.885	51.59	34.0	1.9
20.0	65.6	10.985	51.77	40.0	2.2
22.5	73.8	11.240	52.23	102.0	5.6
25.0	82.0	11.535	52.76	118.0	6.5
27.5	90.2	11.815	53.27	112.0	6.1
30.0	98.4	12.110	53.80	118.0	6.5
32.5	106.6	12.420	54.36	124.0	6.8
35.0	114.8	12.540	54.57	48.0	2.6
37.5	123.0	12.710	54.88	68.0	3.7
40.0	131.2	12.880	55.18	68.0	3.7
42.5	139.4	13.055	55.50	70.0	3.8
45.0	147.6	13.230	55.81	70.0	3.8
47.5	155.8	13.410	56.14	72.0	4.0
50.0	164.0	13.610	56.50	80.0	4.4
52.5	172.2	13.845	56.92	94.0	5.2
55.0	180.4	14.085	57.35	96.0	5.3
57.5	188.6	14.280	57.70	78.0	4.3
60.0	196.8	14.430	57.97	60.0	3.3

LOCATION: HARNEY CO, OREGON
SB-RD4
HOLE NUMBER: 24S 25E 3DD
DATE MEASURED: 8/02/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
10.0	32.8	10.740	51.33	.0	.0
12.5	41.0	10.970	51.75	92.0	5.0
15.0	49.2	11.060	51.91	36.0	2.0
17.5	57.4	11.180	52.12	48.0	2.6
20.0	65.6	11.430	52.57	100.0	5.5
22.5	73.8	11.810	53.26	152.0	8.3
25.0	82.0	12.100	53.78	116.0	6.4
27.5	90.2	12.310	54.16	84.0	4.6
30.0	98.4	12.520	54.54	84.0	4.6
32.5	106.6	12.900	55.22	152.0	8.3
35.0	114.8	13.230	55.81	132.0	7.2
37.5	123.0	13.480	56.26	100.0	5.5
40.0	131.2	13.730	56.71	100.0	5.5
42.5	139.4	13.920	57.06	76.0	4.2
45.0	147.6	14.000	57.20	32.0	1.8
47.5	155.8	14.050	57.29	20.0	1.1
50.0	164.0	14.040	57.27	-4.0	-.2
52.5	172.2	14.040	57.27	.0	.0
55.0	180.4	14.040	57.27	.0	.0
57.5	188.6	14.060	57.31	8.0	.4
60.0	196.8	14.090	57.36	12.0	.7

LOCATION: HARNEY CO, OREGON
SR-ROH
HOLE NUMBER: 24S 26E 13DC
DATE MEASURED: 8/03/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
10.0	32.8	11.990	53.58	.0	.0
20.0	65.6	12.790	55.02	80.0	4.4
30.0	98.4	13.690	56.64	90.0	4.9
40.0	131.2	14.120	57.42	43.0	2.4
50.0	164.0	14.940	58.89	82.0	4.5
55.0	180.4	15.090	59.16	30.0	1.6
60.0	196.8	15.430	59.77	68.0	3.7
65.0	213.2	15.750	60.35	64.0	3.5
70.0	229.6	16.020	60.84	54.0	3.0
75.0	246.0	16.230	61.21	42.0	2.3
80.0	262.4	16.440	61.59	42.0	2.3
85.0	278.8	16.670	62.01	46.0	2.5
90.0	295.2	16.880	62.38	42.0	2.3
95.0	311.6	17.120	62.82	48.0	2.6
100.0	328.0	17.360	63.25	48.0	2.6
105.0	344.4	17.600	63.68	48.0	2.6
110.0	360.8	17.810	64.06	42.0	2.3
115.0	377.2	18.010	64.42	40.0	2.2
120.0	393.6	18.260	64.87	50.0	2.7
125.0	410.0	18.370	65.07	22.0	1.2
130.0	426.4	18.620	65.52	50.0	2.7
135.0	442.8	18.860	65.95	48.0	2.6
140.0	459.2	19.100	66.38	48.0	2.6
145.0	475.6	19.420	66.96	64.0	3.5

LOCATION: WAGONTIRE LEG, OREGON
24S/26E-24AC
HOLE NUMBER: BR-75-13
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
5.0	16.4	11.535	52.76	.0	.0
7.5	24.6	11.970	53.55	174.0	9.5
10.0	32.8	12.500	54.50	212.0	11.6
12.5	41.0	13.000	55.40	200.0	11.0
15.0	49.2	13.590	56.46	236.0	13.0
17.5	57.4	14.090	57.36	200.0	11.0
20.0	65.6	14.880	58.78	316.0	17.3
22.5	73.8	15.470	59.85	236.0	13.0
25.0	82.0	15.830	60.49	144.0	7.9
27.5	90.2	16.570	61.83	296.0	16.2
30.0	98.4	16.905	62.43	134.0	7.4
32.5	106.6	17.510	63.52	242.0	13.3
35.0	114.8	17.880	64.18	148.0	8.1
37.5	123.0	18.490	65.28	244.0	13.4
40.0	131.2	18.820	65.88	132.0	7.2
42.5	139.4	19.155	66.48	134.0	7.4
45.0	147.6	19.465	67.04	124.0	6.8
47.5	155.8	19.660	67.39	78.0	4.3
50.0	164.0	19.880	67.78	88.0	4.8
52.5	172.2	20.070	68.13	76.0	4.2
55.0	180.4	20.260	68.47	76.0	4.2
57.5	188.6	20.465	68.84	82.0	4.5
60.0	196.8	20.675	69.21	84.0	4.6
61.5	201.7	20.745	69.34	46.7	2.6

LOCATION: LAWEN, OREGON
24S/32.5E-23DD
HOLE NUMBER:
DATE MEASURED: 7/21/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
5.0	16.4	16.050	60.89	.0	.0
10.0	32.8	15.330	59.59	-144.0	-7.9
15.0	49.2	15.630	60.13	60.0	3.3
20.0	65.6	15.640	60.15	2.0	.1
25.0	82.0	15.650	60.17	2.0	.1
30.0	98.4	15.700	60.26	10.0	.5
35.0	114.8	15.750	60.35	10.0	.5
40.0	131.2	15.810	60.46	12.0	.7
45.0	147.6	15.870	60.57	12.0	.7
50.0	164.0	15.900	60.62	6.0	.3
55.0	180.4	15.920	60.66	4.0	.2
60.0	196.8	15.980	60.76	12.0	.7
65.0	213.2	16.000	60.80	4.0	.2
70.0	229.6	16.310	61.36	62.0	3.4
75.0	246.0	16.340	61.41	6.0	.3
80.0	262.4	16.660	61.99	64.0	3.5
85.0	278.8	16.750	62.15	18.0	1.0
90.0	295.2	17.170	62.91	84.0	4.6
95.0	311.6	17.490	63.48	64.0	3.5
100.0	328.0	17.700	63.86	42.0	2.3
105.0	344.4	17.980	64.36	56.0	3.1
110.0	360.8	18.300	64.94	64.0	3.5
115.0	377.2	18.630	65.53	66.0	3.6
120.0	393.6	18.880	65.98	50.0	2.7
125.0	410.0	19.210	66.58	66.0	3.6
130.0	426.4	19.510	67.12	60.0	3.3
135.0	442.8	19.760	67.57	50.0	2.7
140.0	459.2	19.950	67.91	38.0	2.1
145.0	475.6	20.650	69.17	140.0	7.7
150.0	492.0	20.910	69.64	52.0	2.9

LOCATION: CRANE, OREGON
24S/33E-35AD

HOLE NUMBER:
DATE MEASURED: 7/21/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	13.230	55.81	.0	.0
10.0	32.8	13.640	56.55	82.0	4.5
15.0	49.2	14.140	57.45	100.0	5.5
20.0	65.6	14.750	58.55	122.0	6.7
25.0	82.0	15.290	59.52	108.0	5.9
30.0	98.4	15.870	60.57	116.0	6.4
35.0	114.8	16.350	61.43	96.0	5.3
40.0	131.2	16.810	62.26	92.0	5.0
45.0	147.6	17.130	62.83	64.0	3.5
50.0	164.0	17.480	63.46	70.0	3.8
55.0	180.4	17.980	64.36	100.0	5.5
60.0	196.8	18.470	65.25	98.0	5.4
65.0	213.2	19.010	66.22	108.0	5.9
70.0	229.6	19.380	66.88	74.0	4.1
75.0	246.0	19.800	67.64	84.0	4.6
80.0	262.4	20.000	68.00	40.0	2.2
85.0	278.8	20.270	68.49	54.0	3.0

LOCATION: WAGONTIRE, OREGON
25S/25E-22B

HOLE NUMBER:
DATE MEASURED: 6/19/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	11.690	53.04	.0	.0
10.0	32.8	10.410	50.74	-256.0	-14.0
15.0	49.2	10.070	50.13	-68.0	-3.7
20.0	65.6	10.040	50.07	-6.0	-.3
25.0	82.0	9.750	49.55	-58.0	-3.2
30.0	98.4	9.460	49.03	-58.0	-3.2
35.0	114.8	9.300	48.74	-32.0	-1.8
40.0	131.2	9.540	49.17	48.0	2.6
45.0	147.6	9.800	49.64	52.0	2.9

LOCATION: WAGONTIRE LEG, OREGON
25S/26E-4CC
HOLE NUMBER: BR-75-14
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	11.110	52.00	.0	.0
7.5	24.6	10.240	50.43	-348.0	-19.1
10.0	32.8	10.450	50.81	84.0	4.6
12.5	41.0	10.730	51.31	112.0	6.1
15.0	49.2	10.900	51.62	68.0	3.7
17.5	57.4	11.030	51.85	52.0	2.9
20.0	65.6	11.170	52.11	56.0	3.1
22.5	73.8	11.310	52.36	56.0	3.1
25.0	82.0	11.550	52.79	96.0	5.3
27.5	90.2	11.775	53.19	90.0	4.9

LOCATION: DOUBLE-O LEG, OREGON
25S/31E-4BB
HOLE NUMBER: BR-75-11
DATE MEASURED: 9/16/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
2.5	8.2	13.340	56.01	.0	.0
5.0	16.4	10.510	50.92	-1132.0	-62.1
7.5	24.6	10.240	50.43	-108.0	-5.9
10.0	32.8	10.460	50.83	88.0	4.8
12.5	41.0	10.480	50.86	8.0	.4
15.0	49.2	10.490	50.88	4.0	.2
17.5	57.4	10.490	50.88	.0	.0
20.0	65.6	10.540	50.97	20.0	1.1
22.5	73.8	10.540	50.97	.0	.0
25.0	82.0	10.550	50.99	4.0	.2
27.5	90.2	10.600	51.08	20.0	1.1
30.0	98.4	10.650	51.17	20.0	1.1
32.5	106.6	10.700	51.26	20.0	1.1
35.0	114.8	10.750	51.35	20.0	1.1
37.5	123.0	10.810	51.46	24.0	1.3
40.0	131.2	10.880	51.58	28.0	1.5
42.5	139.4	10.950	51.71	28.0	1.5
45.0	147.6	11.030	51.85	32.0	1.8
47.5	155.8	11.100	51.98	28.0	1.5
50.0	164.0	11.180	52.12	32.0	1.8
52.5	172.2	11.270	52.29	36.0	2.0
55.0	180.4	11.320	52.38	20.0	1.1
57.5	188.6	11.410	52.54	36.0	2.0
60.0	196.8	11.490	52.68	32.0	1.8

LOCATION: DIAMOND LEG, OREGON
25S/33E-3BD
HOLE NUMBER: BR-75-1
DATE MEASURED: 11/22/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
2.5	8.2	12.450	54.41	.0	.0
5.0	16.4	12.150	53.87	-120.0	-6.6
7.5	24.6	11.980	53.56	-68.0	-3.7
10.0	32.8	12.430	54.37	180.0	9.9
12.5	41.0	12.950	55.31	208.0	11.4
15.0	49.2	13.580	56.44	252.0	13.8
17.5	57.4	14.090	57.36	204.0	11.2
20.0	65.6	14.570	58.23	192.0	10.5
22.5	73.8	15.130	59.23	224.0	12.3
25.0	82.0	15.600	60.08	188.0	10.3
27.5	90.2	15.910	60.64	124.0	6.8
28.6	93.8	16.040	60.87	118.2	6.5

LOCATION: CRANE, OREGON
25S/33E-11BBB
HOLE NUMBER: KR-1
DATE MEASURED: 6/12/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
5.0	16.4	13.950	57.11	.0	.0
10.0	32.8	13.970	57.15	4.0	.2
15.0	49.2	13.970	57.15	.0	.0
20.0	65.6	13.970	57.15	.0	.0
25.0	82.0	13.980	57.16	2.0	.1
30.0	98.4	13.960	57.13	-4.0	-.2
35.0	114.8	13.990	57.18	6.0	.3
40.0	131.2	14.390	57.90	80.0	4.4
45.0	147.6	14.440	57.99	10.0	.5
50.0	164.0	15.200	59.36	152.0	8.3
55.0	180.4	15.440	59.79	48.0	2.6
60.0	196.8	15.610	60.10	34.0	1.9
65.0	213.2	15.750	60.35	28.0	1.5

LOCATION: BOISE AMS, OREGON
25S/46E/18AAA
HOLE NUMBER: RDH-RM
DATE MEASURED: 12/ 8/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
10.0	32.8	12.110	53.80	.0	.0
15.0	49.2	12.520	54.54	82.0	4.5
20.0	65.6	12.790	55.02	54.0	3.0
25.0	82.0	12.910	55.24	24.0	1.3
30.0	98.4	13.180	55.72	54.0	3.0
35.0	114.8	13.490	56.28	62.0	3.4
40.0	131.2	13.810	56.86	64.0	3.5
45.0	147.6	13.990	57.18	36.0	2.0
50.0	164.0	14.200	57.56	42.0	2.3
55.0	180.4	14.380	57.88	36.0	2.0
60.0	196.8	14.640	58.35	52.0	2.9
65.0	213.2	14.950	58.91	62.0	3.4
70.0	229.6	15.200	59.36	50.0	2.7
75.0	246.0	15.480	59.86	56.0	3.1
80.0	262.4	15.770	60.39	58.0	3.2
85.0	278.8	16.060	60.91	58.0	3.2
90.0	295.2	16.400	61.52	68.0	3.7
95.0	311.6	16.580	61.84	36.0	2.0
100.0	328.0	16.960	62.53	76.0	4.2
105.0	344.4	17.260	63.07	60.0	3.3
110.0	360.8	17.610	63.70	70.0	3.8
115.0	377.2	17.850	64.13	48.0	2.6
120.0	393.6	18.050	64.49	40.0	2.2
125.0	410.0	18.300	64.94	50.0	2.7
130.0	426.4	18.500	65.30	40.0	2.2
135.0	442.8	18.730	65.71	46.0	2.5
140.0	459.2	19.000	66.20	54.0	3.0
145.0	475.6	19.230	66.61	46.0	2.5
150.0	492.0	19.460	67.03	46.0	2.5

LOCATION: WAGONTIRE LEG, OREGON
26S/24E-24AD
HOLE NUMBER: BR-75-17
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
5.0	16.4	10.585	51.05	.0	.0
7.5	24.6	10.725	51.30	56.0	3.1
10.0	32.8	11.025	51.84	120.0	6.6
12.5	41.0	11.180	52.12	62.0	3.4
15.0	49.2	11.320	52.38	56.0	3.1
17.5	57.4	11.495	52.69	70.0	3.8
20.0	65.6	11.705	53.07	84.0	4.6
22.5	73.8	11.840	53.31	54.0	3.0
25.0	82.0	12.075	53.73	94.0	5.2
27.5	90.2	12.330	54.19	102.0	5.6
30.0	98.4	12.540	54.57	84.0	4.6
32.5	106.6	12.760	54.97	88.0	4.8
35.0	114.8	12.970	55.35	84.0	4.6
37.5	123.0	13.185	55.73	86.0	4.7
40.0	131.2	13.415	56.15	92.0	5.0
42.5	139.4	13.655	56.58	96.0	5.3
45.0	147.6	13.845	56.92	76.0	4.2
47.5	155.8	14.035	57.26	76.0	4.2
50.0	164.0	14.230	57.61	78.0	4.3
52.5	172.2	14.440	57.99	84.0	4.6
55.0	180.4	14.595	58.27	62.0	3.4
57.5	188.6	14.850	58.73	102.0	5.6
60.0	196.8	15.050	59.09	80.0	4.4

LOCATION: WAGONTIRE LEG, OREGON
26S/25E-20BB
HOLE NUMBER: BR-75-15
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
5.0	16.4	10.160	50.29	.0	.0
7.5	24.6	10.795	51.43	254.0	13.9
10.0	32.8	10.920	51.66	50.0	2.7
12.5	41.0	10.945	51.70	10.0	.5
15.0	49.2	10.965	51.74	8.0	.4
17.5	57.4	10.995	51.79	12.0	.7
20.0	65.6	11.040	51.87	18.0	1.0
22.5	73.8	11.095	51.97	22.0	1.2

LOCATION: DOUBLE-O LEG, OREGON
26S/30E-3BB
HOLE NUMBER: BR-75-10
DATE MEASURED: 9/16/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
2.5	8.2	14.160	57.49	.0	.0
5.0	16.4	11.940	53.49	-888.0	-48.7
7.5	24.6	12.230	54.01	116.0	6.4
10.0	32.8	12.480	54.46	100.0	5.5
12.5	41.0	12.610	54.70	52.0	2.9
15.0	49.2	12.820	55.08	84.0	4.6
17.5	57.4	12.890	55.20	28.0	1.5
20.0	65.6	12.980	55.36	36.0	2.0
22.5	73.8	13.090	55.56	44.0	2.4
25.0	82.0	13.180	55.72	36.0	2.0
27.5	90.2	13.250	55.85	28.0	1.5
30.0	98.4	13.300	55.94	20.0	1.1

LOCATION: DOUBLE-O LEG, OREGON
~~26S/30E-20DB~~
HOLE NUMBER: BR-75-8
DATE MEASURED: 9/29/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
5.0	16.4	13.010	55.42	.0	.0
7.5	24.6	10.935	51.68	-830.0	-45.5
10.0	32.8	11.215	52.19	112.0	6.1
12.5	41.0	11.330	52.39	46.0	2.5
15.0	49.2	11.365	52.46	14.0	.8
17.5	57.4	11.720	53.10	142.0	7.8
20.0	65.6	12.085	53.75	146.0	8.0
22.5	73.8	12.095	53.77	4.0	.2
25.0	82.0	12.260	54.07	66.0	3.6

LOCATION: DOUBLE-O LEG, OREGON
26S/46E/28AB
HOLE NUMBER: RDH-RKVL
DATE MEASURED: 12/ 8/76

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
10.0	32.8	12.050	53.69	.0	.0
15.0	49.2	12.500	54.50	90.0	4.9
20.0	65.6	12.840	55.11	68.0	3.7
25.0	82.0	13.270	55.89	86.0	4.7
30.0	98.4	13.700	56.66	86.0	4.7
35.0	114.8	14.030	57.25	66.0	3.6
40.0	131.2	14.430	57.97	80.0	4.4
45.0	147.6	14.770	58.59	68.0	3.7
50.0	164.0	15.130	59.23	72.0	4.0
55.0	180.4	15.480	59.86	70.0	3.8
60.0	196.8	15.840	60.51	72.0	4.0
65.0	213.2	16.200	61.16	72.0	4.0
70.0	229.6	16.530	61.75	66.0	3.6
75.0	246.0	16.940	62.49	82.0	4.5
80.0	262.4	17.280	63.10	68.0	3.7
85.0	278.8	17.700	63.86	84.0	4.6
90.0	295.2	18.120	64.62	84.0	4.6
95.0	311.6	18.530	65.35	82.0	4.5
100.0	328.0	18.990	66.18	92.0	5.0
105.0	344.4	19.280	66.70	58.0	3.2
110.0	360.8	19.590	67.26	62.0	3.4
115.0	377.2	20.070	68.13	96.0	5.3
120.0	393.6	20.510	68.92	88.0	4.8
125.0	410.0	20.720	69.30	42.0	2.3

LOCATION: DOUBLE-O LEG, OREGON
27S/29E-21AC
HOLE NUMBER: BR-75-9
DATE MEASURED: 9/29/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	12.650	54.77	.0	.0
7.5	24.6	11.650	52.97	-400.0	-22.0
10.0	32.8	11.140	52.05	-204.0	-11.2
12.5	41.0	11.420	52.56	112.0	6.1
15.0	49.2	11.630	52.93	84.0	4.6
17.5	57.4	11.770	53.19	56.0	3.1
20.0	65.6	11.880	53.38	44.0	2.4
22.5	73.8	11.970	53.55	36.0	2.0
25.0	82.0	12.070	53.73	40.0	2.2
27.5	90.2	12.195	53.95	50.0	2.7
30.0	98.4	12.325	54.18	52.0	2.9
32.5	106.6	12.450	54.41	50.0	2.7
35.0	114.8	12.600	54.68	60.0	3.3
37.5	123.0	12.730	54.91	52.0	2.9
40.0	131.2	12.860	55.15	52.0	2.9
42.5	139.4	13.010	55.42	60.0	3.3
45.0	147.6	13.180	55.72	68.0	3.7

LOCATION: COYOTE BUTTE, OREGON
27S/30E-36CC
HOLE NUMBER: BR-75-7
DATE MEASURED: 9/16/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
2.5	8.2	12.000	53.60	.0	.0
5.0	16.4	10.280	50.50	-688.0	-37.8
7.5	24.6	10.670	51.21	156.0	8.6
10.0	32.8	11.040	51.87	148.0	8.1
12.5	41.0	11.200	52.16	64.0	3.5
15.0	49.2	11.360	52.45	64.0	3.5
17.5	57.4	11.650	52.97	116.0	6.4
20.0	65.6	12.060	53.71	164.0	9.0
22.5	73.8	12.160	53.89	40.0	2.2
25.0	82.0	12.340	54.21	72.0	4.0
27.5	90.2	12.530	54.55	76.0	4.2
30.0	98.4	12.770	54.99	96.0	5.3
32.5	106.6	12.980	55.36	84.0	4.6
35.0	114.8	13.200	55.76	88.0	4.8
37.5	123.0	13.430	56.17	92.0	5.0
40.0	131.2	13.640	56.55	84.0	4.6
42.5	139.4	13.850	56.93	84.0	4.6
45.0	147.6	14.070	57.33	88.0	4.8
47.5	155.8	14.260	57.67	76.0	4.2
50.0	164.0	14.470	58.05	84.0	4.6
52.5	172.2	14.640	58.35	68.0	3.7
55.0	180.4	14.710	58.48	28.0	1.5
57.5	188.6	15.160	59.29	180.0	9.9
60.0	196.8	15.410	59.74	100.0	5.5
62.5	205.0	15.650	60.17	96.0	5.3
65.0	213.2	15.890	60.60	96.0	5.3
67.5	221.4	16.120	61.02	92.0	5.0

LOCATION: MALHEUR LAKE, OREGON
27S/32E-23BB
HOLE NUMBER: VW-2
DATE MEASURED: 7/17/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	10.100	50.18	.0	.0
10.0	32.8	12.090	53.76	398.0	21.8
15.0	49.2	12.090	53.76	.0	.0
20.0	65.6	12.100	53.78	2.0	.1
25.0	82.0	12.360	54.25	52.0	2.9
30.0	98.4	12.450	54.41	18.0	1.0
35.0	114.8	12.670	54.81	44.0	2.4
40.0	131.2	12.990	55.38	64.0	3.5
45.0	147.6	13.160	55.69	34.0	1.9
50.0	164.0	13.440	56.19	56.0	3.1
55.0	180.4	13.750	56.75	62.0	3.4
60.0	196.8	14.110	57.40	72.0	4.0
65.0	213.2	14.340	57.81	46.0	2.5
70.0	229.6	14.660	58.39	64.0	3.5
75.0	246.0	14.890	58.80	46.0	2.5
80.0	262.4	15.100	59.18	42.0	2.3
85.0	278.8	15.340	59.61	48.0	2.6
90.0	295.2	15.670	60.21	66.0	3.6
95.0	311.6	15.880	60.58	42.0	2.3
100.0	328.0	16.240	61.23	72.0	4.0
105.0	344.4	16.600	61.88	72.0	4.0
110.0	360.8	16.940	62.49	68.0	3.7
115.0	377.2	17.270	63.09	66.0	3.6
120.0	393.6	17.660	63.79	78.0	4.3
125.0	410.0	18.070	64.53	82.0	4.5
130.0	426.4	18.470	65.25	80.0	4.4
135.0	442.8	18.860	65.95	78.0	4.3
140.0	459.2	19.230	66.61	74.0	4.1

LOCATION: DIAMOND LEG, OREGON
27S/33E-33CB
HOLE NUMBER: BR-75-2
DATE MEASURED: 11/22/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
2.5	8.2	12.570	54.63	.0	.0
5.0	16.4	12.760	54.97	76.0	4.2
7.5	24.6	11.810	53.26	-380.0	-20.9
10.0	32.8	11.360	52.45	-180.0	-9.9
12.5	41.0	11.350	52.43	-4.0	-.2
15.0	49.2	11.350	52.43	.0	.0
17.5	57.4	11.310	52.36	-16.0	-.9
20.0	65.6	11.330	52.39	8.0	.4
22.5	73.8	11.290	52.32	-16.0	-.9
25.0	82.0	11.280	52.30	-4.0	-.2
27.5	90.2	11.290	52.32	4.0	.2
30.0	98.4	11.280	52.30	-4.0	-.2
30.5	100.0	11.290	52.32	20.0	1.1

LOCATION: WAGONTIRE LEG, OREGON
28S/24E-4BA
HOLE NUMBER: BR-75-16
DATE MEASURED: 9/30/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
5.0	16.4	10.145	50.26	.0	.0
7.5	24.6	9.340	48.81	-322.0	-17.7
10.0	32.8	9.340	48.81	.0	.0
12.5	41.0	9.520	49.14	72.0	4.0
15.0	49.2	9.655	49.38	54.0	3.0
17.5	57.4	9.760	49.57	42.0	2.3
20.0	65.6	9.890	49.80	52.0	2.9
22.5	73.8	10.040	50.07	60.0	3.3
25.0	82.0	10.200	50.36	64.0	3.5
27.5	90.2	10.255	50.46	22.0	1.2
30.0	98.4	10.365	50.66	44.0	2.4

LOCATION: COYOTE BUTTES, OREGON
28S/30E-13DA
HOLE NUMBER: HP-12
DATE MEASURED: 7/22/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
20.0	65.6	13.040	55.47	.0	.0
25.0	82.0	13.450	56.21	82.0	4.5

LOCATION: DIAMOND LEG, OREGON
28S/32E-36CC
HOLE NUMBER: BR-75-3
DATE MEASURED: 8/12/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
20.0	65.6	12.990	55.38	.0	.0
22.5	73.8	13.050	55.49	24.0	1.3
25.0	82.0	13.120	55.62	28.0	1.5
27.5	90.2	13.200	55.76	32.0	1.8
30.0	98.4	13.300	55.94	40.0	2.2
32.5	106.6	13.430	56.17	52.0	2.9
35.0	114.8	13.570	56.43	56.0	3.1
37.5	123.0	13.680	56.62	44.0	2.4
40.0	131.2	13.700	56.66	8.0	.4
42.5	139.4	13.700	56.66	.0	.0
45.0	147.6	13.700	56.66	.0	.0
47.5	155.8	13.710	56.68	4.0	.2
50.0	164.0	13.710	56.68	.0	.0

LOCATION: DIAMOND LEG, OREGON
29S/32E-34DC
HOLE NUMBER: BR-75-4
DATE MEASURED: 9/16/75

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
2.5	8.2	15.960	60.73	.0	.0
5.0	16.4	13.290	55.92	-1068.0	-58.6
7.5	24.6	12.120	53.82	-468.0	-25.7
10.0	32.8	12.100	53.78	-8.0	-.4
12.5	41.0	12.320	54.18	88.0	4.8
15.0	49.2	12.500	54.50	72.0	4.0
17.5	57.4	12.680	54.82	72.0	4.0
20.0	65.6	12.910	55.24	92.0	5.0
22.5	73.8	13.120	55.62	84.0	4.6
25.0	82.0	13.360	56.05	96.0	5.3
27.5	90.2	13.630	56.53	108.0	5.9
30.0	98.4	13.920	57.06	116.0	6.4
32.5	106.6	14.220	57.60	120.0	6.6
35.0	114.8	14.540	58.17	128.0	7.0
37.5	123.0	14.860	58.75	128.0	7.0
40.0	131.2	15.200	59.36	136.0	7.5
42.5	139.4	15.550	59.99	140.0	7.7
45.0	147.6	15.930	60.67	152.0	8.3
47.5	155.8	16.360	61.45	172.0	9.4
50.0	164.0	16.790	62.22	172.0	9.4
52.0	170.6	17.130	62.83	170.0	9.3

LOCATION: DIAMOND LEG, OREGON
30S/31E-23BC
HOLE NUMBER: BR-75-5
DATE MEASURED: 9/16/75

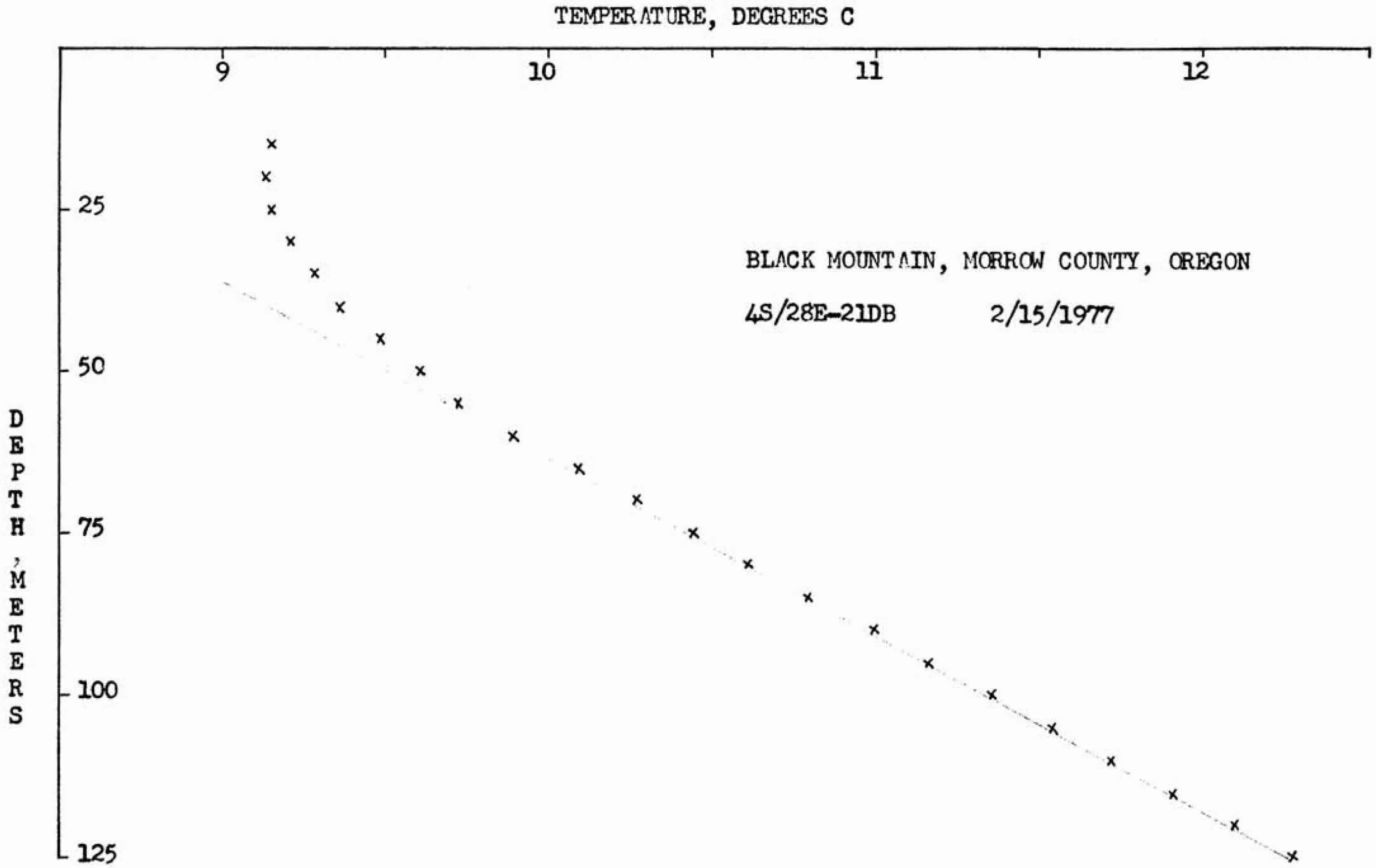
DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
2.5	8.2	14.700	58.46	.0	.0
5.0	16.4	11.890	53.40	-1124.0	-61.7
7.5	24.6	11.730	53.11	-64.0	-3.5
10.0	32.8	12.100	53.78	148.0	8.1
12.5	41.0	12.400	54.32	120.0	6.6
15.0	49.2	12.440	54.39	16.0	.9
17.5	57.4	12.530	54.55	36.0	2.0
20.0	65.6	12.730	54.91	80.0	4.4
22.5	73.8	12.800	55.04	28.0	1.5
25.0	82.0	12.830	55.09	12.0	.7
27.5	90.2	13.060	55.51	92.0	5.0
30.0	98.4	13.190	55.74	52.0	2.9

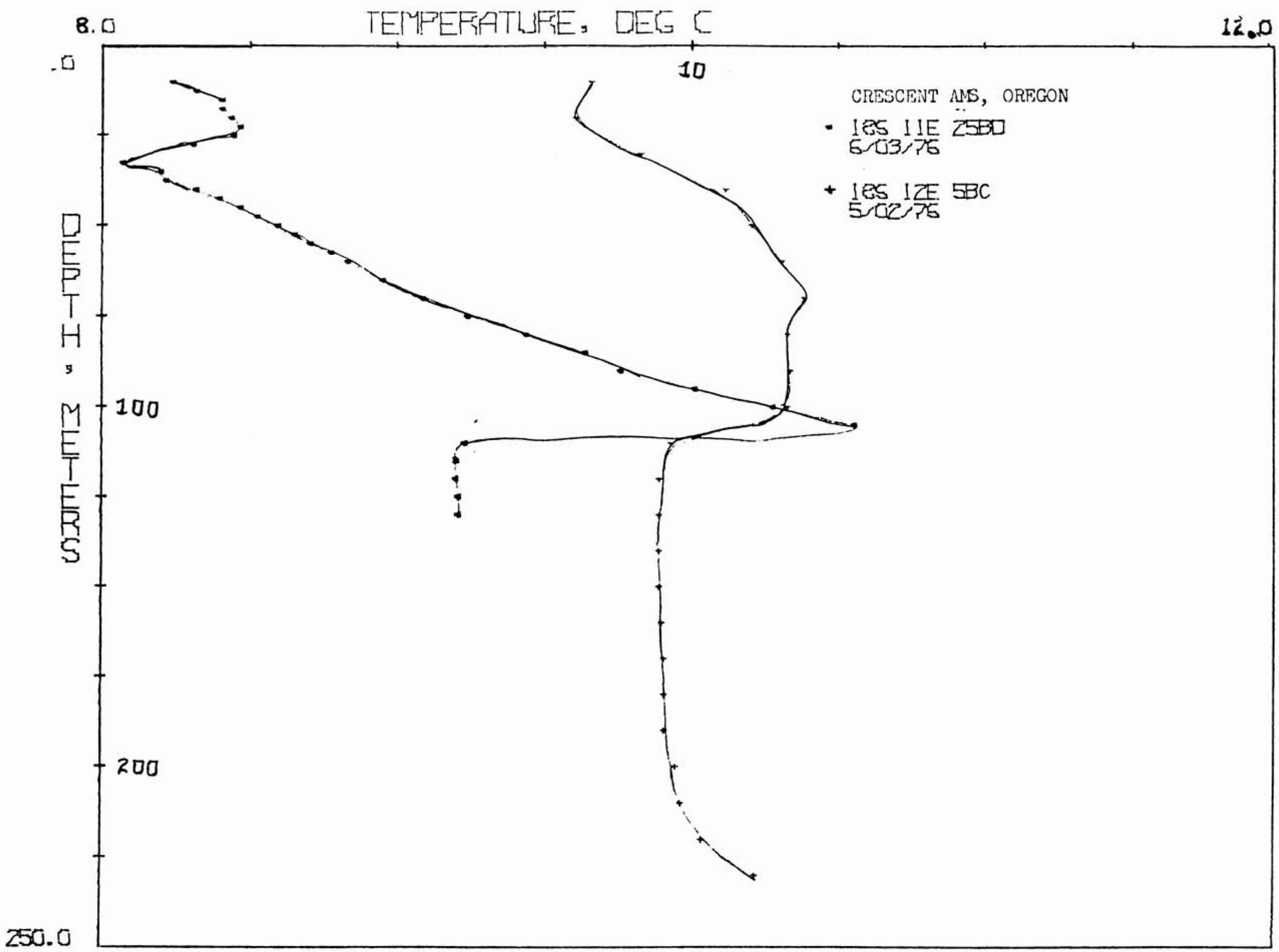
LOCATION: DIAMOND LEG, OREGON
32S/32E-16BA
HOLE NUMBER: BR-75-6
DATE MEASURED: 9/16/75

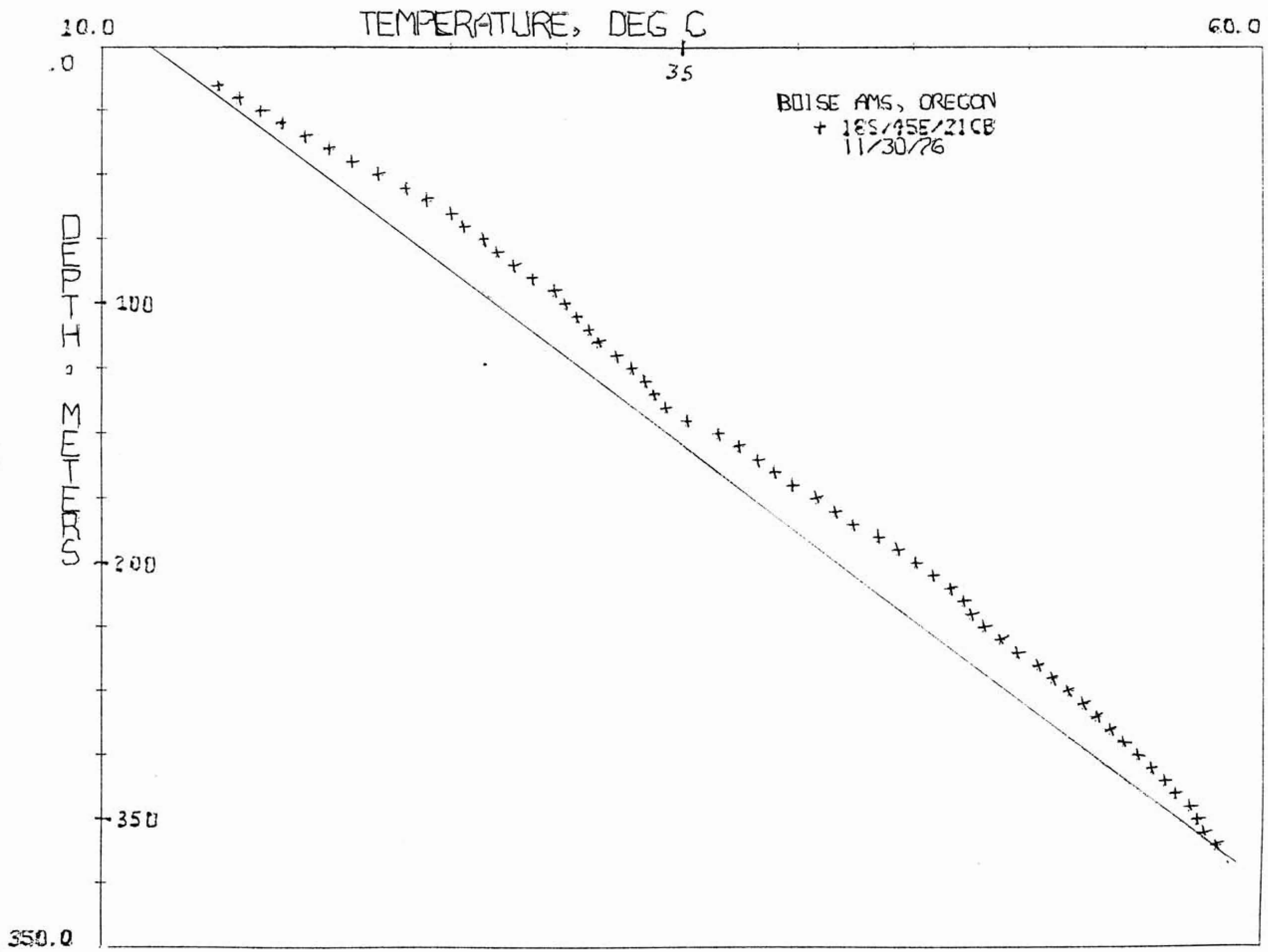
DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
2.5	8.2	13.890	57.00	.0	.0
5.0	16.4	10.600	51.08	-1316.0	-72.2
7.5	24.6	10.520	50.94	-32.0	-1.8
10.0	32.8	10.720	51.30	80.0	4.4
12.5	41.0	10.820	51.48	40.0	2.2
15.0	49.2	10.830	51.49	4.0	.2
17.5	57.4	10.850	51.53	8.0	.4
20.0	65.6	10.890	51.60	16.0	.9
22.5	73.8	10.930	51.67	16.0	.9
25.0	82.0	10.970	51.75	16.0	.9
27.5	90.2	11.020	51.84	20.0	1.1
30.0	98.4	11.060	51.91	16.0	.9
32.5	106.6	11.100	51.98	16.0	.9
35.0	114.8	11.140	52.05	16.0	.9
37.5	123.0	11.190	52.14	20.0	1.1
40.0	131.2	11.230	52.21	16.0	.9
42.5	139.4	11.270	52.29	16.0	.9
45.0	147.6	11.310	52.36	16.0	.9
47.5	155.8	11.360	52.45	20.0	1.1
50.0	164.0	11.400	52.52	16.0	.9
52.5	172.2	11.450	52.61	20.0	1.1
55.0	180.4	11.490	52.68	16.0	.9
57.5	188.6	11.540	52.77	20.0	1.1
60.0	196.8	11.590	52.86	20.0	1.1

APPENDIX B

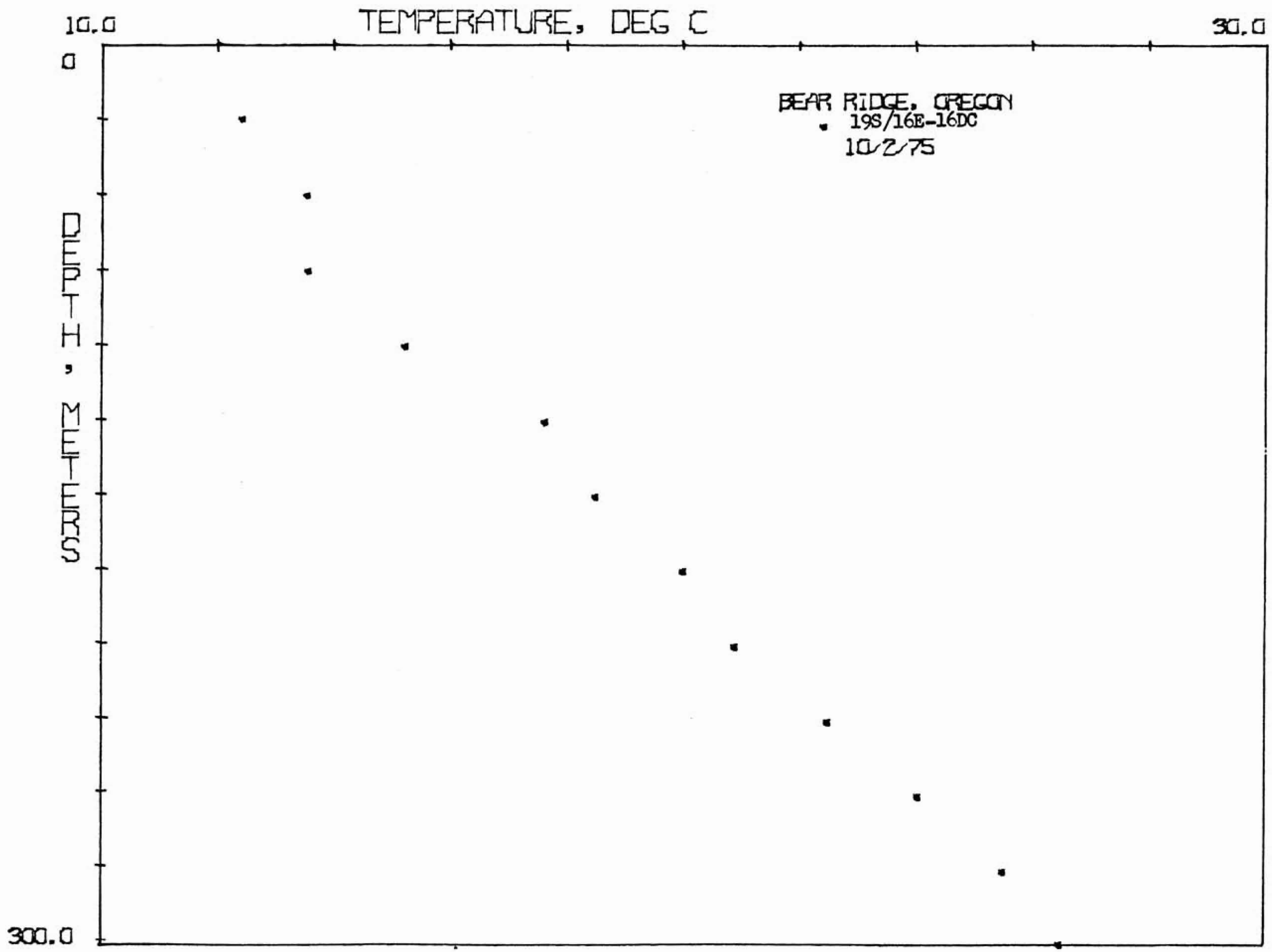
GEOTHERMAL GRADIENT GRAPHS

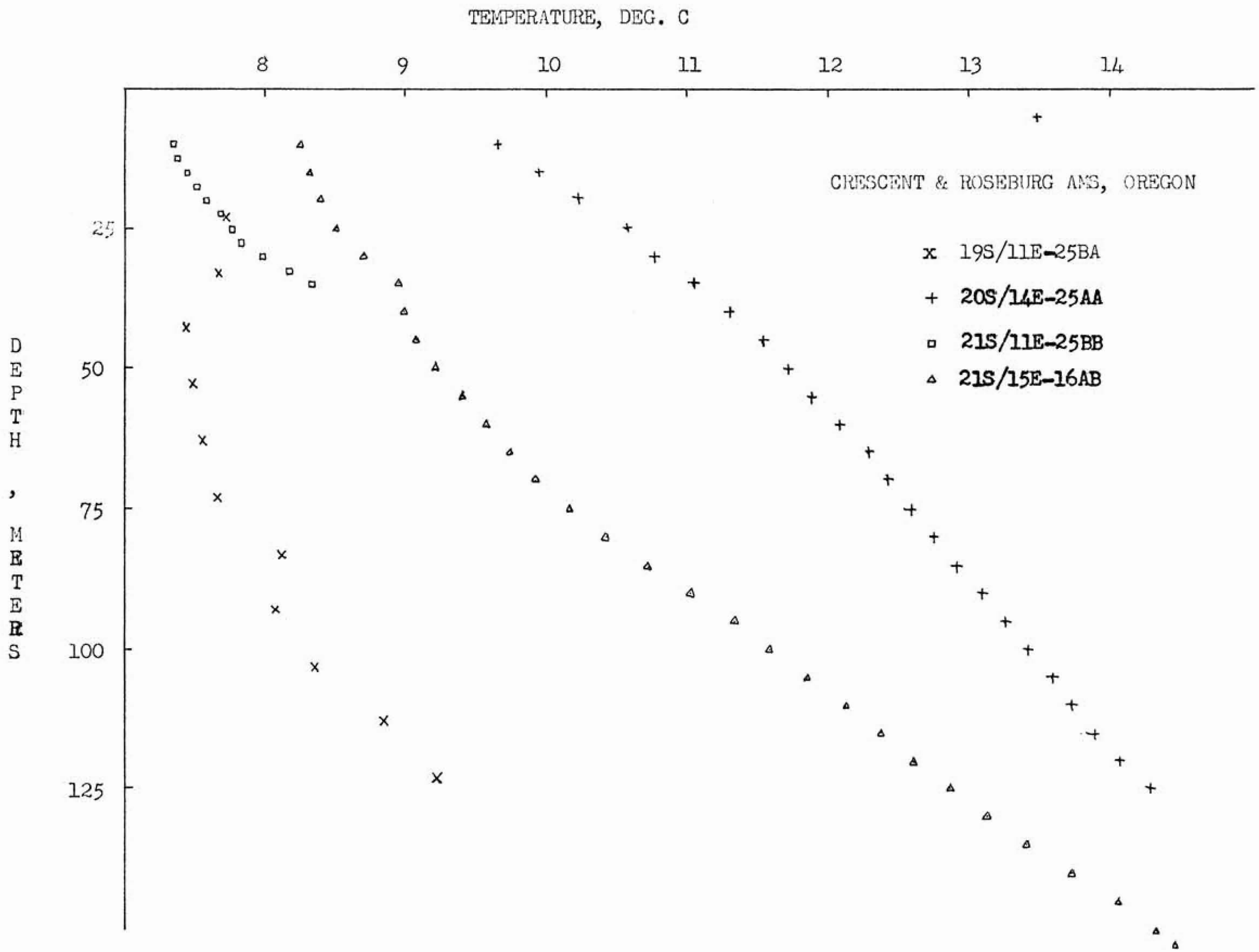

TEMPERATURE, DEGREES C
9
10
11
12
DEPTH, METERS
25
50
75
100
125
BLACK MOUNTAIN, MORROW COUNTY, OREGON
4S/28E-21DB
2/15/1977

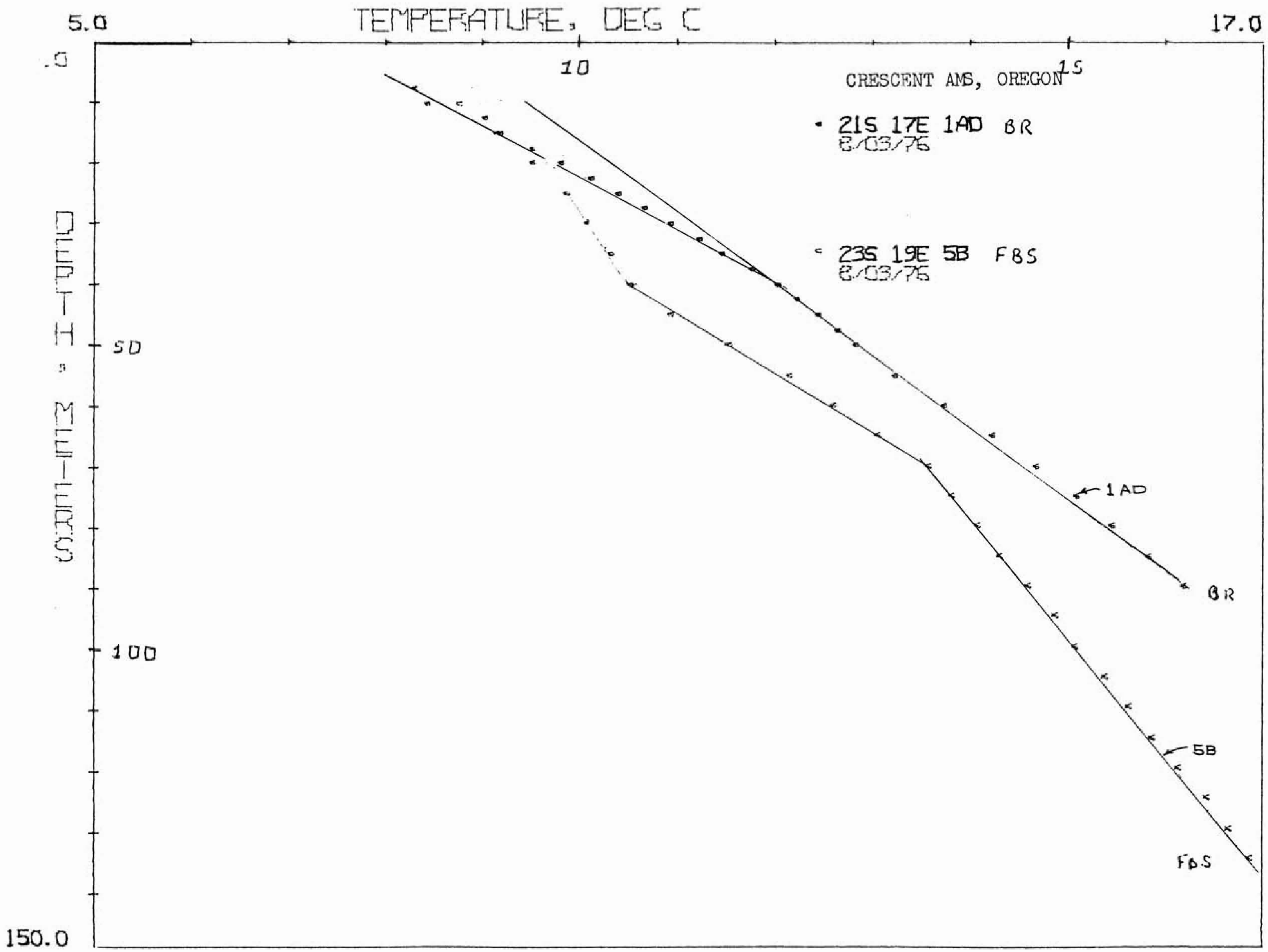

TEMPERATURE, DEG C
8.0
10
12.0
.0
100
200
250.0
DEPTH, METERS
CRESCENT AMS, OREGON
18S 11E 25BD
6/03/76
18S 12E 5BC
5/02/76

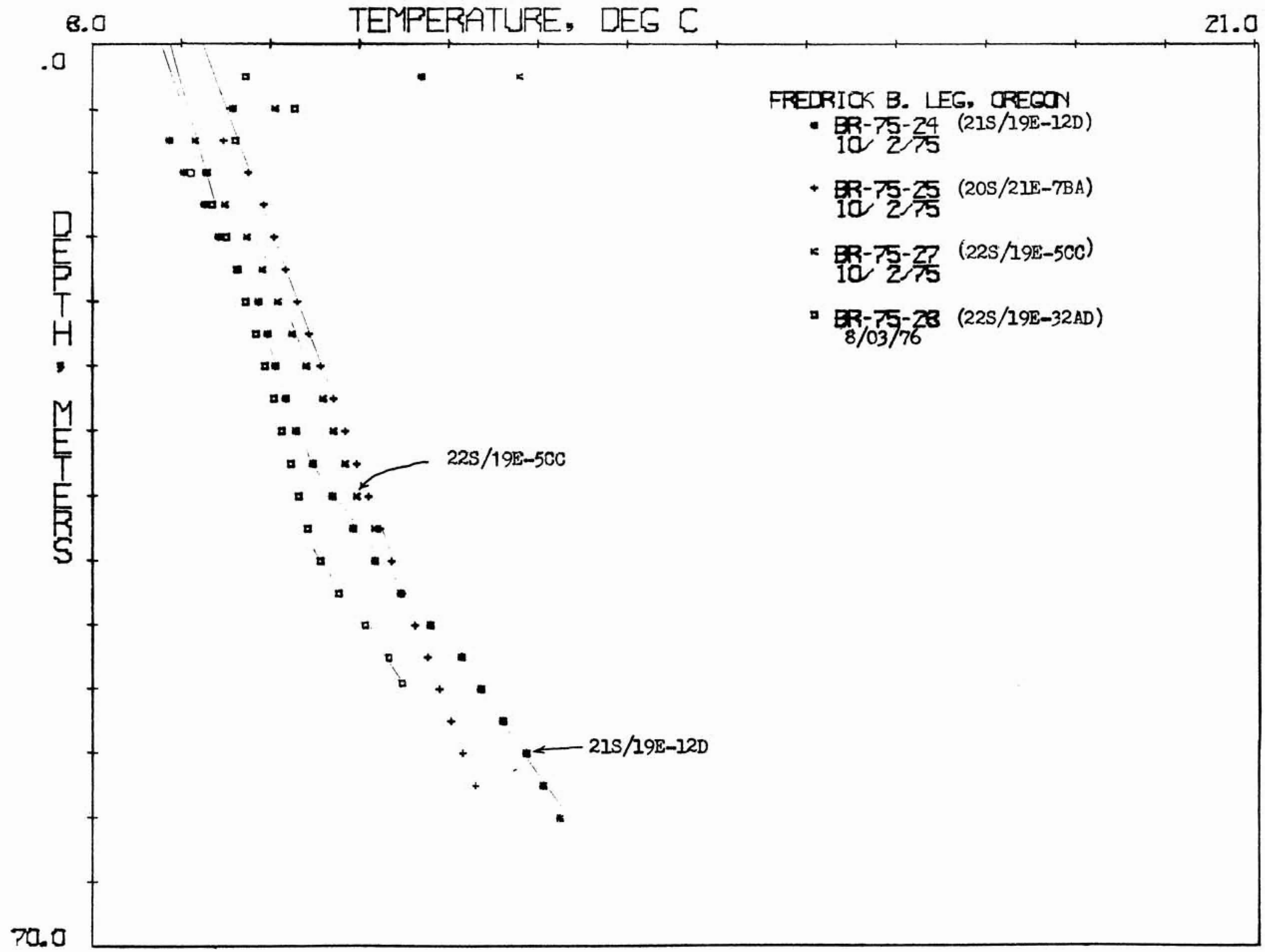


TEMPERATURE, DEG C
10.0
60.0
35
.0
100
200
350
350.0
DEPTH, METERS
BOISE AMS, OREGON
+ 18S/45E/21CB
11/30/76

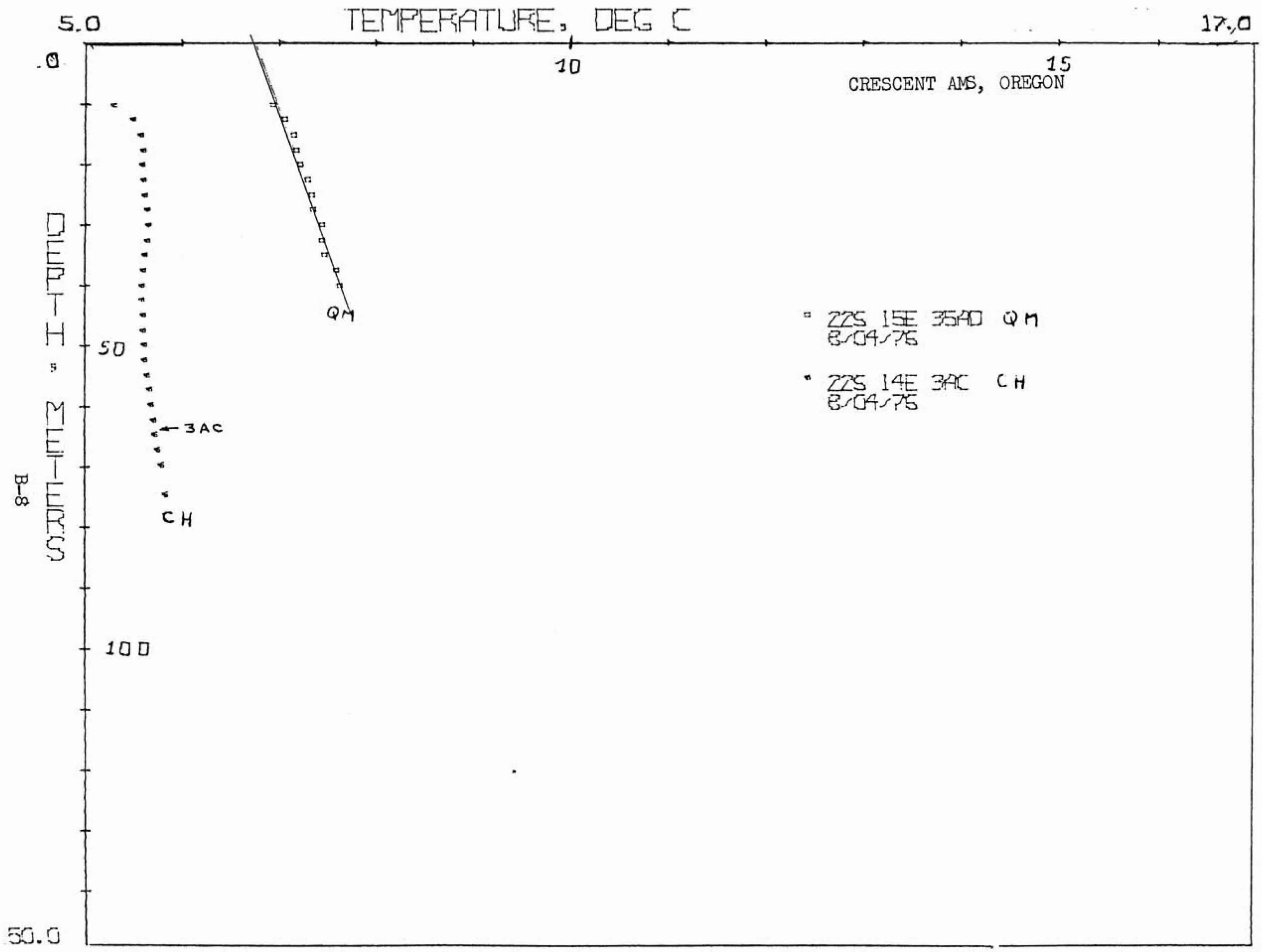

TEMPERATURE, DEG C
10.0
30.0
0
300.0
DEPTH, METERS
BEAR RIDGE, OREGON
19S/16E-16DC
10/2/75


TEMPERATURE, DEG. C
8
9
10
11
12
13
14
DEPTH, METERS
25
50
75
100
125
CRESCENT & ROSEBURG AMS, OREGON
x 19S/11E-25BA
+ 20S/14E-25AA
□ 21S/11E-25BB
△ 21S/15E-16AB

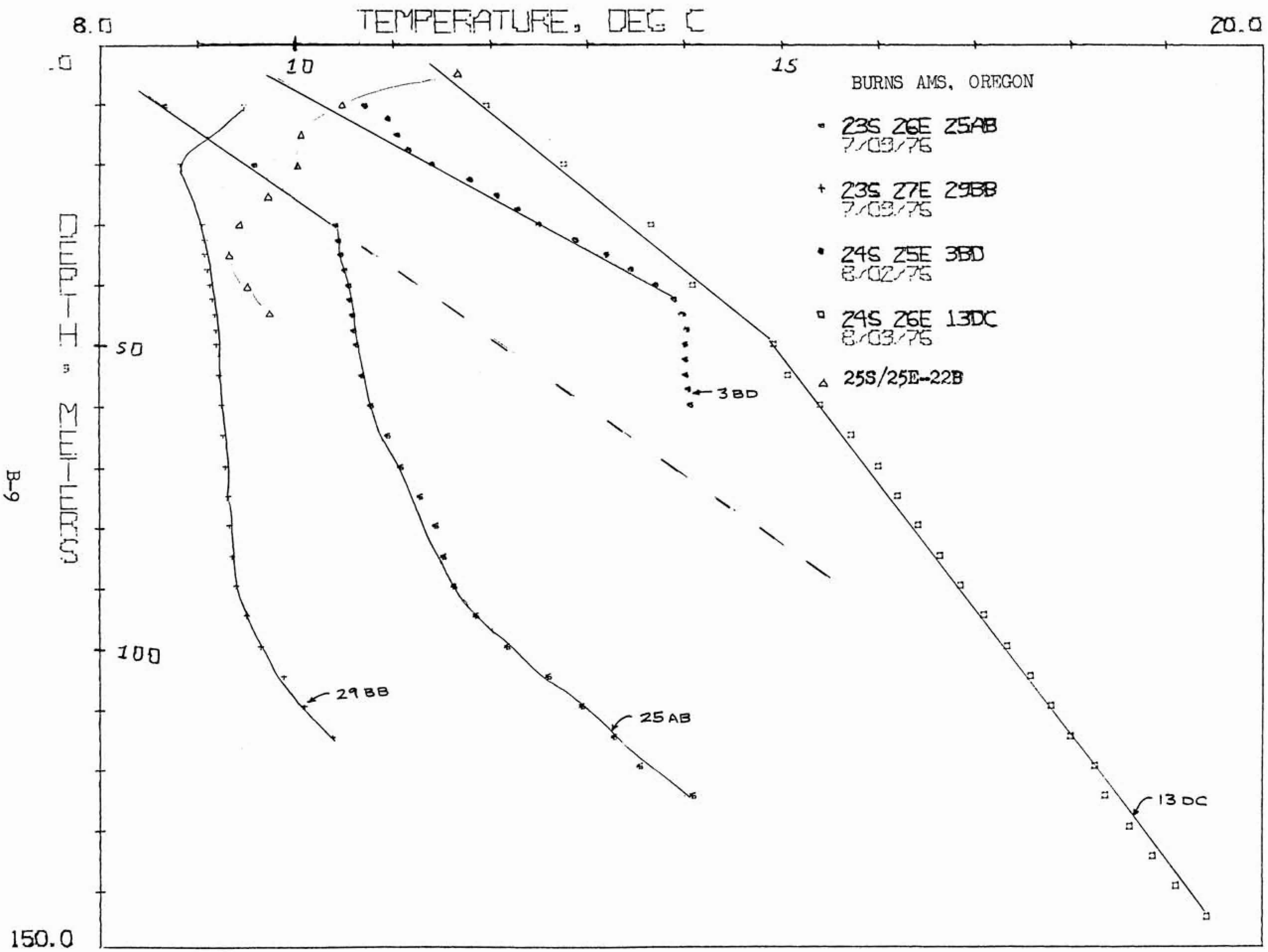

TEMPERATURE, DEG C
5.0
10
15
17.0
DEPTH, METERS
.0
50
100
150.0
CRESCENT AMS, OREGON
21S 17E 1AD BR
8/03/76
23S 19E 5B FBS
8/03/76
1AD
BR
5B
FBS



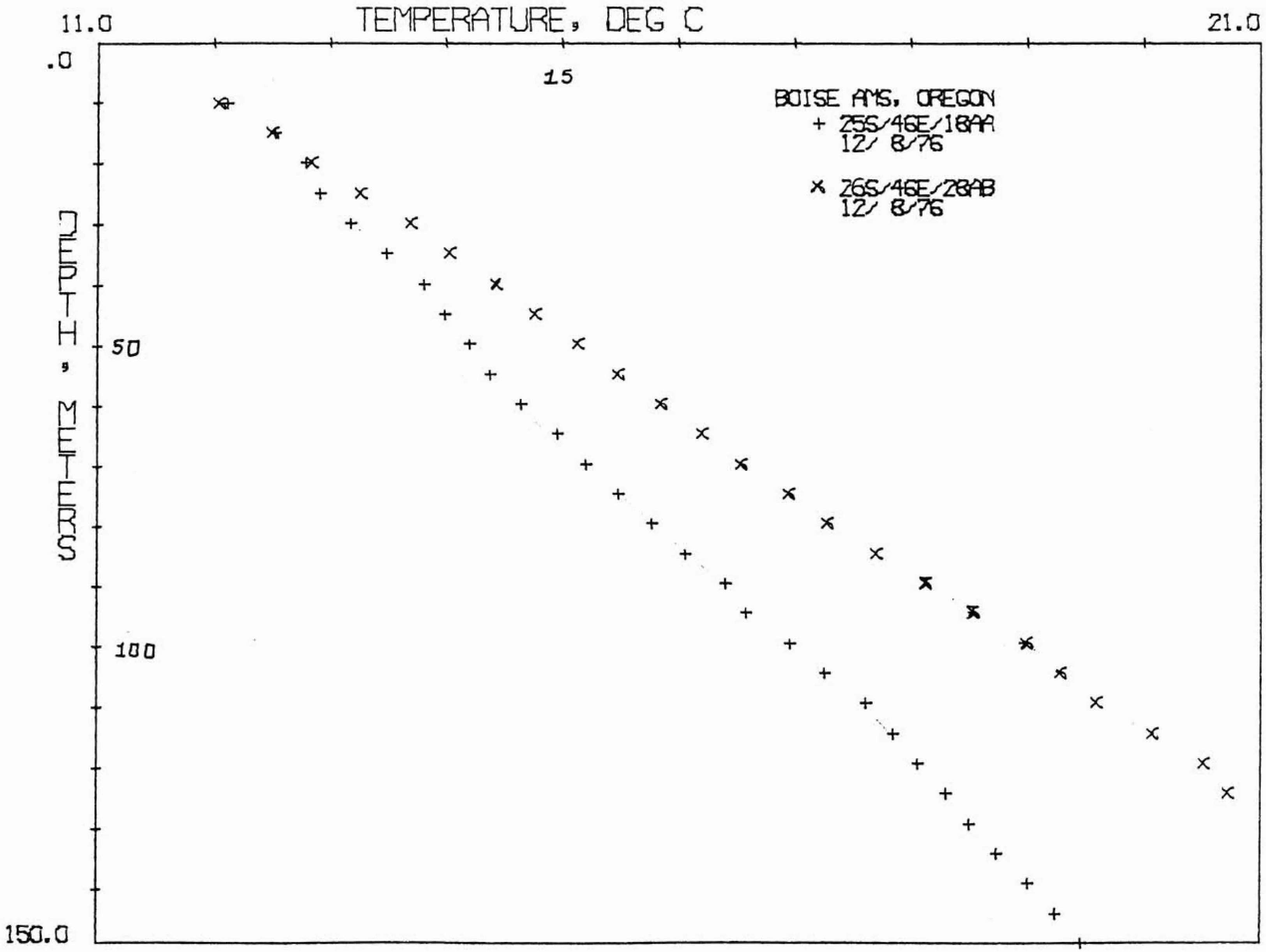
TEMPERATURE, DEG C
8.0
21.0
.0
70.0
DEPTH, METERS
FREDRICK B. LEG, OREGON
BR-75-24 (21S/19E-12D)
10/ 2/75
BR-75-25 (20S/21E-7BA)
10/ 2/75
BR-75-27 (22S/19E-5CC)
10/ 2/75
BR-75-28 (22S/19E-32AD)
8/03/76
22S/19E-5CC
21S/19E-12D

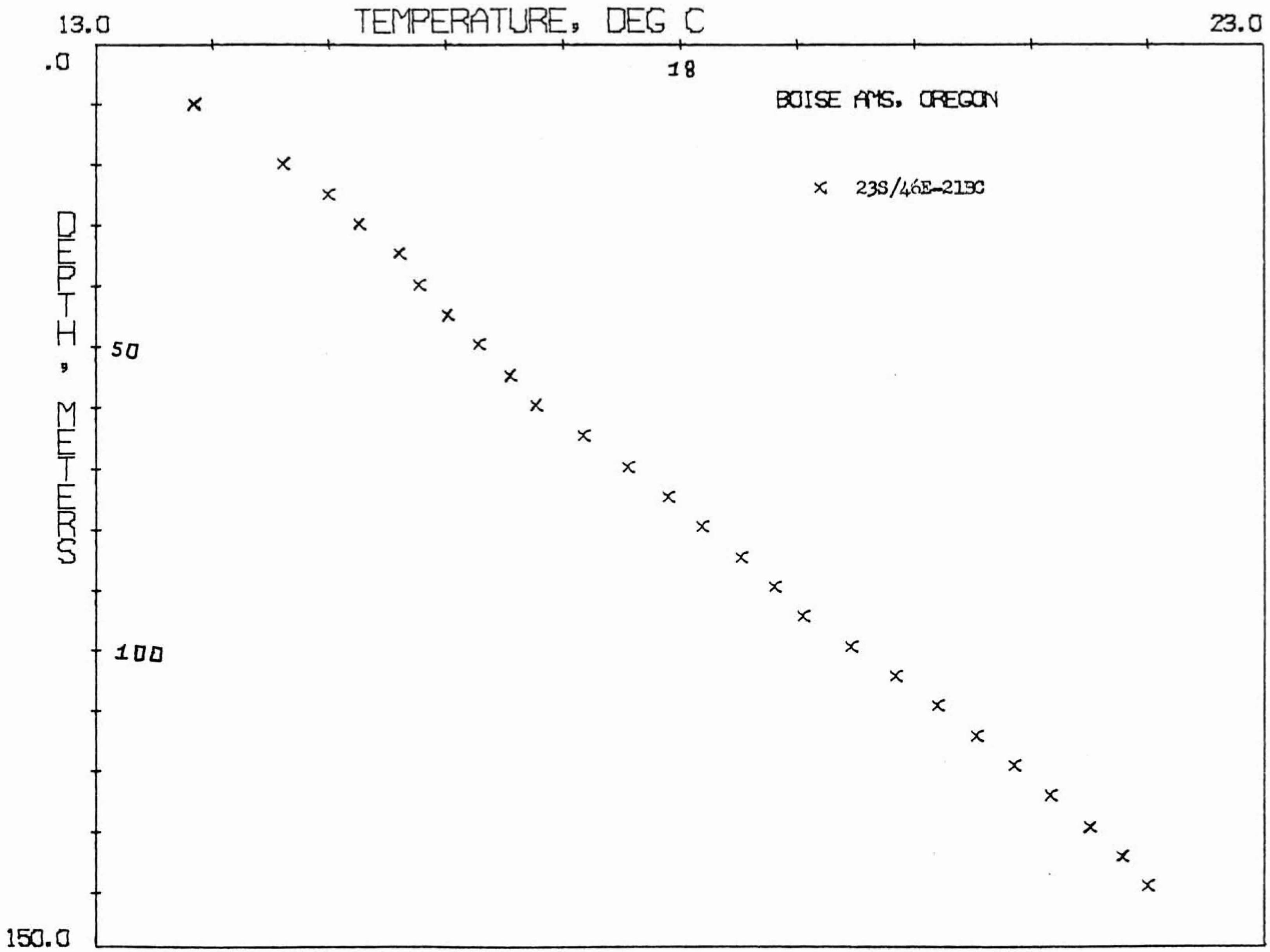

TEMPERATURE, DEG C
5.0
10
15
17.0
.0
50
100
150.0
DEPTH, METERS
CRESCENT AMS, OREGON
QM
3AC
CH
22S 15E 35AD QM
8/04/75
22S 14E 3AC CH
8/04/75

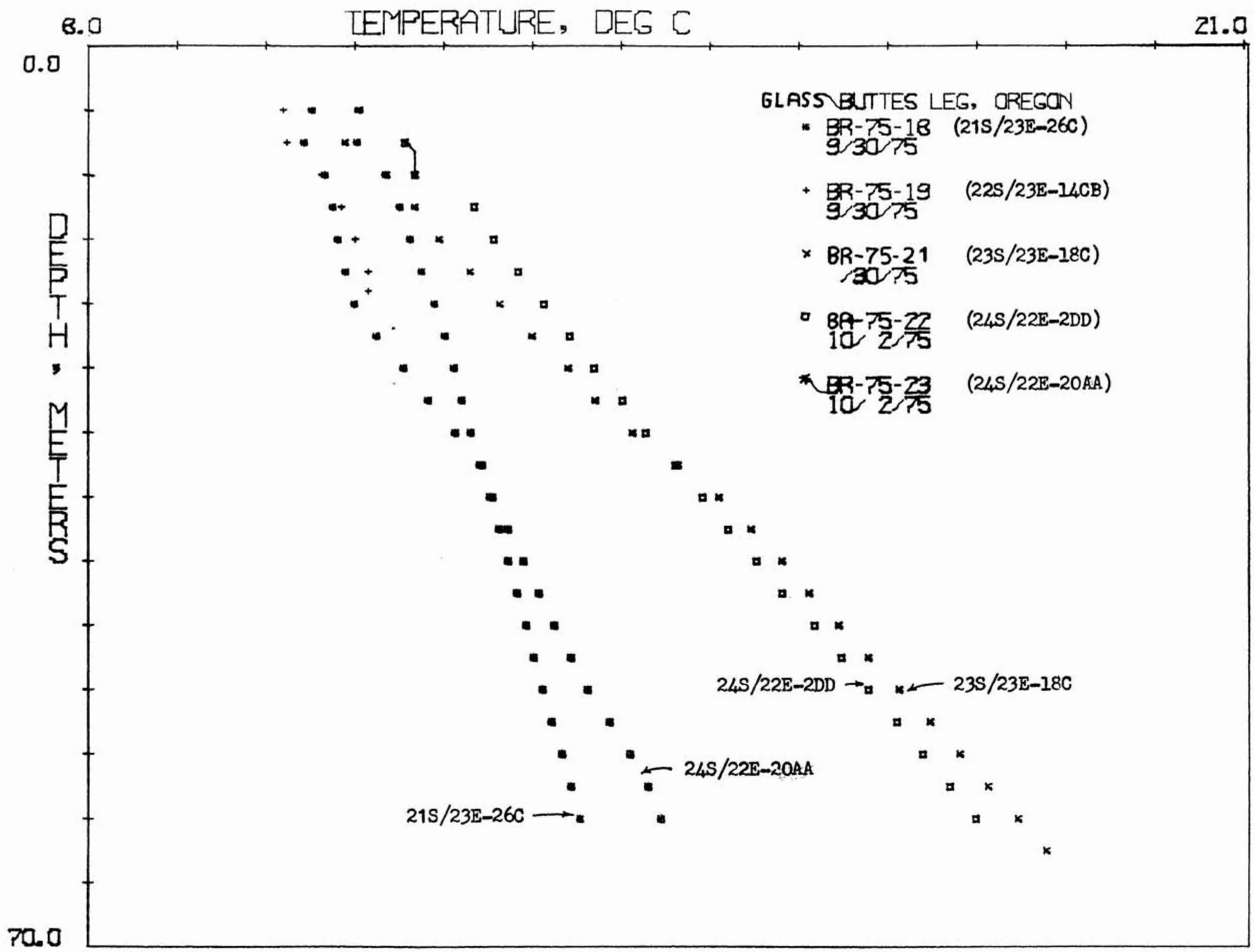
B-8

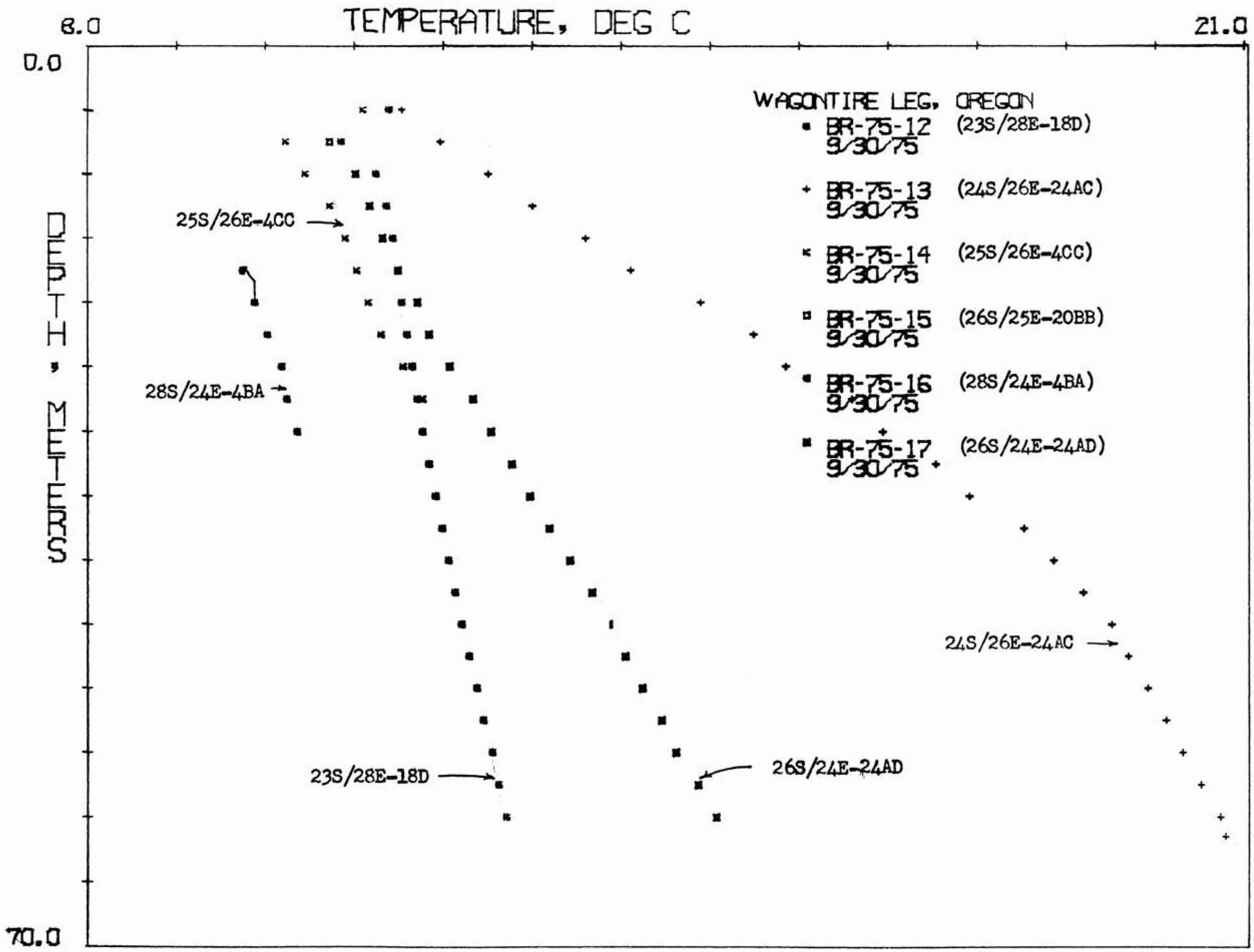


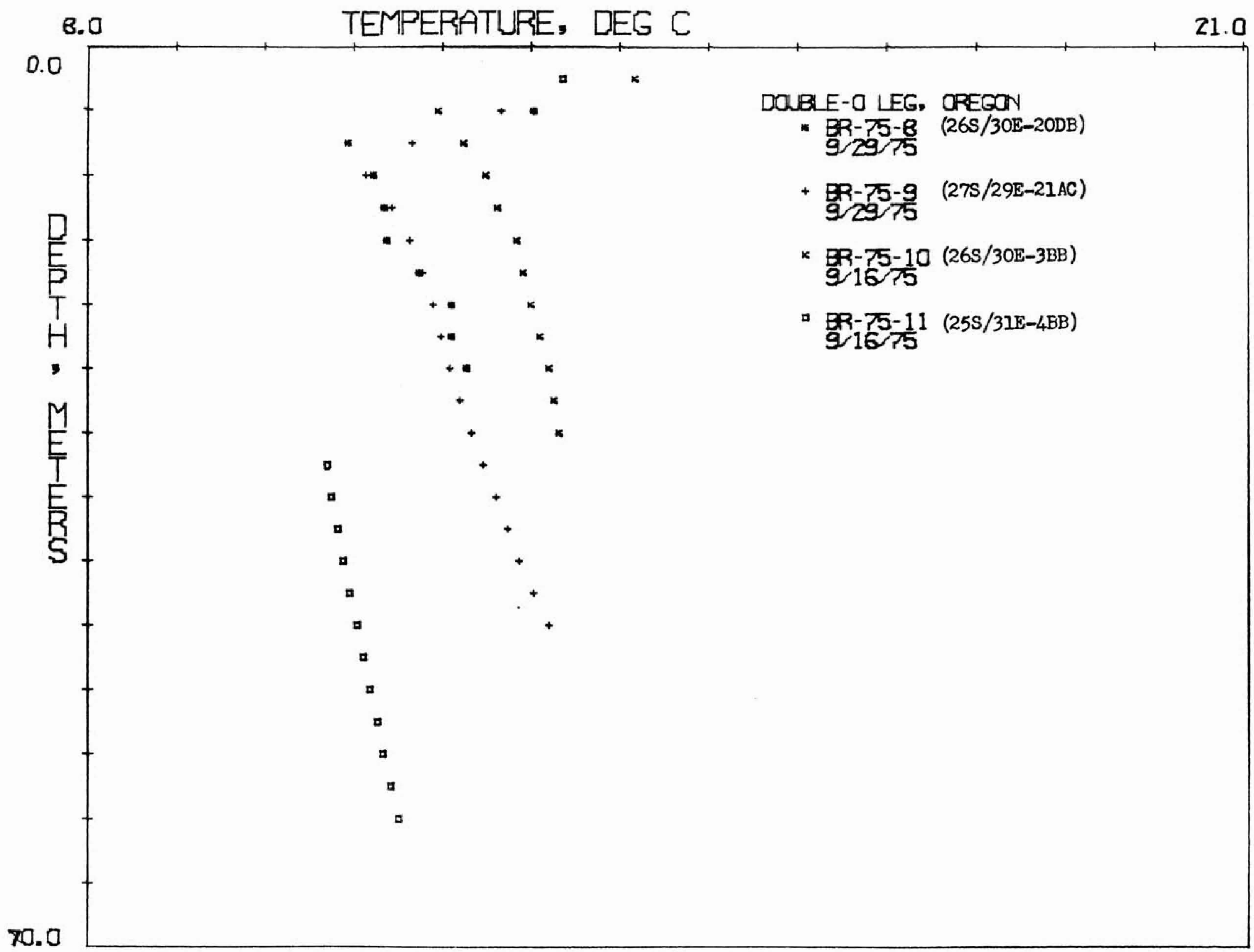
TEMPERATURE, DEG C
8.0
10
15
20.0
.0
50
100
150.0
DEPTH, METERS
BURNS AMS, OREGON
23S 26E 25AB
7/09/75
23S 27E 29BB
7/09/75
24S 25E 3BD
8/02/75
24S 26E 13DC
8/03/75
25S/25E-22B
3BD
29BB
25AB
13DC


TEMPERATURE, DEG C
11.0
21.0
15
.0
50
100
150.0
DEPTH, METERS
BOISE AMS, OREGON
+ 25S/46E/18AA
12/ 8/76
× 26S/46E/28AB
12/ 8/76

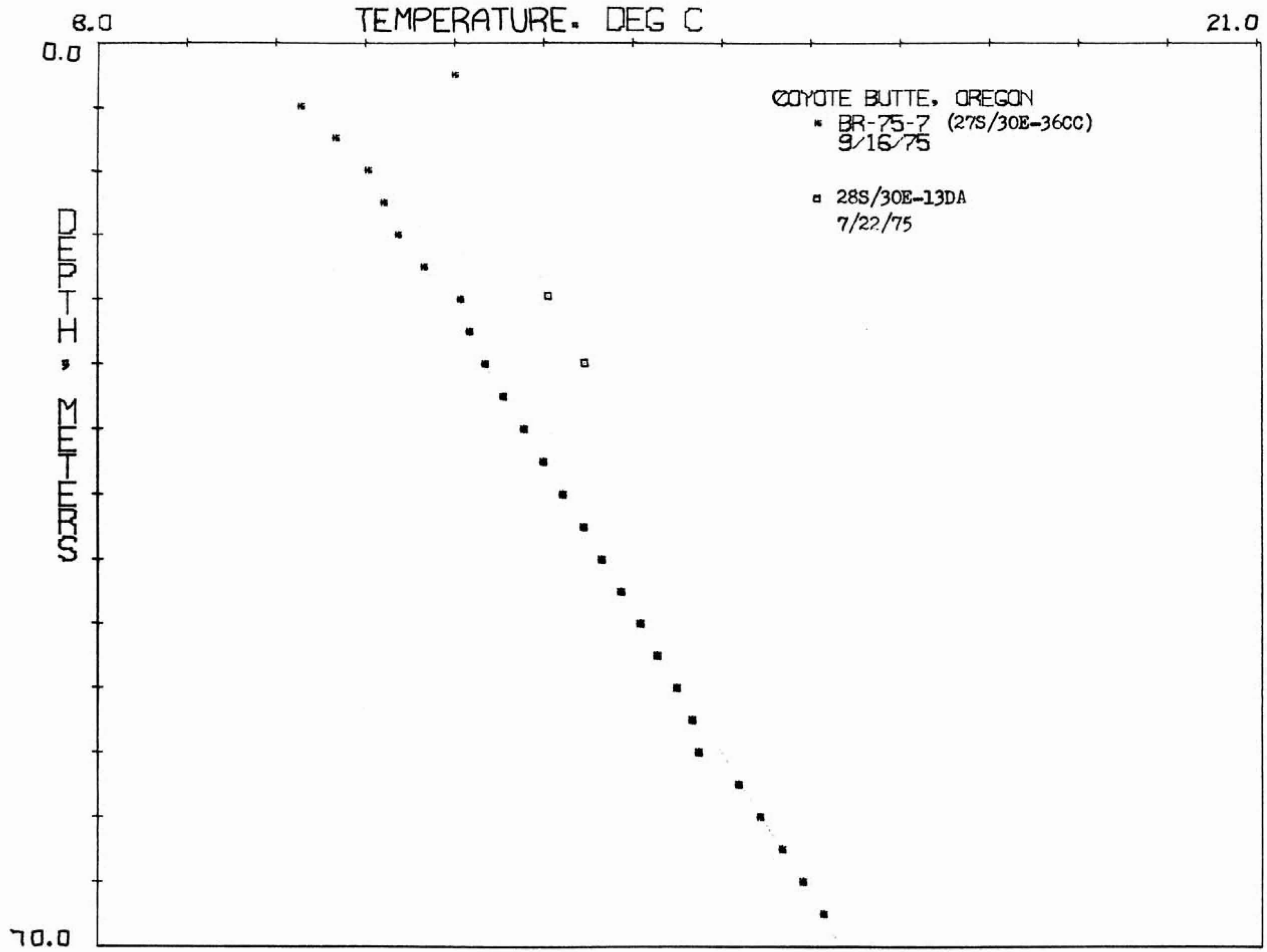

TEMPERATURE, DEG C
13.0
23.0
18
.0
50
100
150.0
DEPTH, METERS
BOISE AMS. OREGON
× 23S/46E-21BC

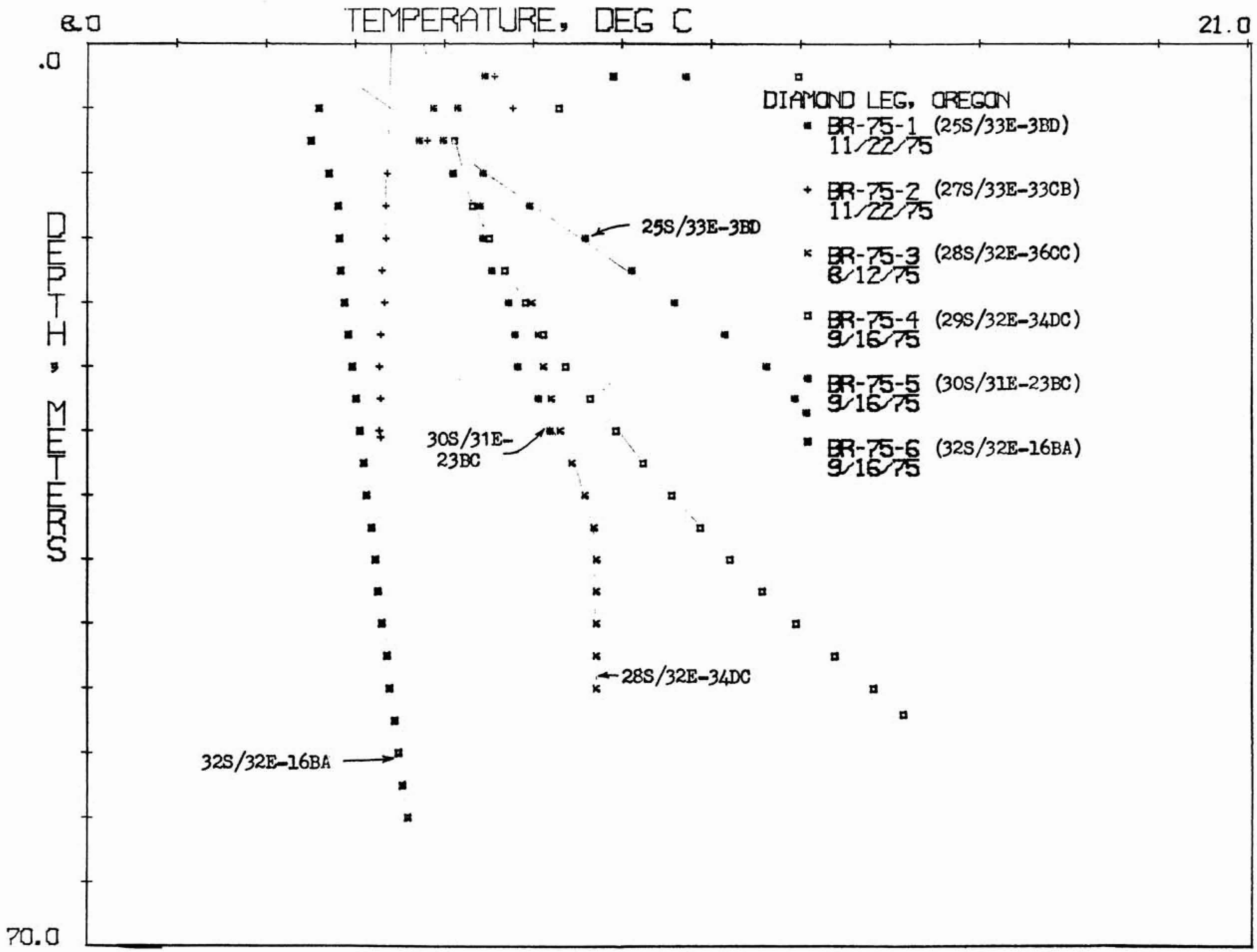

TEMPERATURE, DEG C
8.0
21.0
0.0
70.0
DEPTH, METERS
GLASS BUTTES LEG, OREGON
BR-75-18 (21S/23E-26C)
9/30/75
BR-75-19 (22S/23E-14CB)
9/30/75
BR-75-21 (23S/23E-18C)
/30/75
BA-75-22 (24S/22E-2DD)
10/ 2/75
BR-75-23 (24S/22E-20AA)
10/ 2/75
24S/22E-2DD
23S/23E-18C
24S/22E-20AA
21S/23E-26C

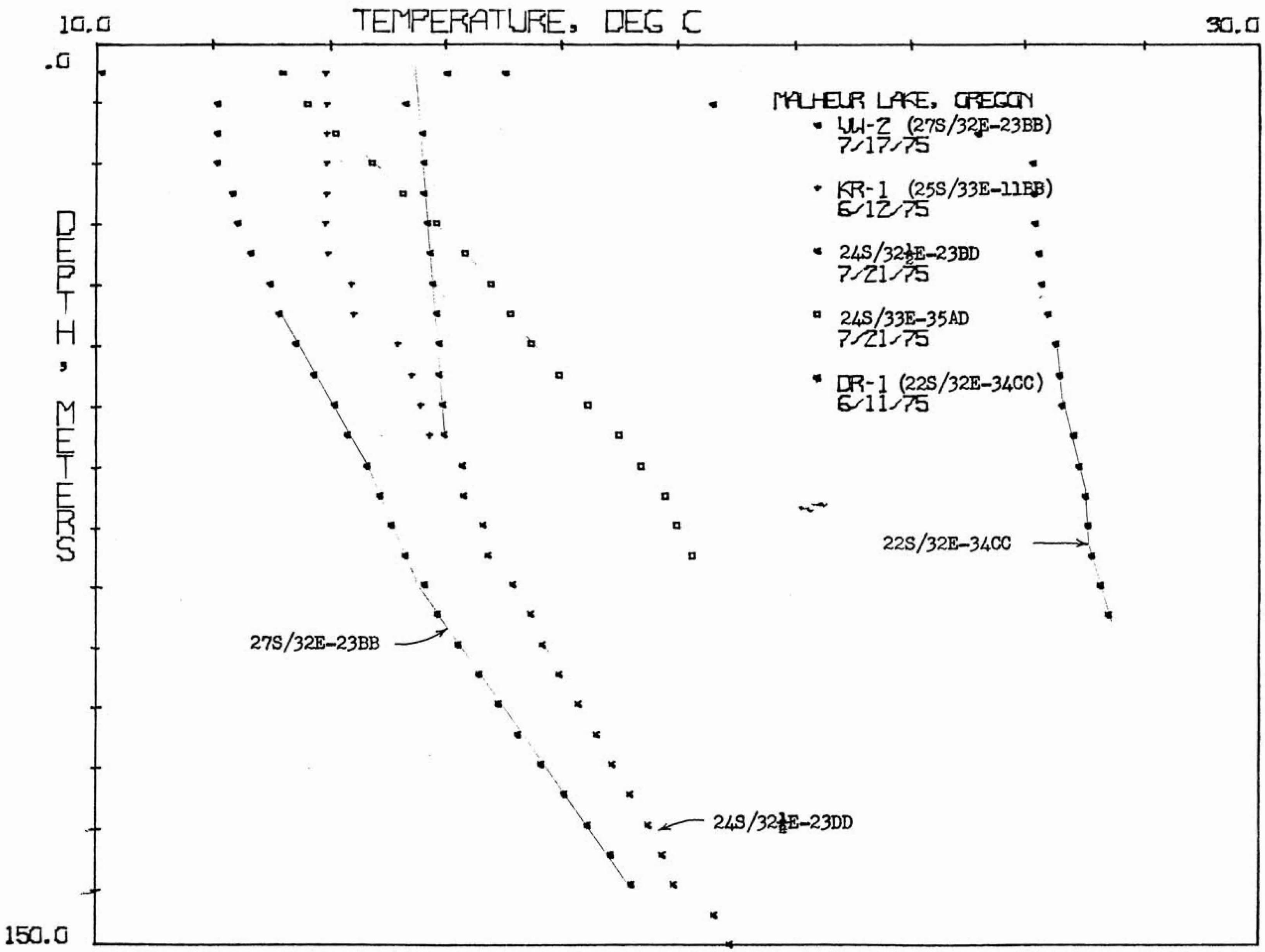

TEMPERATURE, DEG C
8.0
21.0
0.0
70.0
DEPTH, METERS
WAGONTIRE LEG, OREGON
BR-75-12 9/30/75 (23S/28E-18D)
BR-75-13 9/30/75 (24S/26E-24AC)
BR-75-14 9/30/75 (25S/26E-4CC)
BR-75-15 9/30/75 (26S/25E-20BB)
BR-75-16 9/30/75 (28S/24E-4BA)
BR-75-17 9/30/75 (26S/24E-24AD)
25S/26E-4CC
28S/24E-4BA
23S/28E-18D
26S/24E-24AD
24S/26E-24AC



TEMPERATURE, DEG C
8.0
21.0
0.0
70.0
DEPTH, METERS
DOUBLE-O LEG, OREGON
BR-75-8 (26S/30E-20DB)
9/29/75
BR-75-9 (27S/29E-21AC)
9/29/75
BR-75-10 (26S/30E-3BB)
9/16/75
BR-75-11 (25S/31E-4BB)
9/16/75


TEMPERATURE, DEG C
8.0
21.0
0.0
70.0
DEPTH, METERS
COYOTE BUTTE, OREGON
* BR-75-7 (27S/30E-36CC)
9/16/75
▫ 28S/30E-13DA
7/22/75


TEMPERATURE, DEG C
8.0
21.0
.0
70.0
DEPTH, METERS
DIAMOND LEG, OREGON
BR-75-1 (25S/33E-3BD)
11/22/75
BR-75-2 (27S/33E-33CB)
11/22/75
BR-75-3 (28S/32E-36CC)
8/12/75
BR-75-4 (29S/32E-34DC)
9/16/75
BR-75-5 (30S/31E-23BC)
9/16/75
BR-75-6 (32S/32E-16BA)
9/16/75
25S/33E-3BD
30S/31E-
23BC
28S/32E-34DC
32S/32E-16BA



TEMPERATURE, DEG C
10.0
30.0
DEPTH, METERS
.0
150.0
MALHEUR LAKE, OREGON
WW-2 (27S/32E-23BB)
7/17/75
KR-1 (25S/33E-11BB)
6/12/75
24S/32½E-23DD
7/21/75
24S/33E-35AD
7/21/75
DR-1 (22S/32E-34CC)
6/11/75
22S/32E-34CC
27S/32E-23BB
24S/32½E-23DD